STUDIES ON TROPICAL FRUIT FLIES

(DIPTERA : TEPHRITIDAE : DACINAE)

VOLUME 1

BIOLOGY, ECOLOGY, PHEROMONE CHEMISTRY

R. A. I. DREW

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UNIVERSITY OF QUEENSLAND
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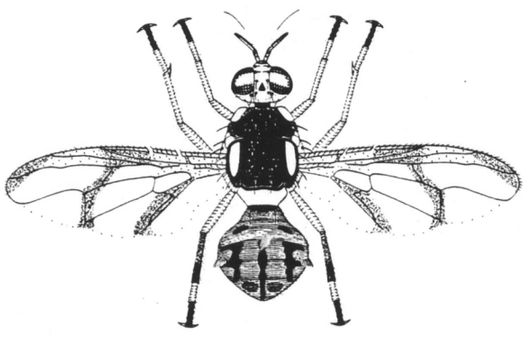
STUDIES ON TROPICAL FRUIT FLIES
(DIPTERA: TEPHRITIDAE: DACINAE)

Volume I - biology, ecology, pheromone chemistry

by

RICHARD ARTHUR IAN DREW



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STUDIES ON TROPICAL FRUIT FLIES (DIPTERA: TEPHRITIDAE: DACINAE)

by

Richard Arthur Ian Drew

ABSTRACT

This submission consists of published papers presenting original research carried out by the writer since 1967. The research has covered aspects of the taxonomy, biogeography, biology, ecology, pheromone chemistry and control of tropical fruit flies (subfamily Dacinae). Papers published on research used for the previously awarded degree, Doctor of Philosophy, are not included.

The primary aim of the research has been to increase our knowledge of the species of Dacinae, particularly in the South Pacific area, and to elucidate new information on their geographic distributions, host plants (wild and commercial), biology, ecology and pheromone communication systems.

In the taxonomy studies 8 new subgenera and 172 new species have been described. The first descriptions of dacine species from the South Pacific area were by Macquart (1835) and Francis Walker (1859-1865). The 172 species described by the writer represent 60% of the 290 species now known. This research has culminated in a comprehensive monograph (publication No.38) treating all 290 species. It included, for the first time, a revision of the Australian fauna and data on biology, distribution and attractant records. A new generic/subgeneric classification has been developed based on data of biological and zoogeographic significance in addition to standard morphology. This is the first supraspecific classification of Dacinae that accommodates species from all biogeographic regions of the world.

Many species, including some major pest species, occur within sibling species complexes, e.g. *Bactrocera tryoni* (Froggatt) (Queensland fruit fly) and *Bactrocera dorsalis* (Hendel) (Oriental fruit fly). In the diagnosis of sibling species, a combination of techniques has been used, viz., morphology (including scanning electron microscopy), cytology, enzyme electrophoresis, pheromone chemistry, biology (host records, assortative mating experiments and sterility studies) (see publications 18 and 29). Currently, the writer is using a combination of these techniques in a study of the Oriental fruit fly complex of South East Asia. Consequently, the taxonomic research has gone beyond standard morphological taxonomy and has incorporated other

disciplines. This is the first time that such a broad approach has been taken in tephritid taxonomy.

Results of the taxonomic research have had significant economic applications -

(1) Species of major economic importance throughout the Pacific area have been determined.

(2) Data have been incorporated into Plant Quarantine guidelines for Asian and South Pacific nations.

(3) Target species and their host fruits have been defined for development of post-harvest disinfestation treatments.

This has been of particular value to 'developing' countries which have been building international trade in fresh fruits.

A new family of Strepsiptera containing one species has been described (publication No.26). The species, *Dipterophagus daci* Drew and Allwood, is the first strepsipteran parasite to be described in Diptera and now has been recorded from eleven dacine host species across Northern Australia.

The ecological research has focused on species distribution and abundance with particular emphasis on populations in the endemic rainforest habitat (publications 12, 15, 19, 21, 24, 25). Host records have been obtained for species breeding in Queensland rainforests and are published in publication No.38. Prior to this research, very little had been done on tropical fruit flies in their endemic habitat, even though fruit fly ecology has received a great deal of attention worldwide over many years.

An important new finding in the rainforest ecology is that the major biotic population-reducing mechanisms in that habitat are fruit feeding vertebrates (publications 32 and 36), not hymenopterous parasites as previously thought.

The biological research has been concentrated on aspects of the identity, distribution and abundance of adult fly food in nature, for certain dacine species. These investigations have led to the discovery that certain bacteria species are utilised as adult food and have established a much improved understanding of fruit fly biology. A discovery of particular importance is the introduction and distribution of bacteria over the host plant by regurgitation. Relevant publications are Nos 22, 30, 33, 34, 43 and 45. These studies have increased our understanding of fruit fly/host plant relationships which is now proving vital to our knowledge of fruit fly biology and development of control methods based on attractants.

The fruit fly/bacteria biology data are now being used by organisations developing bait spraying strategies for fruit fly eradication programs; for example, the Western Australian Department of Agriculture eradication program for *Bactrocera tryoni* (Queensland fruit fly) and the New Zealand Department of Agriculture contingency plans for eradication of introduced species.

Understanding the biology of fruit flies has become an important facet of the taxonomic research. Biological data have been used to help identify sibling species. Also, this work has shown that understanding the associations of fruit fly species and their host plants, the biological differences between even closely related species, and the factors governing species distribution, are vital to understanding speciation and therefore to sound taxonomy.

Control studies have centred on the use of food bacteria species in attractant bait sprays. Improved attractancy has been obtained by the addition of bacteria to hydrolysed protein suspensions (publication No.37). Chemical analyses of volatile bacterial metabolites have identified some components, and their attractant properties are being assessed.

A major contribution of the research has been on emphasising the value of basic research in finding solutions to economic problems. Such solutions could not be found in short-term applied research. Significant discoveries arose from studies of the fruit flies in their endemic habitat and not by pursuing the standard economic entomology approach in commercial orchards. The work has also shown that taxonomy and biology are interdependent and that neither should be overlooked in biological research programs.

STATEMENT OF AUTHENTICITY

I hereby declare that

(1) The published results submitted herein have resulted from original research I have undertaken during my employment as an Entomologist in the Queensland Department of Primary Industries from 1967 to the present.

(2) This submission does not contain published works that resulted from research carried out for the degree of Doctor of Philosophy, awarded in 1972.

(3) Except as otherwise indicated for the joint-authorship publications, this submission comprises my own unaided work. The material has not been submitted before for examination in either the University of Queensland or any other University.

R.A.I. Drew. — R.A.I. DREW

1/8/1990 — DATE

DEDICATION

To my wife Glenys,

children Leanne, Alasdair and Cameron

and my father Dudley and late mother Dorothy, for

years of encouragement, support and patience during my absorbing program of research activities.

ACKNOWLEDGEMENTS

Much of the help so generously given to me by colleagues and friends, in many parts of the world and in many different ways, is acknowledged in the enclosed publications. To these acknowledgements I add a special word of thanks to the following people -

Professor H.E.H. Paterson, Department of Entomology, University of Queensland, for many thought-provoking discussions, and for advice and encouragement during the preparation of this submission;

Mrs Glenys Drew, for many hours of meticulous typing of manuscripts;

Mr T. Passlow, formerly Director, Entomology Branch, Queensland Department of Primary Industries, for his patience, encouragement and support in allowing me to pursue a program of basic research;

Dr G.H.S. Hooper, Director, Australian Plague Locust Commission and formerly Department of Entomology, University of Queensland, for valuable encouragement and teaching during my early career;

Dr D.E. Hardy, Department of Entomology, University of Hawaii, for collaboration and stimulating discussions in fruit fly taxonomy;

Mr A.J. Allwood, Department of Primary Industry and Fisheries, Darwin, for many years of friendship and collaboration in field research.

INTRODUCTION

Since the mid-nineteenth century, some fruit fly species have been recognised worldwide as major economic pests. In the earlier years of subsistence agriculture in Australia, fruit fly infestations in fruit were chiefly of nuisance value. However, with the development of large scale horticulture in the twentieth century, fruit fly infestations have become one of the most important of all insect pest problems.

The more recent colonisation of Australia, relative to other older colonies, has enabled an assessment of how fruit fly problems can evolve (Drew 1989, publication No.44). Briefly, with the clearing of endemic forests containing the wild host fruits of fruit flies, and the introduction of exotic fruits for commercial production, the endemic fly species with wide wild host ranges have transferred into the cultivated fruits and expanded their geographic ranges. That is, the tephritid species with wide endemic host ranges and greater climatic tolerances, have shown the capacity to become pests.

Since World War II, fruit flies worldwide have posed serious quarantine problems. These have two aspects. Firstly, the potential for the introduction of exotic species into new areas or countries. Examples of this are the spread of *Bactrocera tryoni* (Froggatt) (Queensland fruit fly) from Australia, across the South Pacific to New Caledonia and the Society Islands, and *Bactrocera dorsalis* (Oriental fruit fly) from South East Asia into Hawaii. Secondly, there have been severe restrictions on interstate and international trade as authorities work to restrict the spread of fruit fly species. The expansion of trade in fresh horticultural commodities is extremely important to developing countries of Asia and the Pacific and has now become a major area of quarantine effort. Most nations in these regions require export dollars and successfully produce large quantities of fresh fruits which are in great demand in the more developed countries. Growth in horticultural trade for these countries requires the establishment of good pre-harvest fruit fly control strategies in orchards and the development of post-harvest treatments to guarantee that commodities are free of all living fruit fly eggs and larvae.

Historically, control strategies have involved insecticide cover sprays for pre-harvest control and primarily chemical fumigation for post-harvest control. Current concern over chemical residues in food commodities and the environment has highlighted the need to develop attractants and bait sprays of maximum efficacy in pre-harvest control and non-chemical methods of post-harvest disinfestation.

Attractants and baits for fruit fly control will make significant contributions to Integrated Pest Management systems in many horticultural crops.

Worldwide, there have been major contributions to our knowledge of Tephritidae, through research into temperate and tropical species. The family consists of approximately 4,000 known species covering a wide range of climate and habitat types. Relatively few species are recognised as economic pests. The Tephritidae are all phytophagous, their larvae infesting almost all plant parts depending on the species involved. Fruits, vegetables, flowers (especially Asteraceae), flower buds, bamboo shoots, stems and woody branches are all utilised by larvae. They exhibit a range of unusual larval habitats such as leaf mines and stem galls in addition to the normal behaviour of larvae feeding in bacteria-decayed tissue.

In addition to the investigations necessary for developing control procedures for tephritid pest species, fruit flies are an excellent subject for basic research. For example, the family has undergone extensive speciation, particularly in the tropical and subtropical regions. This has given rise to large numbers of species and a wide range of habitat associated biologies. Consequently, research into the taxonomy, biology and evolution of species is most rewarding in biological knowledge.

Because an understanding of the species and their biology (particularly host plant biology) is basic to developing integrated pest management procedures and pest control techniques based on minimal pesticide usage, in addition to the benefits noted above in basic research, the writer has followed these general themes in research on the Dacinae.

Consequently, this submission, covering the writer's research since 1967, is presented in three volumes as follows -

Volume I - biology, ecology, pheromone chemistry
Volume II - taxonomy (part A)
Volume III - taxonomy (part B).

The taxonomic studies were planned to define the species of Dacinae occurring in Australia and throughout the South Pacific region. Although species are always defined, and placed in keys, on morphological criteria, the occurrence of large numbers of sibling species necessitated the use of biological data in order to determine more accurately the specific status of populations.

Consequently, the writer initiated research into the biology and ecology of some species of Dacinae in the mid-1970's. Particular emphasis was placed on species in their endemic rainforest habitat. These studies have been most rewarding and have revealed that endemic host plant records are valuable in detecting species. This research was expanded into studies on the seasonal abundance and geographic distributions of species, trapping and methods of monitoring populations, adult fruit fly

nutrition (including bacterial relationships and the use of certain bacteria as an extrinsic food source), host plant relationships and the reduction in fruit fly populations due to biotic factors such as parasites and predators.

The biology research, and its value in understanding species, led to the compilation of data on the species-specific responses of males to the synthetic lures, cue lure and methyl eugenol.

The differentiation of species has been enhanced further through research into the electrophoresis of tissue enzymes and chemistry of male pheromones. The pheromone research and host plant biology are inter-related in that the male flies release the pheromone during courtship within the host tree, usually at dusk. These studies have pioneered the application of the Recognition Concept of species in tephritid taxonomic research. In particular, the understanding of host plant mating in endemic hosts, and the data on fruit fly - host plant relationships, have assisted in developing discussions on the relevance of this concept to speciation in the Dacinae.

In summary, studies into the biology and ecology of species (particularly host plant mating and host plant relationships), responses to attractants, tissue enzyme electrophoresis, pheromone chemistry, taxonomy, biogeography and evolution of species have combined to provide a large amount of valuable data. The various aspects have proven to be inter-related, each facet providing data of significant value to understanding the other. Although unpublished, the combined data are now throwing light on the probable process of speciation in the Dacinae.

The bacterial biology deserves further comment in that it is a new, original and innovative approach to researching the relationship of fruit flies and their bacteria. Prior to this research, the bacteria associated with tephritids have been classed as obligate symbionts. This new approach has shown that species of tropical Dacinae utilise some bacteria as an adult food source and as important cues in the fly/host plant relationships. Behaviour patterns such as the introduction and distribution of bacteria over the host fruit surfaces by adult flies entering the host plant, have been described. These aspects of fruit fly biology suggest that the insect/bacteria relationships are complex and deserve further intensive investigations.

The host plant biology and bacteria studies have provided a basis for developing more attractive bait sprays and for designing more efficient strategies for bait spray applications. Most of this research is recent and yet to be published (except publication No.37). However, proteinaceous suspensions inoculated with certain fruit fly associated bacteria have shown marked increases in attractancy for some species of Dacinae. The addition of some inert thickening agents such as carboxy methyl

cellulose also has increased the attractancy of some bait sprays. This work has shown that bacterial fermentation of proteinaceous suspensions is a significant component of attraction. Bacterial fermentation research and chemistry studies of such processes are likely to lead to new and more powerful bait sprays for fruit fly control and eradication. The research has shown also that the host plant is a primary centre of activity for tropical dacine species. Consequently, bait spray applications to host plant areas during the period of fruit maturation will probably maximise the chances of success of control and eradication programs.

A new family of the parasitic order Strepsiptera was described. The only species, *Dipterophagus daci* Drew and Allwood, is the only strepsipteran parasite to be described worldwide from any species of Diptera. This is a unique association and the authors (Drew and Allwood) are presently compiling data on the parasitism levels, seasonal abundance, geographic distribution and fruit fly hosts for the parasite.

Overall, the reserach has illustrated that both basic and applied research are essential in Entomology and that basic research in insect biology and taxonomy can provide results of significant applied value.

The writer's plans for future research are to provide answers to some of the gaps in the above work. This is particularly so for the bacteria biology and attractant studies. Also, the taxonomy of the *dorsalis* complex of over forty species in Asia/South East Asia is presently being researched and plans are now being formulated to produce a monograph of Asian/South East Asian Dacinae.

Material submitted for examination

The material submitted for examination consists of published papers, or manuscripts accepted for publication, covering the writer's research on tropical fruit flies (Diptera: Tephritidae: Dacinae).

The following bibliography lists all papers published but those marked with an '*' are not presented because they represent material submitted by the writer for the degree of Doctor of Philosophy.

Publication No.3 was used as part of the requirements for the writer's Honours degree. It is included in the submission for two reasons - (a) it describes growth changes with age in the male genital endoskeletal structures and illustrates why these structures could not be used in later taxonomic research, and (b) it describes how the growth changes in the endoskeletal structures can be used to assess the sexual maturity of adult male flies; this was used in later ecological research.

List of Publications

(publications marked with an '*' are not presented for examination)

1. **DREW, R.A.I. (1968a).** - Two new species of Dacinae (Diptera: Trypetidae) from New Britain. *J. Aust. ent. Soc.* 7:21-24.

2. **DREW, R.A.I. (1968b)** - Two new species of Dacinae (Diptera:Trypetidae) from New Guinea. *J. Aust. ent. Soc.* 7:77-79.

3. **DREW, R.A.I. (1969).** Morphology of the reproductive system of *Strumeta tryoni* (Froggatt) (Diptera:Trypetidae) with a method of distinguishing sexually mature adults males. *J. Aust. ent. Soc.* 8:21-32.

*4. **DREW, R.A.I. (1971)** - New species of Dacinae (Diptera:Trypetidae) from the South Pacific Area. *Qd J. agric. Sci.* 28:29-103.

*5. **DREW, R.A.I. (1972a)** - The generic and subgeneric classification of Dacini (Diptera: Tephritidae) from the South Pacific area. *J. Aust. ent. Soc.* 11:1-22.

*6. **DREW, R.A.I. (1972b)** - Additions to the species of Dacini (Diptera:Tephritidae) from the South Pacific area with keys to species. *J. Aust. ent. Soc.* 11:185-231.

*7. **DREW, R.A.I. (1973)** - Revised descriptions of species of Dacini (Diptera:Tephritidae) from the South Pacific area. I. Genus *Callantra* and the *Dacus* Group of subgenera of genus *Dacus*. Queensland Department of Primary Industries, Division of Plant Industry Bulletin No. 652, 39 pp.

*8. **DREW, R.A.I. (1974a)** - Revised descriptions of species of Dacini (Diptera:Tephritidae) from the South Pacific area. II. The *Strumeta* group of subgenera of genus *Dacus*. Queensland Department of Primary Industries, Division of Plant Industry Bulletin No. 653, 101 pp.

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12. **HOOPER, G.H.S. and DREW, R.A.I. (1978)** - Comparison of the efficiency of two traps for male tephritid fruit flies. *J. Aust. ent. Soc.* 17:95-97.

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14. **DREW, R.A.I. (1978)** - Fruit fly collecting. p. 126-137 *In* Drew, R.A.I., G.H.S. Hooper, and M.A. Bateman. Economic Fruit Flies of the South Pacific Region, Australian Dept Health, Canberra. 137 pp.

15. **HOOPER, G.H.S. and DREW, R.A.I. (1979)** - Effect of height of trap on capture of tephritid fruit flies with cue lure and methyl eugenol in different environments. *Environmental Entomology* 8:786-788.

16. **DREW, R.A.I. (1979)** - The genus *Dacus* Fabricius (Diptera:Tephritidae) - Two new species from Northern Australia and a discussion of some subgenera. *J. Aust. ent. Soc.* 18:71-80.

17. **DREW, R.A.I., HANCOCK, D.L. and ROMIG, M.C. (1981)** - Australian Dacinae (Diptera:Tephritidae) - New Species from Cape York Peninsula, a discussion of species complexes and key to species. *Aust. J. Zool.* 29:49-91.

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22. **DREW, R.A.I., COURTICE, A.C. and TEAKLE, D.S. (1983)** - Bacteria as a Natural Source of food for adult fruit flies (Diptera:Tephritidae). *Oecologia (Berlin)* 60:279-284.

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26. **DREW, R.A.I. and ALLWOOD, A.J. (1985)** - A new family of Strepsiptera parasitising fruit flies (Tephritidae) in Australia. *Systematic Entomology* 10:129-134.

27. **KITCHING, W., LEWIS, J.A., FLETCHER, M.T., DREW, R.A.I., MOORE, C.J. and FRANCKE, W. (1986)** - Spiroacetals in Rectal Gland Secretions of Australasian Fruit Fly species. *J. Chem. Soc., Chem. Commun.* 853-854.

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29. **DREW, R.A.I. and LAMBERT, D.M. (1986)** - On the specific status of *Dacus (Bactrocera) aquilonis* and *Dacus (Bactrocera) tryoni* (Diptera:Tephritidae). *Ann. ent. Soc. Am.* 79: 870-878.

30. **LLOYD, A.C., DREW, R.A.I., TEAKLE, D.S., and HAYWARD, A.C. (1986)** - Bacteria associated with some *Dacus* species (Diptera:Tephritidae) and their host fruit in Queensland. *Aust. J. biol. Sci.* 39:361-368.

31. **MACFARLANE, J.R., EAST, R.W., DREW, R.A.I. and BETLINSKI, G.A. (1987)** - Dispersal of Irradiated Queensland Fruit Flies, *Dacus tryoni* (Froggatt) (Diptera:Tephritidae), in South-Eastern Australia. *Aust. J. Zool.* 35:275-281.

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35. **LEWIS, J.A., MOORE, C.J., FLETCHER, M.T., DREW, R.A.I., KITCHING, W. (1988)** - Volatile compounds from the flowers of *Spathiphyllum cannaefolium. Phytochemistry* 27:2755 2757.

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37. **DREW, R.A.I. and FAY, H.A.C. (1988)** - Comparison of the roles of Ammonia and Bacteria in the attraction of *Dacus tryoni* (Froggatt) (Queensland fruit fly) to proteinaceous suspensions. *J. Pl. Prot. Tropics* 5:127-130.

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41. **DREW, R.A.I. (1989)** - Chapter 1.2 The taxonomy and distribution of tropical and subtropical Dacinae (Diptera:Tephritidae). Ibid, pp 9-14.

42. **HOOPER, G.H.S. and DREW, R.A.I. (1989)** - Chapter 2.5 Australia and South Pacific islands. Ibid, pp 67-72.

43. **DREW, R.A.I. and LLOYD, A.C. (1989)** - 3.1.3 Bacteria associated with fruit flies and their host plants. Ibid, pp 131-140.

44. **DREW, R.A.I. (1989)** - A century of fruit fly research in Australia. Perkins Memorial Lecture. Entomological Society of Queensland News Bulletin 17: 89-104.

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47. **PERKINS, M.V., KITCHING, W., DREW, R.A.I., MOORE, C.J., and KONIG, W.A. (1990)** - Chemistry of fruit flies: Composition of the male rectal gland secretions of some species of South-East Asian Dacinae. Re-examination of *Dacus cucurbitae* (Melon fly). *J. Chem. Soc., Perkin Trans.* 1, 1111-1117.

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49. **PERKINS, M.V., KITCHING, W., KONIG, W.A., DREW, R.A.I. (in press)** - An (S) - (+) - Lactic Acid route to (2S, 6R, 8S) - 2, 8 - Dimethyl - 1, 7 - dioxaspiro [5.5] undecane and (2S, 6R, 8S) - 2 - Ethyl - 8 - Methyl - 1, 7 - dioxaspiro [5.5] undecane and demonstration of their presence in the rectal glandular secretion of *Bactrocera nigrotibialis* (Perkins). *J. Chem. Soc., Perkin Trans.* 1.

CONTRIBUTIONS TO JOINT PUBLICATIONS

Nos 12, 15, 19, 21, 24, 25 - These arose from a project funded by the Rural Credits Development Fund. The concept of ecological research in the rainforest habitat was originated by R. Drew. The grant application and research was planned by R. Drew and G. Hooper, and funds paid to Department of Primary Industries. R. Drew carried out most of the field work and wrote the first drafts of Nos 19, 21 and 24. G. Hooper collaborated closely during the conduct of the research and revised the manuscripts. M. Zalucki carried out the statistical analyses upon completion of the research.

No. 20 - The book was planned and edited by R. Drew who wrote two of the four chapters. The second edition (No.20) required considerable rewriting by all authors and editing by R. Drew to enable a valuable update.

No. 17 - The research was planned and conducted by R. Drew. D. Hancock collected the material in Cape York over a two year period, while M. Romig prepared the art work.

No. 18 - Most of the research was conducted by R. Drew who also wrote the manuscript. D. Hardy carried out a morphological comparison of the species and revised the manuscript.

Nos 22, 30, 34, 43, 45 - These papers are based on the new bacteria biology work. The concept was pioneered and developed by R. Drew. The other authors are microbiologists who have made valuable contributions in the bacteria isolation and identification areas. A.C. Lloyd has conducted much of the research in close collaboration with R. Drew.

No. 23 - The research was planned and carried out by A. Courtice who also wrote the manuscript. R. Drew provided background literature for the introduction in the paper and provided fruit fly identifications on the field collected specimens.

No. 26 - The research was carried out and manuscript written by R. Drew. A. Allwood undertook extensive field collections over a twelve-month period in the Northern Territory to provide material for study.

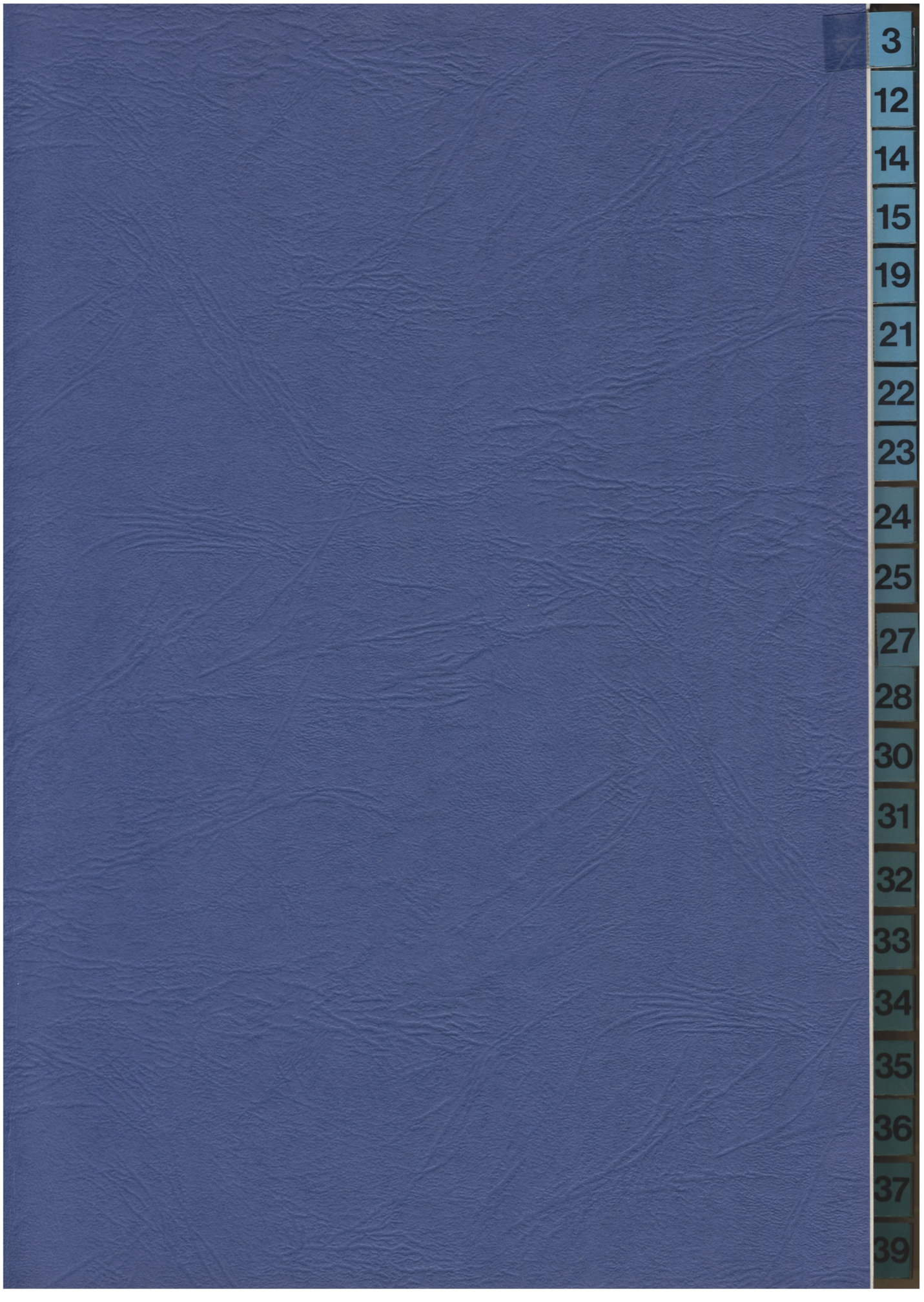
Nos 27, 28, 35, 39, 47, 48, 49 - The concept of pheromone research was conceived by R. Drew who collected the flies and isolated the pheromones from the glands. The other authors (all chemists) carried out the chemistry research. This work was partly supported by Plant Quarantine and Rural Credits Development Fund grants to the Department of Primary Industries.

No. 29 - All research except the tissue enzyme electrophoresis was carried out by R. Drew. D. Lambert assisted in the electrophoresis.

No. 31 - The project was planned by J. Macfarlane and R. Drew. Also, R. Drew cultured and supplied the sterile fruit flies for release. J. Macfarlane, R. East and G. Betlinski are officers of the Victorian Department of Agriculture and carried out the field work.

No. 37 - R. Drew planned the research and assisted in the experiments. R. Drew also wrote the manuscript. H. Fay provided assistance in the conduct of the experiments.

No. 42 - Jointly written by both authors based on data accumulated from field surveys organised by R. Drew over many years.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MORPHOLOGY OF THE REPRODUCTIVE SYSTEM OF *STRUMETA TRYONI* (FROGGATT) (DIPTERA: TRYPETIDAE) WITH A METHOD OF DISTINGUISHING SEXUALLY MATURE ADULT MALES

By R. A. I. DREW*

[*Manuscript received December* 11, 1968]

Abstract

Morphology of adult female and male reproductive systems of *Strumeta tryoni* (Froggatt) is described and figured.

Growth changes in adult male reproductive endoskeleton are described under differing conditions of temperature and light intensity. For the environmental conditions studied, physiological age was correlated with size of the male reproductive endoskeleton and a method for distinguishing teneral from sexually mature adults is given.

INTRODUCTION

There is increasing interest in the use of insect genitalia for descriptive purposes in systematics because of the unreliability of many external characters such as colour. Correct use of genitalia characters in taxonomy requires a sound knowledge of the morphology and function of the various parts of the reproductive system.

In ecological studies, it is important to be able to distinguish between teneral and sexually mature adults. Munro (1947) recognized two different ejaculatory apodeme shapes for *Isoconia rubida* Munro, but did not give any reason for such variation. Preliminary examination of the male reproductive endoskeleton of *Strumeta tryoni* (Froggatt) showed irregularities in shape and size. Studies were carried out to correlate these variations with geographic distribution, colour form and age.

METHODS AND MATERIALS

Cultures

Material of *S. tryoni* was obtained from the University of New South Wales, Sydney in February 1968. Adults were maintained in 8 in. × 8 in. × 12 in. cages after the method of Osborn and Shipp (1965). Eggs were collected in hollowed out apple skin and cultured at 25°C after the method of May (1961). All flies used in experiments were reared from one colony of adults.

Morphological studies

Reproductive systems were dissected under water. Genital ducts, ovipositors, male endoskeletons, and male 9th abdominal segments were boiled in 10 per cent. potassium hydroxide before being stained in mercurochrome and mounted in canada balsam for microscopical examination. Ejaculatory apodemes were mounted separately on flat microscope slides, and genital rings and fultellas mounted in cavity slides as *in situ*.

Geographical variation

Ten males of unknown physiological age were examined from each of six areas of Queensland, the Atherton Tableland, Ayr, Byfield, Brisbane, Toowoomba and Chinchilla.

Colour forms

Six stages of melanin formation were recognized by May (1963). Ten males of unknown physiological age of each colour stage were examined.

Development of male reproductive endoskeleton

Reproductive endoskeletal structures were dissected out, boiled in potassium

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hydroxide, stained in chlorazol black E and mounted in canada balsam as described above. The ejaculatory apodeme of each specimen was drawn using a prism camera lucida, and the length (mm) and area (sq. mm) calculated. A fixed arm planimeter was used for area measurements.

Development at 25°C and natural light intensity.—Five hundred flies which emerged between 9 a.m. and 12 noon on June 7, 1968, were held in a single cage at 25°C and exposed to natural light. The relative humidity decreased during the course of the experiment from 75 per cent. to 55 per cent. Five male flies were sampled at emergence and subsequently each evening after dusk for 24 days.

Number of pairs in copulation was recorded daily.

Development at 25°C and 120 lumens per square foot light intensity.—Five hundred flies which emerged from the same batch of pupae at the same time as the flies in the above study were held in a single cage in the light cabinet (Fig. 29) at 25°C and exposed to 120 lumens per square foot light intensity between 9 a.m. and 4.30 p.m. At 4.30 p.m. each day, the cabinet was opened to expose the flies to dusk lighting, and after the onset of dark, the cabinet was resealed. Relative humidity in the light cabinet fell to 55 per cent. each day after opening, slowly returning to 80 per cent. by 4.30 p.m. the following day. Five male flies were sampled at emergence and subsequently each evening after dusk for 24 days.

Number of pairs in copulation was recorded daily.

Development under natural conditions of temperature and light intensity.—Five hundred flies which emerged from the laboratory culture at 25°C between 9 a.m. and 12 noon on July 27, 1968, were held in a single cage in a sheltered, shady location and exposed to natural conditions. Temperatures and relative humidities were recorded by a thermohygrograph kept in the breeding cage and times of sunrise and sunset obtained for the period of sampling. Relative humidity remained between 90 per cent. and 100 per cent. for duration of the study. Five males were sampled at emergence and subsequently after dusk every third day for the first 30 days, and every second day for the next 10 days.

Number of pairs in copulation was recorded daily.

Development of musculature on the ejaculatory apodeme

A small batch of flies which emerged between 9 a.m. and 12 noon on the same day was maintained in the laboratory at 25°C, 70 per cent. relative humidity and exposed to natural light. Five male flies were sampled at emergence and subsequently each evening after dusk for 10 days. Ejaculatory apodemes and musculatures were dissected out, stained in mercurochrome and mounted in canada balsam, without boiling in potassium hydroxide.

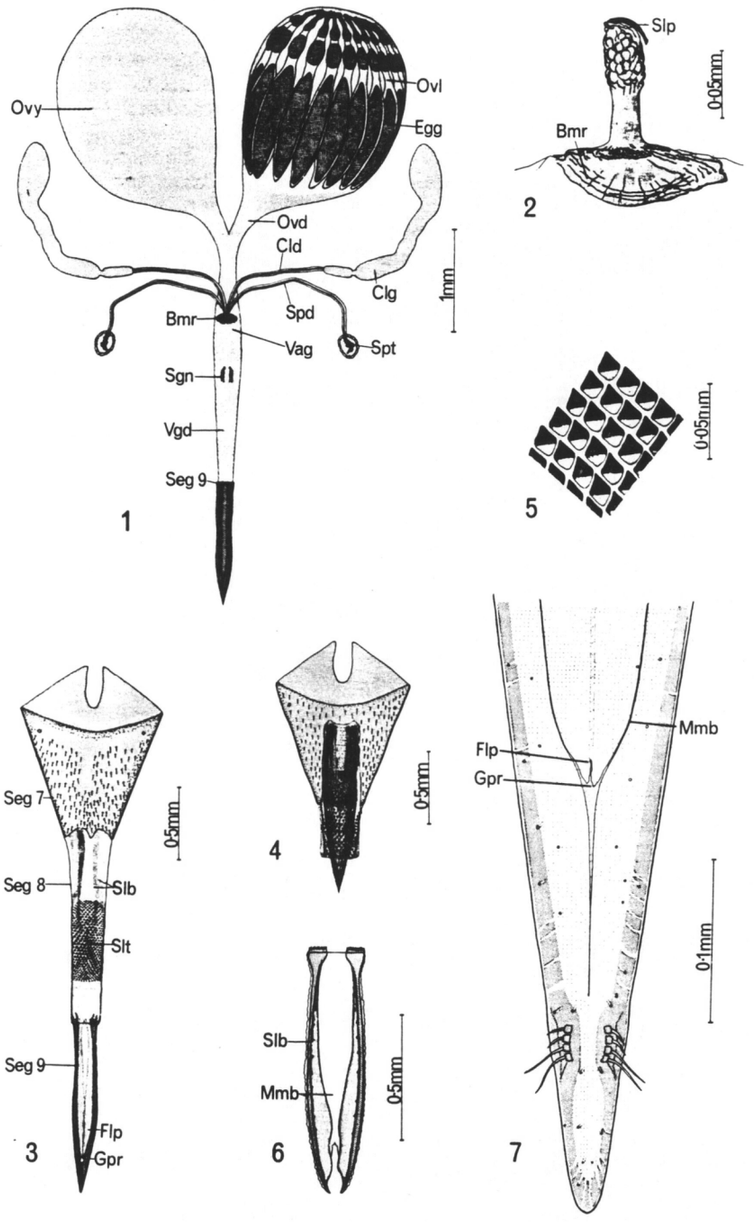
RESULTS

Female reproductive system (Figs. 1-7)

Ovaries.—The ovaries of a teneral female are small because of the immature ovarioles. At sexual maturity, an egg is formed in the basal section of each convoluted ovariole thus expanding the ovaries to fill almost the entire body cavity. The ovaries contain panoistic ovarioles bound together by a transparent membrane. Distal ends of the ovarioles meet in a point at the tip of the ovary.

Genital ducts.—Two short lateral oviducts end in a common oviduct which widens into the vagina. The vaginal duct runs into the modified 9th abdominal segment, the apical segment of the ovipositor. Two sclerotized pieces occur in the dorsal membranous vaginal duct wall. Because of their similarity to signum bursae of Lepidoptera, these sclerotized pieces have been designated as signa. A morula gland is situated on the ventral wall of the vagina. This gland is a stalked body of berry-like spherules with an apical sclerotized process.

Spermathecae.—Two spermathecae are present, functioning for reception and storage of sperm. Each consists of a small, black convoluted tube of glandular tissue surrounded by a layer of fat body. The spermathecal duct is surrounded by

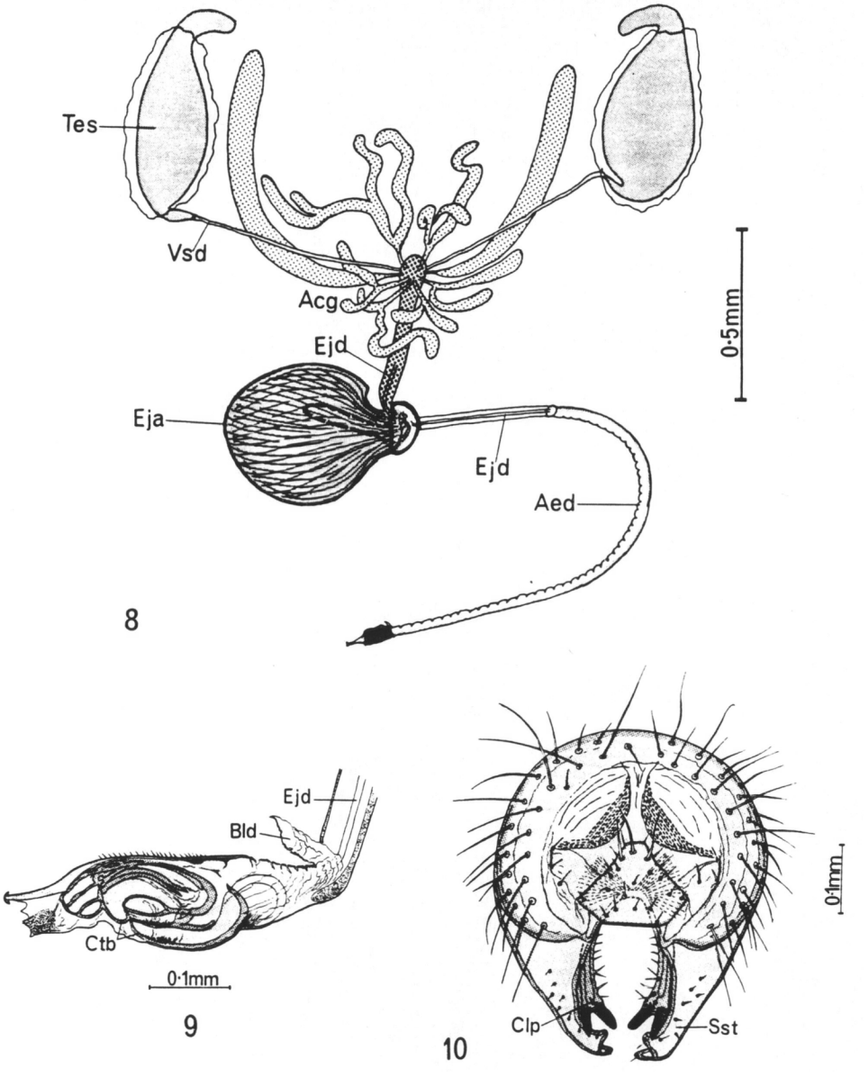


FIGS. 1-7.—*Strumeta tryoni* (Froggatt): (1) female reproductive system—Bmr., base of morula gland; Cld., duct of collaterial gland; Clg., collaterial gland; Egg, egg; Ovd., lateral oviduct; Ovl., ovariole; Ovy., ovary; Seg. 9, abdominal segment 9; Sgn., signum; Spd., duct of spermatheca; Spt., spermatheca; Vag., vagina; Vgd., vaginal duct: (2) lateral view of morula gland—Bmr., base of morula gland; Slp., sclerotized process: (3) extended ovipositor—Flp., ventral flap; Gpr., gonopore; Seg. 7, abdominal segment 7; Seg. 8, abdominal segment 8; Seg. 9, abdominal segment 9; Slb., sclerotized bands; Slt., sclerotized teeth: (4) retracted ovipositor: (5) sclerotized teeth of abdominal segment 8: (6) ventral flap of abdominal segment 9—Mmb., membrane; Slb., sclerotized band: (7) extreme tip of abdominal segment 9—Flp., ventral flap; Gpr., gonopore; Mmb., membrane.

glandular tissue and enters the vagina on the dorsal surface opposite the morula gland base.

Collaterial glands.—Two elongate, slightly convoluted collaterial glands are present. The collaterial gland duct is surrounded by glandular tissue and enters the vagina dorsally immediately posterior to the spermathecal duct.

Ovipositor.—Abdominal segments 7, 8 and 9 are modified to form the ovipositor. Segment 7, the oviscape, is setose, conical in shape, dorso-ventrally compressed and with the tergum and sternum fused laterally. The sternum is produced anteriorly to form a triangular area, the cuticle of which is very thin anteriorly, forming an oval membrane. Segment 8 is long and tubular, strengthened anteriorly by two wide, lateral sclerotized bands which thin out and disappear posteriorly.



FIGS. 8-10.—*Strumeta tryoni* (Froggatt): (8) male reproductive system—Acg., accessory glands; Aed., aedeagus; Eja., ejaculatory apodeme; Ejd., ejaculatory duct; Tes., testis; Vsd., vas deferens: (9) head of aedeagus—Bld., bladder; Ctb., sclerotized bands; Ejd., ejaculatory duct: (10) posterior view of abdominal segment 9—Clp., clasper; Sst., surstylus.

Triangular, sclerotized teeth are present on the posterior 2/3 of the segment surface. The teeth show a gradation in size, being small at the anterior and posterior extremities and well developed in the central region. Each tooth is formed by a raised anterior part of a quadrate plate, the posterior region being embedded in the segment surface. Segment 9, the aculeus, is long, dorso-ventrally compressed and pointed posteriorly, and is thus adapted for piercing the skin of fruit. The dorsal part of this segment, the tergum, is heavily sclerotized, elliptical in cross section and pointed posteriorly to form the body of the piercing organ. The sternum is represented as a ventral flap, consisting of two sclerotized bands connected by membrane along the mid line, and to the body of the piercing organ along its lateral margins. The gonopore is situated ventrally at the posterior end of the flap. On the sub-apical lateral margins of the aculeus there are four small bristles, two long and two short. The sclerotized area of the aculeus is traversed by small, irregularly placed canals which open on the surface. At rest, segment 9 is retracted inside segment 7, with segment 8 folding such that its posterior part lies anteriorly inside segment 7. During oviposition the ovipositor is extended to form a tube with the sclerotized teeth of segment 8 pointing anteriorly. During copulation, the ovipositor is partly extended and the aedeagus enters the ventral gonopore, traverses the length of the aculeus and comes to lie in the vaginal duct. Membrane along the lateral margins of the flap allows the flap to be raised during copulation and oviposition, so allowing passage of objects of greater diameter than the lumen of the aculeus.

Male reproductive system (Figs. 8-11, 25)

Testes.—The testes are yellow, pyriform bodies with their anterior ends bent over, and surrounded by a layer of fat body. The vasa deferentia lead from the posterior ends of the testes into a common duct, the ejaculatory duct, which is surrounded by glandular tissue and runs into the erecting and pumping organ. The ejaculatory duct between the sac and aedeagus is surrounded by a less developed layer of glandular tissue.

Accessory glands.—Four pairs of accessory glands enter subapically the anterior end of the ejaculatory duct. The largest pair are elongated and slightly curved, the remainder shorter and variously branched.

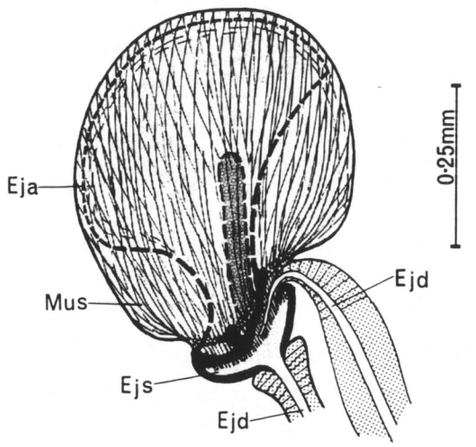


FIG. 11.—*Strumeta tryoni* (Froggatt): erecting and pumping organ—Eja., ejaculatory apodeme; Ejd., ejaculatory duct; Ejs., ejaculatory sac; Mus., muscle.

Erecting and pumping organ.—This organ is composed of a sclerotized disc. the ejaculatory apodeme, and a dome shaped ejaculatory sac with slightly sclerotized walls attached to the base of the apodeme. At the junction of the apodeme and sac, the apodeme expands into a sclerotized basal plate. The ejaculatory duct enters the sac through an aperture at the junction of the sac and apodeme basal plate and continues from the centre of the sac dome through the aedeagus. Muscles, connected to the side wall of the sac by fine fibrillae, run to the extremity of the apodeme where they are firmly attached. Contraction of these muscles draws the wall of the sac to the basal plate closing the inlet of the ejaculatory duct and reducing the sac volume. The resulting pressure on the contained seminal fluid forces it down the ejaculatory duct to the tip of the aedeagus.

Aedeagus.—The aedeagus is a long, curved, slender tube attached proximally to the internal sclerotized endoskeleton and with its distal end leaving the abdomen at the venter of segment 9 between the male claspers. At rest it is coiled and in this position the inner margin is wrinkled while the outer margin has a fine sclerotized band. The head of the aedeagus is a complicated structure with sclerotized bands and muscle attachments, probably acting as a valve serving to hold the fluid in the aedeagus, permitting pressure increase while the erecting and pumping organ is operating, thus erecting the aedeagus. A membranous bladder lies at the base of the aedeagus head.

Abdominal segments.—Abdominal segments 1-5 are well developed, segments 6-8 are absent while segment 9 is reduced and forms the genital segment. The dorsum is produced latero-ventrally to form the surstyli which are immovable non-musculated clasper-like organs. Segment 10 is membranous, invaginated inside segment 9, and has two movable, musculated claspers suspended ventrally. Each clasper possesses two small, black, terminal tooth-like structures. Surstyli and claspers, which bear sensory setae, function to hold the aedeagus during copulation.

Endoskeleton.—The endoskeleton of the reproductive system is suspended internally from the anterior wall of segment 9, and thus is an ectodermal cuticular invagination of this segment. The *genital ring* consists of a sternal apodeme anteriorly and two outwardly curved lateral arms which are connected to a bar on the anterior wall of segment 9. The *fultella* lies above the genital ring and consists of a median posterior bar which expands anteriorly into a laterally compressed phallic apodeme. At the junction of the posterior bar and phallic apodeme, two lateral arms, the vanes, are produced ventrally, and fit inside the genital ring. The vanes are slightly curved, diverge ventrally and at their ventral extremity are connected to sclerotized arms which in turn are connected to the posterior ends of the corresponding genital ring arms. The median posterior bar of the fultella has a posterior bifurcation to which is attached the basal end of the aedeagus. The endoskeleton supports a complex musculature which functions to control the aedeagus during copulation.

Geographical variation

Mean length of the ejaculatory apodeme for each area was: Atherton Tableland, 0·554 mm; Ayr, 0·546 mm; Byfield, 0·544 mm; Brisbane, 0·427 mm; Toowoomba, 0·478 mm; Chinchilla, 0·579 mm.

TABLE I

GEOGRAPHICAL VARIATION OF LENGTH OF EJACULATORY APODEME OF *Strumeta tryoni*—ANALYSIS OF VARIANCE.

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F
Between areas	0·079	5	0·0158	8·77
Residual	0·04	22	0·0018	
Total	0·119	27		

The mean length of the ejaculatory apodemes of specimens from Brisbane and

Toowoomba was significantly different (5 per cent. level) from the mean length of apodemes of specimens from all other areas. The structure of the ejaculatory apodemes of specimens from Brisbane and Toowoomba, however, resembled those of immature specimens. There was no significant difference between measurements of specimens from Brisbane and Toowoomba, and between specimens from Atherton Tableland, Ayr, Byfield and Chinchilla.

Colour forms

The mean length of the ejaculatory apodeme for each colour form was: A, 0·441 mm; B, 0·421 mm; C, 0·362 mm; D, 0·343 mm; E, 0·388 mm; F, 0·330 mm.

TABLE 2

VARIATION IN LENGTH OF EJACULATORY APODEME OF COLOUR FORMS OF *Strumeta tryoni*-ANALYSIS OF VARIANCE

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F
Between colour forms	0·051	5	0·0102	2·37
Residual	0·113	26	0·0043	
Total	0·164	31		

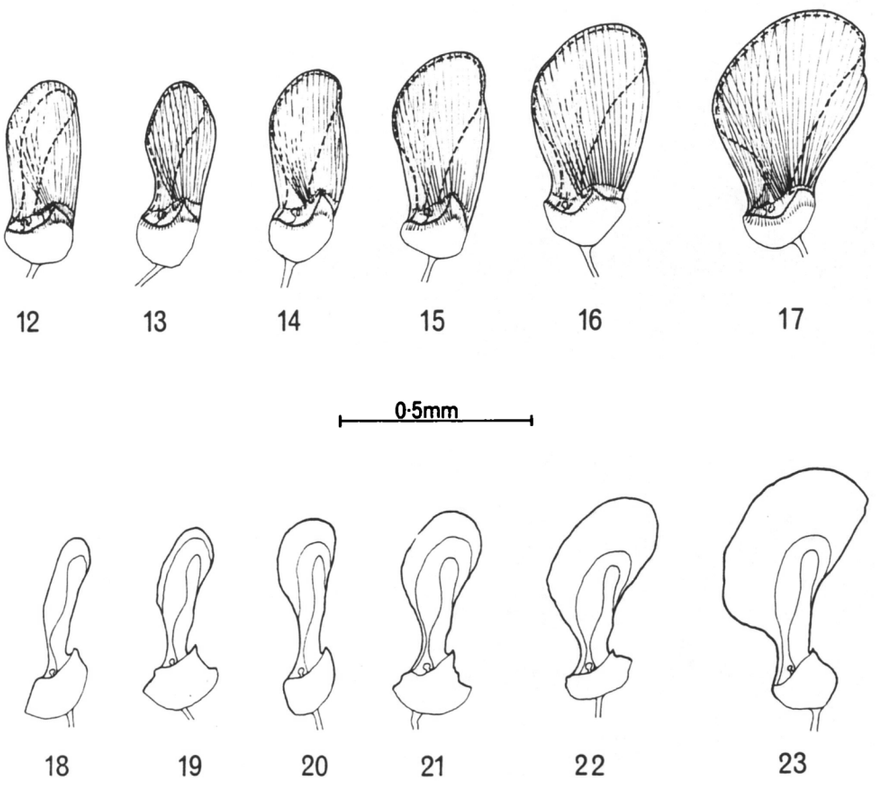
As F was not significant, it was assumed that colour form was not correlated with the mean length of the ejaculatory apodeme.

Development of male reproductive endoskeleton

Development at 25°C and natural light intensity.—Endoskeletal structures increased in size from emergence for the first 5 days, after which they remained relatively unchanged for a further 19 days. Daily growth changes of length and area of ejaculatory apodemes are shown in Figure 26. The relative daily sizes of the ejaculatory apodeme from emergence to 5 days are illustrated in Figures 18-23. At emergence, mean ejaculatory apodeme length was 0·336 mm and mean area 0·024 sq. mm, while from 5 days to 24 days mean length ranged from 0·511 mm to 0·554 mm and mean area 0·107 sq. mm to 0·131 sq. mm. These figures show an increase in length up to 1·5 times and an increase in area of up to 5·5 times that at emergence. The relative humidity range over the 5 day period was 70-75 per cent. Figure 24 shows the genital ring and fultella at emergence, and Figure 25 shows the corresponding structures 5 days later. Changes observed in these structures are an increase in thickness of the lateral arms of the genital ring, a large increase in area of the sternal apodeme, an increase in thickness of the median posterior bar of the fultella, a large increase in area of the phallic apodeme, and a widening of the vanes. Flies began copulating 5 days from emergence and copulation was observed daily at dusk, for a further 5 days. As the ratio of males to females was being constantly changed by daily sampling of males, the daily counts of numbers of flies in copulation will not be considered.

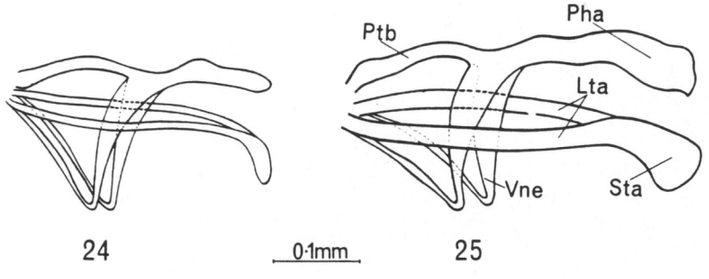
Development at 25°C and 120 lumens per square foot light intensity.—Endoskeletal structures were found to increase in size after emergence. Daily growth changes of length and area of ejaculatory apodemes are shown in Figure 27 at a light intensity of 120 lumens per sq. ft. at the top of the cage shown in Figure 29. At emergence the mean length of ejaculatory apodeme was 0·336 mm and mean area 0·024 sq. mm, while from 5 to 24 days after emergence the mean length ranged from 0·507 mm to 0·563 mm and mean area 0·101 sq. mm to 0·127 sq. mm. These figures show similar increases in size to those of the previous experiment, and flies similarly began copulating 5 days from emergence and copulations were observed daily at dusk, until the 11th day.

Development under natural conditions of temperature and light intensity.—Endoskeletal structures increased in size after emergence; growth changes in length and area of ejaculatory apodemes are shown in Figure 28. Mean length and area



FIGS. 12-23.—*Strumeta tryoni* (Froggatt), ejaculatory apodemes at various times after emergence: (12-17) with musculatures; (18-23) without musculatures: (12, 18) at emergence; (13, 19) 1 day; (14, 20) 2 day; (15, 21) 3 day; (16, 22) 4 day; (17, 23) 5 day.

reached the 5 day value of the previous experiments at 24 days with measurements of 0·534 mm and 0·108 sq. mm, respectively. Copulations were first observed at 24 days after emergence and continued each day, at dusk, until the 39th day.



FIGS. 24, 25.—*Strumeta tryoni* (Froggatt), genital ring and fultella with musculatures removed: (24) at emergence, (25) 5 days after emergence. Lta., lateral arms of genital ring; Pha., phallic apodeme; Ptb., median posterior bar; Sta., sternal apodeme; Vne., vane.

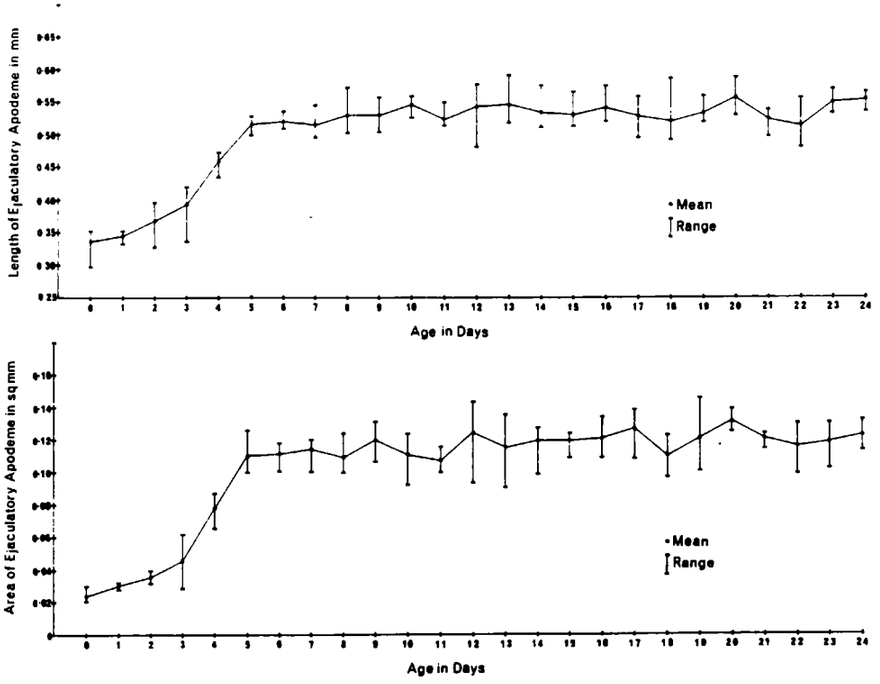


FIG. 26.—Change in length and area of ejaculatory apodeme of *Strumeta tryoni* (Froggatt) with age at 25°C and natural light intensity.

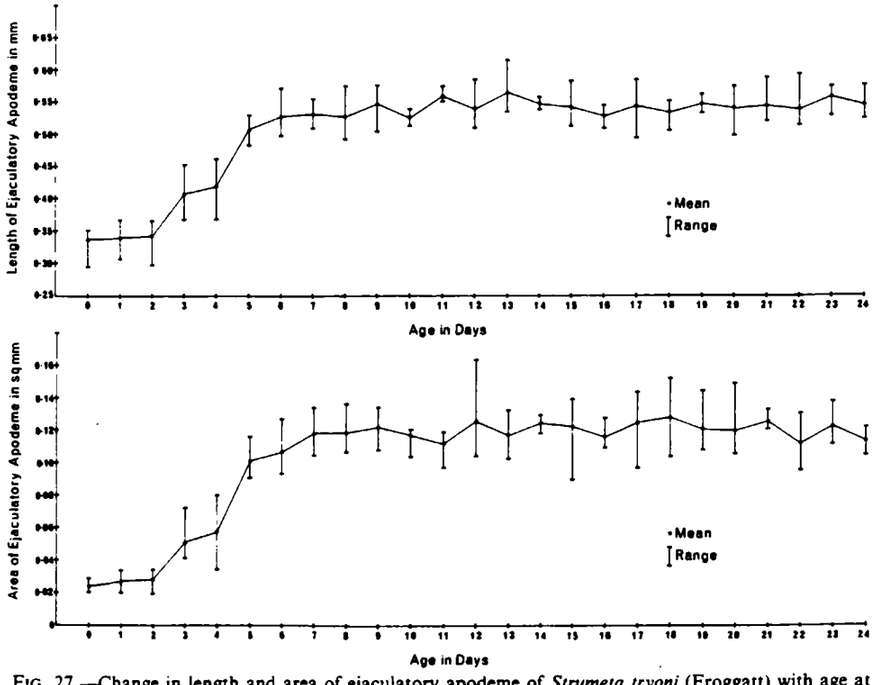


FIG. 27.—Change in length and area of ejaculatory apodeme of *Strumeta tryoni* (Froggatt) with age at 25°C and 120 lumens per square foot light intensity.

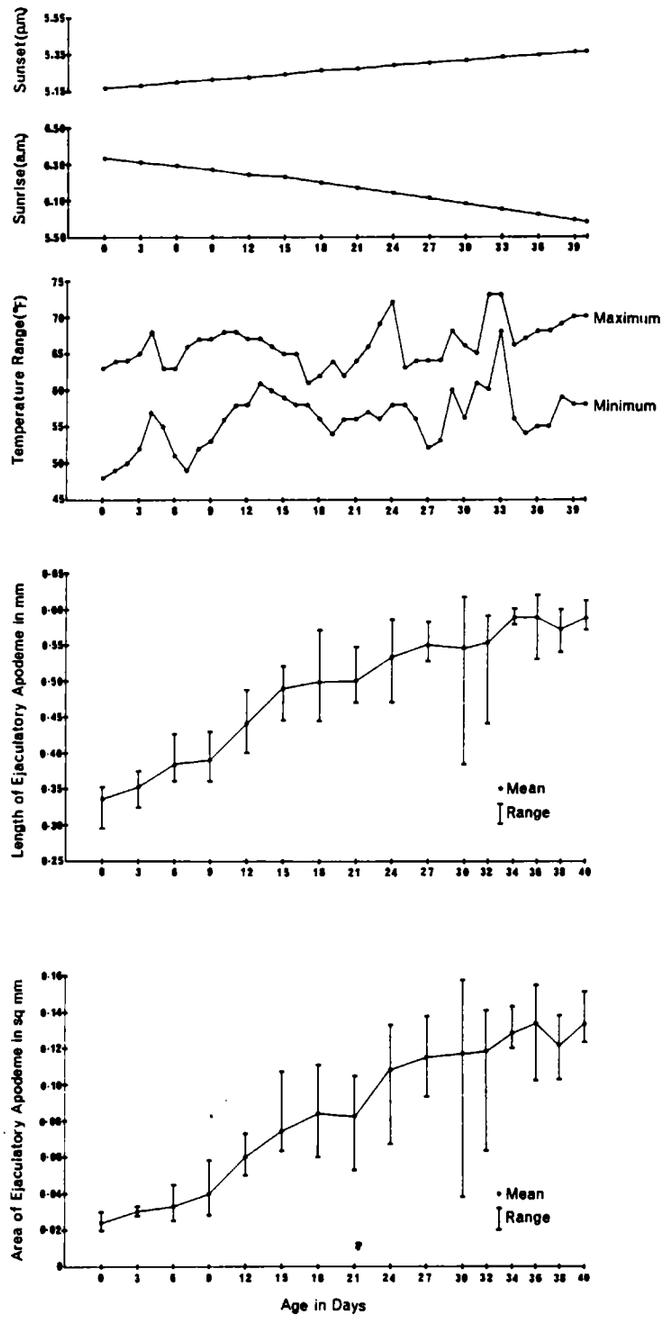


FIG. 28.—Changes in length and area of ejaculatory apodeme of *Strumeta tryoni* (Froggatt) with age, under natural conditions of temperature and light intensity. Maximum, minimum temperatures and sunrise, sunset times are figured.

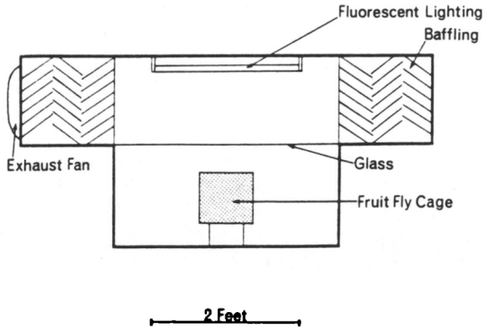


FIG. 29.—Front elevation of light cabinet. All walls light proofed; light proof baffling in upper section allowed air flow from exhaust fan to disperse heat from fluorescent tube; light ballasts located away from cabinet to reduce heat load.

Development of musculature on the ejaculatory apodeme

The relative daily sizes of the ejaculatory apodeme and its musculature from emergence to 5 days, of adults held at 25°C and natural light intensity, are illustrated in Figures 12-17. At emergence the apodeme had a small musculature which increased in size with the apodeme until 5 days old. At each stage, the musculature covered the apodeme.

DISCUSSION

At 25°C, 70-75 per cent. relative humidity and natural light conditions, flies were sexually mature and began copulating 5 days after emergence. Sexual maturity was therefore correlated with size of the ejaculatory apodeme, and both length and area of the apodeme gave an accurate estimation of this parameter. Because of the greater increase in area than length, from emergence to sexual maturity, area was found to provide a better index than length, though in practice length was easier to measure and would be sufficient. Because the endoskeletal structures function as supports for muscles which control the mechanics of copulation, the flies were not able to copulate until the structures had reached a certain size and so supported well developed musculatures.

The flies maintained at 25°C, 55-80 per cent. relative humidity and 120 lumens per square foot light intensity developed a mature ejaculatory apodeme 5 days after emergence and also began copulating at this age. Thus the change in light regime to which the flies were subjected did not affect either the development of endoskeletal structures or the age at which the flies began to copulate.

These results differ from those of Barton Browne (1957) who stated that the age at which males became active was influenced by illuminance and daily period, and that at 25°C, 75 per cent. relative humidity and 120 lumens per square foot for 7½ hours per day, 50 per cent. of males were first sexually active after 31·6 days.

Under the variable conditions of external temperature and light intensity, the flies were not sexually mature until 24 days old and there was a greater daily range in apodeme measurements than under the stable 25°C temperature.

Comparison of these four sets of results does not implicate temperature, relative humidity or light as the critical factor determining the different rates of development to sexual maturity. Undetermined differences in intensity and duration of dusk lighting may have been a factor possibly interrelated with temperature and high relative humidity.

Significant differences between means of samples from different geographical areas (Table 1) were probably due to differences in physiological age, and not geographical variations.

The growth changes of the endoskeletal structures caused corresponding changes in shape. Great care must therefore be taken in attempting to use characters of these structures for descriptive purposes in systematics.

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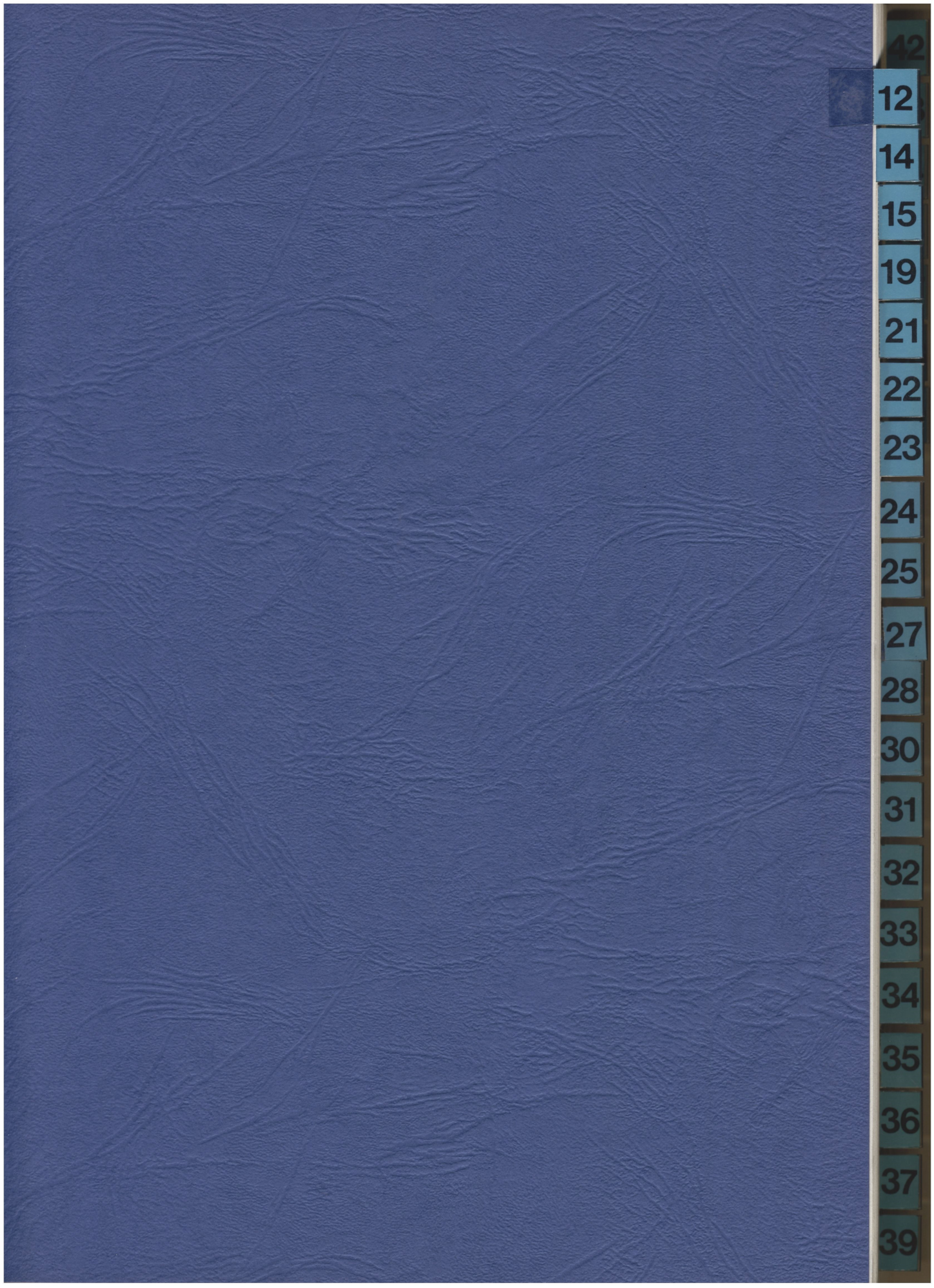
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NOTE

COMPARISON OF THE EFFICIENCY OF TWO TRAPS FOR MALE TEPHRITID FRUIT FLIES

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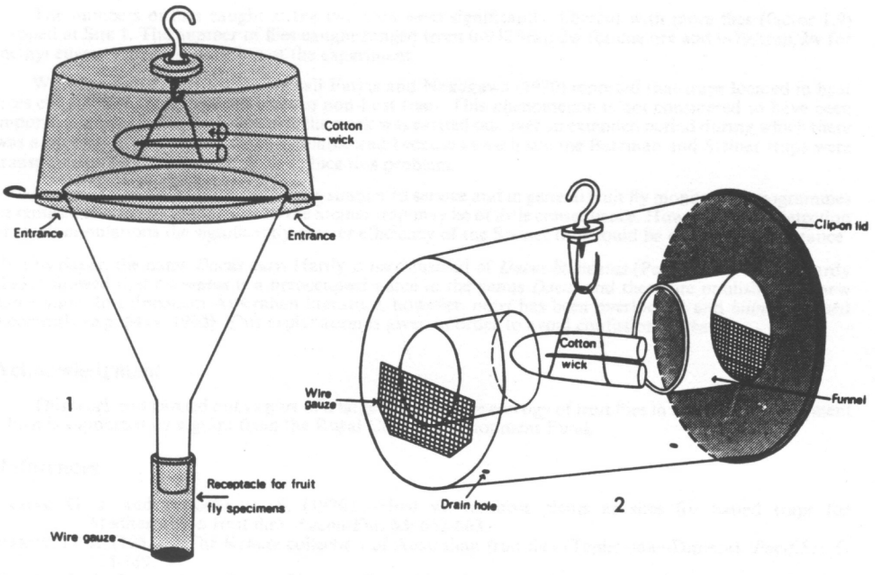
Abstract

Comparison of traps of two designs, one a locally produced Steiner trap and the other designed by M. A. Bateman, baited with either cuelure or methyl eugenol showed that the Steiner trap caught significantly more male fruit flies.

Following the discovery of synthetic attractants for Tephritid fruit flies, traps of various designs have been developed to monitor populations. The first trap, utilising angelica seed oil for the Mediterranean fruit fly, *Ceratitis capitata* (Wiedeman), was developed by Steiner (1957) and this Steiner trap has been used extensively in fruit fly work. Design is important in determining the efficiency of a trap and a given trap may not be equally efficient for all species. For example, when baited with trimedlure the Steiner trap caught more *C. capitata* than did the "Nadel" trap (Nakagawa *et al.* 1971), and whereas a variety of sticky traps caught more *C. capitata* than did the Steiner trap such differences were much less with the oriental fruit fly, *Dacus dorsalis* Hendel, and the melon fly, *Dacus cucurbitae* Coquillett (Harris *et al.* 1971).

In Australia M. A. Bateman of CSIRO Division of Entomology designed a simple trap for research with the Queensland fruit fly *Dacus tryoni* (Froggatt) (Fig. 1). With the current emphasis on detection of fruit flies, both exotic and native, it was considered important that the efficiency of the Bateman trap be evaluated against that of a locally produced version of the Steiner trap (Fig. 2) designed by one of us (R.A.I.D.). This paper reports an evaluation of the two types of trap using the lures cuelure and methyl eugenol.

Two trapping sites were established along a track in rain forest (vine forest according to Webb (1959)) in the Cooloola area of coastal south-eastern Queensland. At each site there were two Steiner traps baited with either cuelure or methyl eugenol and on the opposite side of the track two Bateman traps similarly baited with the two lures. The pairs of Bateman and Steiner traps at each site were 100 m apart and the distance between the two sites was 400 m. The traps were cleared at 2-weekly intervals and at each sampling the positions of the Steiner and Bateman traps at each site were transposed. The experiment ran for 40 weeks from late June 1976, when fly numbers were low, through a period of considerable fruit fly activity to early April 1977, when fly numbers were declining as a result of the onset of winter. Thus the data are based on 20 samples of flies caught in 2-week periods.



FIGS 1,2—Fruit fly traps: (1) Bateman trap; (2) Steiner trap.

Each trap was baited with a cotton dental wick impregnated with 3 ml of a 4:1 mixture of either cuelure or methyl eugenol and a 50% dichlorvos emulsifiable concentrate, and new wicks were substituted at 4-weekly intervals.

The results are summarised in the Table. Three species, *D. cacuminatus* (Hering), *D. endiandrae* (Perkins and May) and *D. mayi* Hardy[1] were caught in the methyl eugenol traps. The cuelure traps caught six species of which *D. neohumeralis* Hardy, *D. tryoni* and *Callantra aequalis* (Coquillett) were the most abundant species. The other species caught in small numbers were *D. bryoniae* (Tryon), *D. signatifrons* (May) and *D. choristus* (May). Both types of trap caught all species.

The Steiner trap caught significantly more flies than did the Bateman trap. When individual species were examined the difference between traps was also significant except for *D. cacuminatus* where there was no difference in size of catch. The significantly greater efficiency of the Steiner trap was also demonstrated when the data for the two sites were analysed individually, except again for *D. cacuminatus*. With this species the Bateman trap was significantly superior at Site 1, but the reverse was true at Site 2 thus leading to the lack of significant difference in the pooled data.

TABLE

NUMBER OF TEPHRITID FRUIT FLIES CAUGHT IN STEINER AND BATEMAN TRAPS OVER A 40-WEEK PERIOD IN RAIN FOREST AT COOLOOLA

Lure and species	Bateman trap	Steiner trap
Methyl eugenol		
Total flies	552	848
D. cacuminatus	223	220*
D. endiandrae	242	502
D. mayi	87	126
Cuelure		
Total flies†	3027	3883
D. neohumeralis	2112	2527
D. tryoni	670	803
C. aequalis	215	528

*No significant difference, all other comparisons are significant at P=0.005 level; †species caught other than those listed—*D. bryoniae, D. signatifrons, D. choristus.*

The numbers of flies caught at the two sites were significantly different with more flies (factor 1.9) trapped at Site 1. The number of flies caught ranged from 0-932/trap/2w for cuelure and 0-79/trap/2w for methyl eugenol over the duration of the experiment.

Working with *C. capitata* in Hawaii Farias and Nakagawa (1970) reported that traps located in host trees caught more flies than did traps in non-host trees. This phenomenon is not considered to have been important in the present study because the work was carried out over an extended period during which there was a succession of different fruits available and because at each site the Bateman and Steiner traps were transposed at each sampling date to reduce this problem.

In some respects the Bateman trap is simpler to service and in general fruit fly monitoring programmes its reduced efficiency compared with the Steiner trap may be of little consequence. However, in the detection of small populations the significantly greater efficiency of the Steiner trap could be of critical importance.

[1]In this paper, the name *Dacus mayi* Hardy is used instead of *Dacus bilineatus* (Perkins and May). Hardy (1951) showed that *bilineatus* is a preoccupied name in the genus *Dacus* and therefore published the new name *mayi*. In subsequent Australian literature, however, *mayi* has been overlooked and *bilineatus* used incorrectly (e.g. May, 1963). This explanation is given in order to avoid confusion to readers.

Acknowledgment

This work was carried out as part of a larger study of the ecology of fruit flies in a natural environment which is supported by a grant from the Rural Credits Development Fund.

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ECONOMIC FRUIT FLIES OF THE SOUTH PACIFIC REGION

SECTION IV FRUIT FLY COLLECTING

R. A. I. DREW

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(2) Fruit Fly Attractants 131
(3) Strategy of Trap Distribution for Detection Programmes in Queensland 134
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Introduction

Fruit flies are usually collected by lure trapping (Steiner, 1957; Farias and Nakagawa, 1970; Drew, 1974), by rearing from infested hosts (May, 1953, 1957, 1960) and occasionally by individual captures (Sonleitner and Bateman, 1963; Bateman and Sonleitner, 1967). Clearly the purpose of the particular project and the resources available determine the nature and extent of the collection to be undertaken. Consideration must be given to factors such as the species to be collected, the prevailing environmental conditions, population density, presence of predators which devour insects in traps, accessibility of the collection area and the availability of host fruit.

The current section is based on extensive experience in the collection of fruit flies in Australia and the South West Pacific Area. It is presented as a practical guide to those who may become involved in similar programmes.

(1) TRAP TYPES

(a) *STEINER TRAP*—The Steiner trap (Steiner, 1957) essentially consists of a horizontal cylinder with a large opening at each end. A mixture of attractant and insecticide is impregnated into a cotton wick suspended within the trap. A slight taper in the main cylinder allows the traps to be nested together into a small volume for transport.

Comments—Significant features are the large surface area provided by the wick for evaporation of the attractant and the large open area at each end which facilitates distribution of the attractant vapour. Good catches of flies are achieved under most climatic conditions and population densities. Because of its relatively large volume it is particularly effective in the tropical and sub-tropical areas where large numbers of flies are often taken in short periods of time. When baited with dichlorvos insecticide, it successfully kills large insect predators which otherwise enter the trap and consume the flies.

Queensland Modification (Figure 55)

A modification of the Steiner trap has been developed at the Department of Primary Industries laboratories in Brisbane and now includes improvements suggested as a result of field testing by Mr. G. B. Monteith, Department of Entomology, University of Queensland. The modified trap has a soft clip-on lid and a readily accessible and removable wick suspension mechanism.
Comments—Field experiments in Queensland have shown that two features of the original Steiner trap are important, i.e., more flies are collected in the Steiner trap when funnels are placed at each opening and when one half of each opening is covered with gauze. The modified trap is relatively inexpensive and can be assembled in the laboratory with a minimum of labour. Samples can be forwarded upon request.

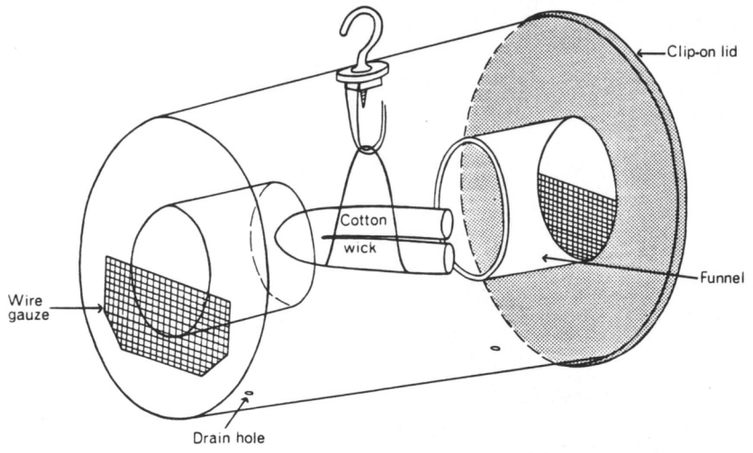


Figure 55—Steiner trap (Queensland modification)

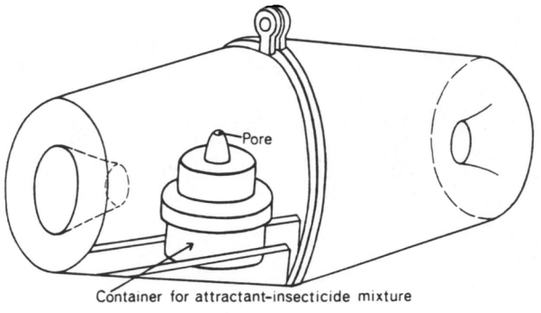


Figure 56—Israeli trap

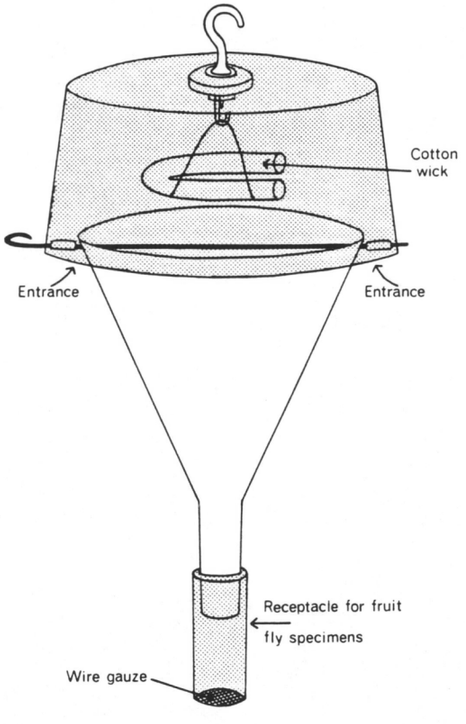


Figure 57—Bateman trap

(b) *ISRAELI TRAP* (Figure 56)—This trap is designed on the same basic principle as the Steiner Trap, being shaped as a horizontal cylinder. Approximately 7 ml of the attractant/insecticide mixture is held in a small plastic container positioned between two ribs on the floor of the trap. The attractant vapour escapes from the container via a pore 2 mm in diameter and this, together with the small opening (6 mm in diameter) at each end of the trap, allows emission of only a small amount of attractant vapour from the trap.
Comments—This trap has higher efficiency than the Steiner trap for *C. capitata* but lower efficiency for *Dacus* species. The smaller openings would probably exclude some of the larger predatory insects, but the smaller volume of the trap would not accommodate some of the larger catches experienced in tropical areas. This trap is easily transported in large numbers.

(c) *BATEMAN TRAP* (Figure 57)—This trap was developed by M. A. Bateman, Division of Entomology, C.S.I.R.O., Sydney. The body of the trap consists of two primary components—(i) a plastic cannister which acts as a hood over (ii) a yellow plastic funnel. A receptacle for holding collected flies is made from soft plastic tubing and placed on the stem of the funnel. The attractant/insecticide mixture is placed on a cotton wick or fibre-board block which is suspended within the hood of the trap.
Comments—The most important aspect of the design of this trap is that it utilises two characteristics of fruit fly behaviour apart from attraction to the lure; that of negative geotropism (i.e. the flies walk vertically into the trap) and a visual response to the yellow colour. This trap could prove more suitable in the temperate areas where there are fewer problems with predatory Arthropods. In a field test in a tropical area, large crickets became lodged in the neck of the funnel and spiders spun webs across the neck, preventing the flies from falling into the receptacle below. This receptacle is removable and so provides a quick method of removing the flies, i.e. simply by taking off and stoppering the receptacle containing the flies and replacing it with a new one. This trap is more difficult to recharge than in the modified Steiner trap and would have to be dismantled in order to transport in the smallest possible volume. It can be assembled in the laboratory as readily as the modified Steiner trap and for a similar cost of materials.

(d) *JACKSON TRAP or STICKY TRAP*—Harris *et al.* (1971) experimented with a variety of sticky traps. Basically the traps consist of either a cardboard container folded flat for transportation and expanded into a cylinder open at two opposite ends when in use, or of various shapes of flat cardboard suspended on a string. The inside surface is lined with a non-drying adhesive which traps the flies when they approach the cotton wick charged

with attractant. An alternative is to insert a removable cardboard tray coated with non-drying adhesive. No insecticide is required.

Comments—Flies collected in this trap are of little value for permanent collection purposes due to damage by the adhesive, but are in good enough condition for identification. The sticky traps have the advantages of being cheap, easy to use and the simplest of all to transport. They would probably be the most convenient trap for quarantine purposes around airports and towns but do not weather well enough for survey work under wet tropical conditions. A commercially available sticky trap is the Sectar 1 trap, manufactured by the 3M Corporation, St. Paul, Minnesota 55101, U.S.A. In this trap, the adhesive is impregnated with the attractant.

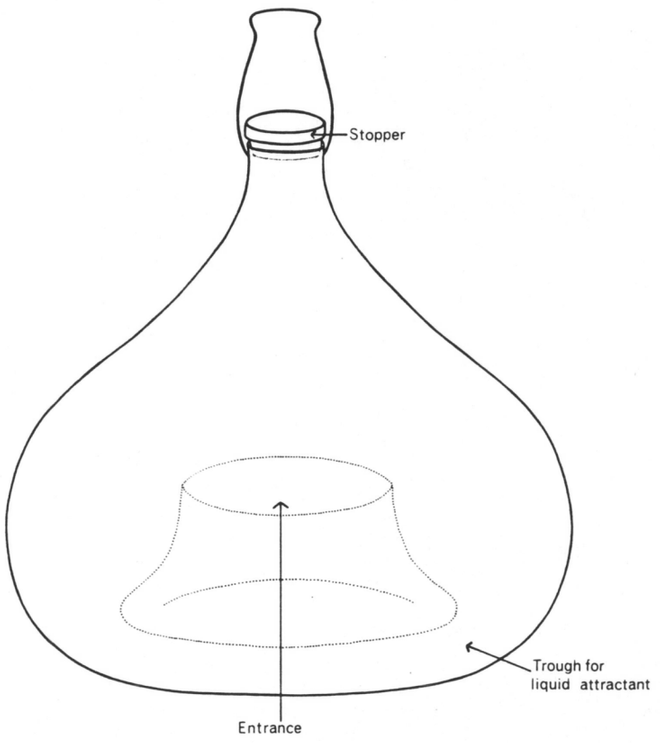


Figure 58—McPhail trap

(e) *McPHAIL TRAP* (Figure 58)—This is a glass or plastic flask-shaped trap with an invaginated entrance at the base. It measures approximately 140 mm high, 160 mm diameter across the widest line, with the entrance 45 mm in diameter. Nakagawa *et al.* (1975) designed a trap based on a gallon plastic tub as a substitute for the McPhail trap.
Comments—The McPhail trap was designed for use with liquid attractants such as fermenting fruit juice solutions and proteinaceous solutions. These lures attract both sexes of fruit flies and also species which do not respond to male lures. The McPhail trap is expensive and attracts only small numbers of flies compared with the male lure traps. It appears to be of limited value for survey and detection programmes.

The Nakagawa modification proved as effective as the McPhail trap for collecting *D. dorsalis* and *D. cucurbitae* but not for collecting *C. capitata.*

(2) FRUIT FLY ATTRACTANTS

Attractants or lures have long been used in association with fruit fly traps. The first attractants were essentially food lures based on combinations of natural plant products, flavouring essences and ammonia (Perkins and Hines, 1934; Caldwell and May, 1943). Ammonia is a product of decomposing organic matter and probably represents a source of food. A major advantage of food lures is that both sexes of many species respond to them. May (1958) developed an effective food lure termed the orange-ammonia lure with which he carried out an extensive collecting programme throughout Queensland. The recipe for this lure is 280 g pulped orange, 25 g ammonium carbonate, 600 ml water and 1 g of mercuric chloride preservative. This mixture should be allowed to stand a minimum of 24 hours before use and will keep for several months. For use the stock solution is diluted with water at a ratio of 1 part to 10 parts of water and used in McPhail traps. This lure has proved valuable in trapping female specimens for ecological and taxonomic studies and in determining the optimum time to apply control measures in orchards.

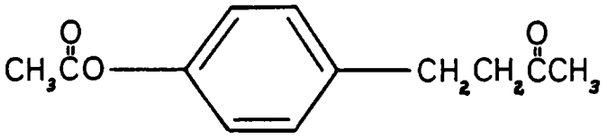
The most powerful attractants are chemicals which attract male tephritids and they can be referred to as parapheromones. However, the flies feed vigorously on cue-lure and methyl eugenol when attracted and in this regard they behave like a food lure. These parapheromones attract flies over larger distances than do the food lures. Beroza and Jacobson (1963) suggest distances up to 0.8 km in the case of methyl eugenol.

The male lures can be divided into three basic groups:
(a) *Cue-lure group*—cue-lure, anisylacetone, Willison's lure;
(b) *Methyl eugenol group*—citronella oil, huon pine oil, methyl eugenol;
(c) *Med-lure group*—siglure, med-lure, trimedlure.

Drew (1974) showed that in the South Pacific area the fruit fly species can be divided into two groups on the basis of the compounds to which they are attracted: (a) cue-lure group and (b) methyl eugenol group. It was found that closely related species all responded to the one attractant. No species from the South Pacific area was recorded as responding to the med-lure group.

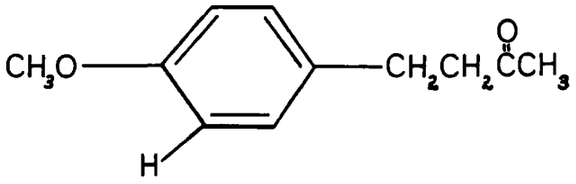
The chemical formulae of some of the attractants are as follows:—

Cue-lure: 4-(*p*-acetoxyphenyl)-2-butanone

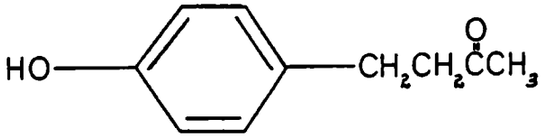


Cue-lure is the *p*-acetoxy derivative of benzylacetone. It attracts teneral specimens of melon fly in addition to mature specimens.

Anisylacetone: 4-(*p*-methoxyphenyl)-2-butanone

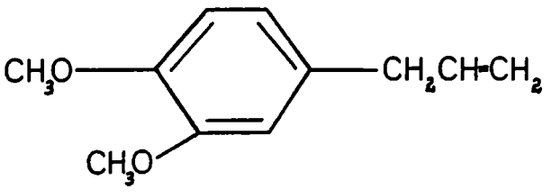


Willison's lure: 4-(*p*-hydroxyphenyl)-2-butanone

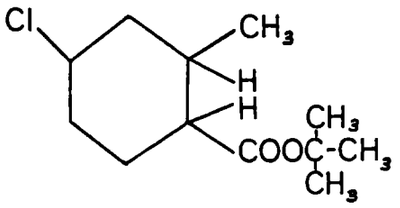


Willison's lure, cue-lure and anisylacetone are similar in molecular structure and are all ketoesters. The acetoxy derivative (cue-lure) is not very stable and is thought to be transformed to the hydroxy derivative (Willison's lure) as a result of hydrolytic degradation when exposed in the field.

Methyl eugenol: O-methyl eugenol (an ether)



Trimedlure: t-butyl-4 (or 5)-chloro-2-methyl cyclohexane carboxylate



Trimedlure is the best attractant available for the Mediterranean fruit fly. It exists in eight different isomeric forms and commercial preparations of the attractant are mixtures of these isomers.

The most readily available attractants are cue-lure, Willison's lure, methyl eugenol and trimedlure. Some suppliers of these attractants are as follows:—

Cue-lure	Food Industries Limited. Bromborough Port, Wirral, Cheshire L62 4SU, England.
Willison's lure	Union Carbide Australia. Sydney.
Methyl eugenol	Fritzsche, Dodge & Olcott Inc., 76 Ninth Avenue. New York, N.Y. 10011. U.S.A.

Trimedlure	UOP Chemical Division, State Highway 17, East Rutherford, New Jersey, 07073, U.S.A.

When charging a trap with male attractant, a mixture of 4 ml attractant and 1 ml of 50 per cent w/v concentrate of malathion or dichlorvos has been found most suitable in Queensland. Malathion persists longer than dichlorvos, but when predacious insects enter the trap dichlorvos is more suitable because of its more rapid killing action.

Identification procedures can take a considerable amount of time when large numbers of flies are collected. Identifications can be expedited by keeping separate the flies that respond to each attractant. In setting the traps therefore, place only one attractant in a trap and avoid contamination with other attractants. The attractants impregnate the plastic and so it is best to use each trap for only one particular attractant throughout its period of use. Small quantities of attractant on the outside surface of traps frequently will attract flies and prevent them from entering the traps. Even minute amounts of attractant such as that carried on hands of personnel servicing the traps have been shown to cause contamination. It has been found valuable, therefore, to carry a plastic washbottle of ethanol to rinse hands after each trap is serviced. The removable wick mechanism in the Queensland Steiner trap has assisted in avoiding contamination during servicing of traps.

Trapping with male attractants is the best method for quarantine detection surveys and compounds are now available for attracting most major fruit fly pest species. It is important to note that some economic pest species of fruit fly do not respond to male attractants. The species with which we are most likely to be concerned in Australia and the attractants to which they respond, are listed in Section I (7). Also high concentrations of an attractant will often have a repellency action. This is the case with trimedlure (Beroza *et al.*, 1961).

(3) STRATEGY OF TRAP DISTRIBUTION FOR DETECTION PROGRAMMES IN QUEENSLAND

The optimum strategy for trap distribution will clearly depend on the purpose of the particular detection programme and on the nature and extent of available resources. Steiner (1969) estimated that for an effective programme for detection of oriental fruit fly, it is necessary to set approximately one methyl eugenol trap per km^2. For quarantine programmes in Queensland such a high trap density is impractical despite the high risk of introduction of exotic fruit fly species. The length of coastline to be surveyed is large and many areas are inaccessible during the wet spring-summer season each year. In Cape York trapping is therefore concentrated firstly at towns, settlements and areas known to be visited by people from outside the mainland and secondly in areas of rainforest along the eastern coast which have a large number of fruit fly host plants.

(4) PLACEMENT OF INDIVIDUAL TRAPS

Within the areas of concern the placement of individual traps is important. Traps are best set along wet gullies, water courses, endemic forests and where possible in known host fruit trees. Farias and Nakagawa (1970) showed that for maximum trap catches in a detection programme the traps should be set in host trees wherever possible. The traps should be hung in shady positions as high as is practicable.

In many areas, particularly in the tropics, ants often pose a problem by entering the traps and eating the dead fruit flies. To counter this problem an insecticide or sticky barrier should be placed on the string supporting the trap. A good non-toxic sticky barrier is provided by using Bird Stop (R. T. Cunningham, personal communication). This can be obtained from: Animal Repellents Inc., Griffin, Georgia, 30223, U.S.A.

(5) REARING FROM INFESTED FRUIT

Rearing adults from infested fruit provides valuable information on distribution, hosts and seasonal activity. When flies are bred from field collected fruit they will die at an immature stage unless suitable conditions are provided. Such premature death makes identification of the specimens difficult and sometimes impossible. Colour characters on the thorax and abdomen, necessary for identification, are not developed until the fly is at least three to four days old.

Essential features in rearing are that collected fruit be held in a container which has a gauze cover to allow aeration. Pupae must be allowed to develop in a dry medium such as sawdust or sand and for efficient sieving of pupae the fruit juices must not wet the pupation medium. Emerging flies must have access to water and sugar for survival. After three to four days the flies can be collected, killed and prepared for taxonomic study.

(6) INDIVIDUAL CAPTURES

Some studies demand the capture of live individual fruit flies. Sonleitner and Bateman (1963) and Bateman and Sonleitner (1967) successfully collected *D. tryoni* adults for mark-recapture sampling of the population in an orchard, using sweep nets.

In the Department of Primary Industries two methods have been used to obtain gravid females (for isolining) and also live adults of both sexes (for cytology and gel electrophoresis).

Flies were either aspirated directly from leaves and fruit or they were attracted to Steiner traps containing pieces of sponge cloth (200 mm × 100 mm) soaked with protein hydrolysate, fresh orange or apple juice. Large numbers of both sexes were attracted and the flies fed on the juice in the sponge cloth and so remained in a healthy condition.

(7) PRESERVATION AND SHIPMENT OF SPECIMENS

Preservation of fruit fly specimens is of vital importance and appropriate steps must be taken as soon as the specimens are obtained. Specimens are often damaged in transit and by bacterial and fungal growth after collection. Such damage may render the fruit flies useless for identification, thus invalidating an entire detection programme.

Wherever possible, place flies in *glass* bottles or tubes, between two firm layers of cotton wool or soft tissue. Beneath the bottom layer of cotton wool, place a few crystals of thymol or chlorocresol preservative. Glass containers are recommended because these preservatives dissolve common plastics.

Liquid preservatives such as ethanol must not be used for adult fruit flies as these liquids dissolve out the body colours which are important taxonomic characters.

Inside the bottle or tube place a small label clearly marked with the following details of the specimens—district in which collected, date collected, collector's name, attractant used in trap and host fruit if specimens have been bred from larvae.

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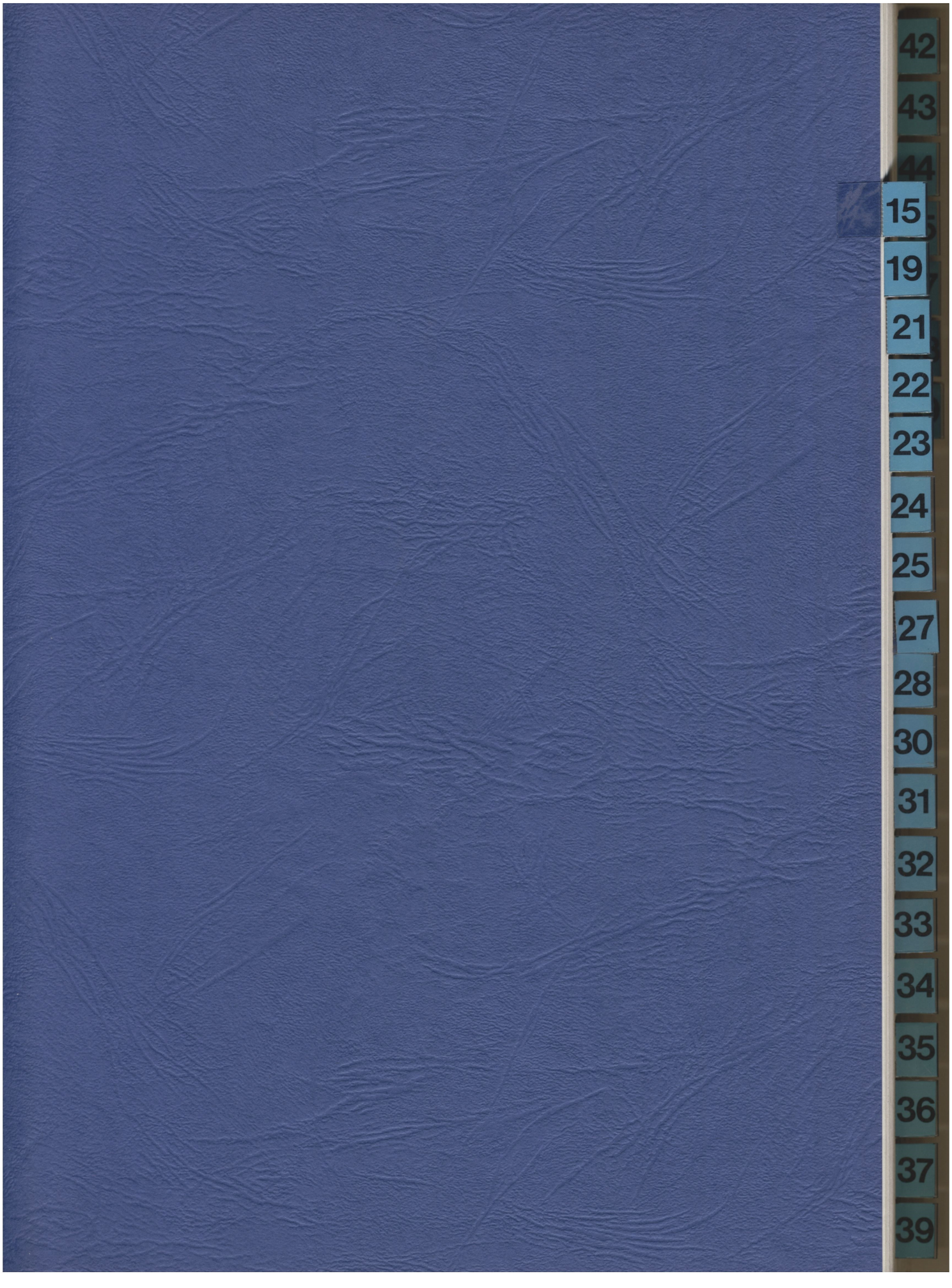
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Effect of Height of Trap on Capture of Tephritid Fruit Flies with Cuelure and Methyl Eugenol in Different Environments[1,2]

G. H. S. HOOPER[3] AND R. A. I. DREW[4]

ABSTRACT

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In a rain forest environment captures of tephritid fruit flies responding to cuelure and methyl eugenol increased as the height of the trap above ground was increased from 0.1 to 12.2 m. In an open forest environment dominated by eucalypts no effect of trap height was found. No effect of height on captures of flies with cuelure or methyl eugenol in a citrus orchard or in suburban gardens was found within the range 0.1–3.6 m above ground.

The number of insects caught in traps has been found to be influenced by the height of the trap above ground level for numerous species (Hart et al. 1967, Holbrook and Fujimoto 1969, Holbrook et al. 1970, Reissig 1975). This phenomenon has important implications for quarantine monitoring and survey work as well as for male annihilation and phermonomal communication disruption control programs.

With tephritid fruit flies no generalizations on the effect of height of trap containing the parapheromones methyl eugenol, cuelure and trimedlure on attraction of males seem possible. Steiner et al. (1965) observed that male oriental fruit flies, *Dacus dorsalis* Hendel, were equally attracted to methyl eugenol baits on the ground or suspended in trees. Similarly cuelure at ground level was at least as effective in catching male melon flies, *D. cucurbitae* Coquillet, as baits placed up to 4.6 m above ground (Hart et al. 1967, Holbrook and Fujimoto 1969). However, Holbrook et al. (1970) found that climatic conditions, primarily humidity and wind, influenced this effect of height. With the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) trimedlure traps placed 4.6 m above ground caught more flies than traps closer to the ground.

The experiments of Holbrook and Fujimoto (1969) tested various heights in paired comparisons; they did not simultaneously compare all heights. This was done with the temperate tephritid *Rhagoletis pomonella* (Walsh) and traps placed higher in trees (2.1 and 3 m above ground) were more efficient than traps placed at 1.2 m (Reissig 1975). The present paper reports experiments in subtropical Queensland with tephritid species responding to cuelure and methyl eugenol in which a number of trap heights were compared simultaneously.

Materials and Methods

The trap used was a local version (Hooper and Drew 1978) of the Steiner trap (Steiner 1957). Each trap was baited with an 8 cm long dental wick containing 3 ml of a 4:1 mixture of either methyl eugenol or cuelure plus dichlorvos. In all experiments the wicks were replaced at 4-wk intervals. The wires on which the traps were suspended were coated with Bird Stop® to prevent predation by ants.

Experiment 1 was established in an area of vine-type rain forest at Cooloola (lat. 26°S, long. 153°E) in coastal, southeastern Queensland. In this environment the forest canopy of broad-leaved trees is at ca. 17 m, there is an abundance of vine growth, and a lower story of shrubs and palms reaching to ca. 3 m. Five trapping stations were established along a track at 300-m intervals. At each station a rope was run through a pulley attached to the branch of a tree ca. 15 m above ground. A methyl eugenol and a cuelure trap were hung 0.5 m apart from a board attached to the rope which enabled the traps to be placed at any of the experimental heights, viz. 0.1, 3.0, 6.1, 9.1 and 12.2 m, above ground. A 2nd rope attached to the board and anchored to a peg in the ground prevented the traps being blown about by wind. At the start of the experiments a pair of traps was located at one of the 5 height positions at each trapping station, with the location of the traps at each height among the 5 stations being determined by random numbers. Traps were cleared at 2-wk intervals at which time the height of the traps was systematically changed so that after 10 wk traps had been located at each of the 5 heights at each station. This was done in an attempt to account for any effect of a particular trapping station on trap catch. The experiment ran for 40 wk from July 1976 to May 1977.

Experiment 2 was established in an open eucalypt forest at Cooloola which surrounds the rain forest and is composed of eucalypt trees with a canopy at 15–21 m, and a sparse, patchy understory of shrubs reaching to ca. 4.6 m with a ground level cover of grass, bracken fern, and scattered cycads. The experimental procedure was the same as in experiment 1 except that the trapping stations were one km apart. The traps were cleared twice weekly and the experiment ran for 30 wk from Oct. 1976 to June 1977.

Experiment 3 was established in a commercial citrus orchard in the Nambour district of southeastern Queensland. The citrus trees averaged 4.6 m in height and 3 trapping stations separated by one km were used to evaluate heights of 0.1, 1.8 and 3.6 m. Traps were placed within the tree canopy and were cleared at 2-wk intervals. This experiment ran for 24 wk from Dec. 1976 to June 1977. Experiment 4 was established within the Brisbane suburban area. There were 3 trapping stations, situated ca. 2 km apart, to evaluate trap heights of 0.1, 1.8 and 3.6 m. Traps were cleared weekly and the experiment ran for 15 wk from Dec. 1976 to Mar. 1977. As in experiments 1 and 2, the height of the traps at each trapping station in experiments 3 and 4 was systematically changed so that, after 3 trapping periods, traps had

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been located at each height at each position. After logarithmic transformation, data were subjected to analysis of variance and differences between treatments were tested by Duncan's multiple range test.

Results and Dicussion

In the rain forest at Cooloola fewer flies responding to cuelure were captured at ground level (0.1 m) than at heights up to 12.2 m (Table 1). With the Queensland fruit fly, *D. tryoni* (Froggatt), while there was no significant difference in numbers caught at heights from 0.1 to 9.1 m, significantly more flies were caught at 12.2 than at 0.1 m. Fewer *D. neohumeralis* Hardy were caught at 0.1 m than at heights of 6.1–12.2 m and with *Callantra aequalis* (Coquillett) fewer flies were caught at 0.1 m than at all the other heights. Other species which were attracted to cuelure, but in numbers too small to warrant analysis, were *D. signatifrons* (May), *D. choristus* (May) and *D. absonifacies* (May). The same pattern of fewer flies caught at ground level than at greater heights was repeated with species responding to methyl eugenol, i.e., in respect of total number of flies and of the 2 major species *D. cacuminatus* (Hering) and *D. endiandrae* (Perkins and May). While *D. mayi* Hardy was often caught in methyl eugenol traps, numbers were again too small to warrant analysis.

In the open forest environment no significant effect of height on capture of flies responding to either cuelure or methyl eugenol was detected (Table 1) although the data suggest that more flies responding to cuelure were captured at 0.1 and 12.2 m than at intermediate heights. In the open forest a few *D. newmani* (Perkins), *D. signatifrons* (May), *D. bancrofti* (Tryon) and *D. choristus* (May) were caught in the cuelure traps and *D. mayi* was commonly caught in the methyl eugenol traps. Similarly within the range 0.1–3.6 m above ground there was no effect of height on number of flies caught with either attractant in either the citrus orchard or the suburban environment (Table 2) except for one instance. The total number of flies responding to cuelure in the suburban environment was significantly greater at 0.1 than at 1.8 m. There was no significant effect with either of the 2 species contributing to the total catch.

We can only theorize on the different effect of trap height in the closed rain forest and open forest. In the open forest we might expect greater air turbulence and therefore greater vertical disperson of the odor plume from any given trap. In the closed rain forest, wind movement would be restricted and thus stratification of odor from a given trap might occur. Further, the rain forest contains a number of host trees, the fruits of which are in the canopy, and hence the fruit flies may prefer-

Table 1.—Capture of male tephritid fruit flies in rain forest and open eucalypt forest at Cooloola in modified Steiner traps, baited with cuelure or methyl eugenol, and placed at 0.1, 3.0, 6.1, 9.1 and 12.2 m above ground.

Lure and species captured	Height of trap above ground (m)				
	0.1	3.0	6.1	9.1	12.2
	Rain forest[a]				
Cuelure					
Total flies[b]	362 a[d]	931 b	1033 b	938 b	1221 b
D. tryoni	101 a	190 a	221 ab	199 ab	284 b
D. neohumeralis	208 a	487 ab	492 b	509 b	698 b
C. aequalis	41 a	209 b	309 b	219 b	211 b
D. bryoniae[c]	11	39	10	10	26
Methyl eugenol					
Total flies	244 a	552 b	686 b	701 b	645 b
D. cacuminatus	95 a	162 ab	179 ab	201 b	157 ab
D. endiandrae	121 a	325 b	454 b	431 b	381 b
D. mayi[c]	28	65	53	64	107
	Open eucalypt forest[e]				
Cuelure					
Total flies[f]	1274	588	883	462	1120 NSD
D. tryoni	406	160	294	121	246 NSD
D. neohumeralis	751	362	498	285	823 NSD
C. aequalis[c]	93	50	47	28	29
D. bryoniae[c]	21	13	37	24	18
Methyl eugenol					
Total flies	612	800	831	873	631 NSD
D. cacuminatus	154	311	309	320	143 NSD
D. endiandrae	429	459	465	528	472 NSD
D. mayi[c]	29	30	57	25	16

[a] Based on 20 trap collections at 2-wk intervals.
[b] Other species caught: *D. signatifrons*, *D. choristus*, *D. absonifacies*.
[c] Data not analyzed.
[d] Figures followed by same letter are not significantly different ($P=0.05$). Comparisons must be made only within rows. NSD=no significant differences.
[e] Based on 15 trap collections at 2-wk intervals.
[f] Other species caught: *D. newmani*, *D. signatifrons*, *D. bancrofti*, *D. choristus*.

Table 2.—Capture of male tephritid fruit flies in a commercial citrus fruit orchard and in suburban gardens in modified Steiner traps, baited with cuelure or methyl eugenol, and placed at 0.1, 1.8, and 3.6 m above ground.

Lure and species captured	Height of trap above ground (m)		
	0.1	1.8	3.6
	Citrus orchard[a]		
Cuelure			
Total flies	1179	1053	1111 NSD[c]
D. tryoni	968	925	840 NSD
D. neohumeralis	203	118	262 NSD
D. bryoniae[b]	8	10	9
Methyl eugenol			
Total flies	2474	2273	1629 NSD
D. cacuminatus	2440	2184	1572 NSD
D. mayi[b]	34	89	57
	Suburban gardens[d]		
Cuelure			
Total flies	2128 a	1650 b	1906 ab
D. tryoni	1946	1450	1746 NSD
D. neohumeralis	182	200	160 NSD
Methyl eugenol			
Total flies	2148	2306	2483 NSD
D. cacuminatus	2145	2302	2481 NSD
D. endiandrae[b]	2	2	1
D. mayi[b]	1	2	0

[a] Based on 12 trap changes at 2-wk intervals.
[b] Data not analyzed.
[c] Figures followed by same letter are not significantly different ($P = 0.05$). Comparisons may be made only within rows. NSD = no significant difference.
[d] Based on 15 trap changes at weekly intervals.

entially frequent this region. Other factors such as thermal, illumination and humidity clines which would be more pronounced in the rain forest than in the open environment could be involved in the observed effect of height on capture of flies in the former environment. Prokopy et al. (1972) suggested that a greater amount of solar energy in the upper region of trees could have been the reason why more *R. pomonella* adults were observed there in the early morning and evening.

Detection systems based on traps utilising cuelure and trimedlure for *D. tryoni* and *C. capitata* respectively are maintained in several areas of Australia (Bateman 1978) and trapping is also utilised to monitor populations in commercial fruit areas. Traps are normally placed within trees ca. 1.8 m above ground level and our results indicate that in commercial citrus orchards and suburban areas there is no significant effect of height within the range 0.1–3.6 m above ground on trap efficiency.

Quarantine monitoring for exotic fruit flies with cuelure and methyl eugenol traps has been carried out along Australia's northern coastline for several years. The mango fly, *D. frauenfeldi* Schiner, was detected in northern Cape York peninsula in 1974 and *D. dorsalis* was found in the Northern Territory in 1975 (Drew 1976). A consequence of the extent of the coastline, and inaccessibility of much of it, is that the number of trapping sites is relatively small. Thus any procedure which would increase existing trapping efficiency could be significant. Our results indicate that in closed forests the higher a trap is placed the more efficient it will be, while in open environments, trap height appears to be of limited importance.

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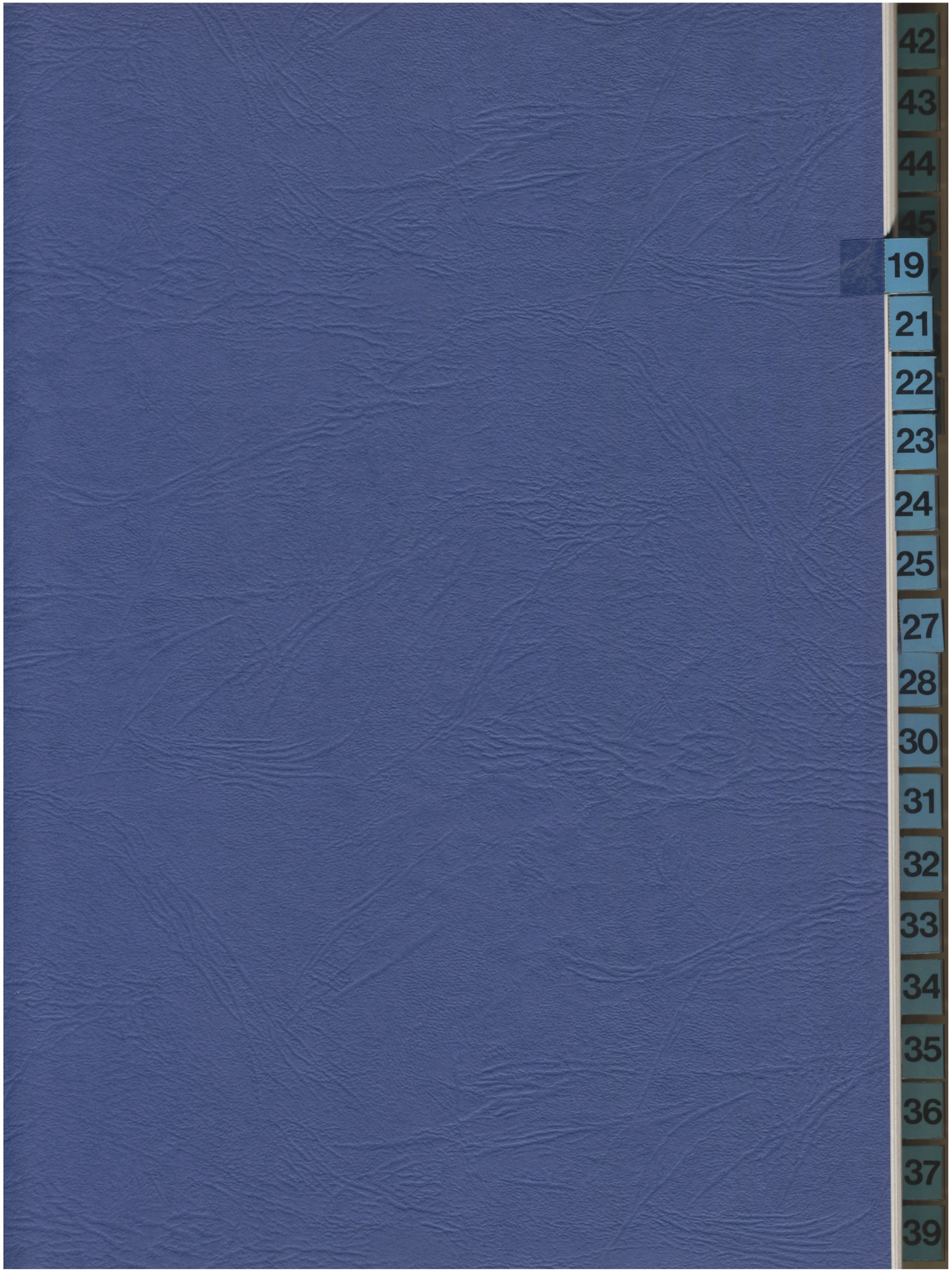
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THE RESPONSES OF FRUIT FLY SPECIES (DIPTERA: TEPHRITIDAE) IN AUSTRALIA TO VARIOUS ATTRACTANTS

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Abstract

Specimens of Dacinae were collected in traps containing male attractants in Queensland and the Northern Territory. The resulting species-attractant records are given for 55 species—39 of which responded to cue-lure and 16 to methyl eugenol. No species responded to trimedlure. Five species which did not respond to male attractants were captured at liquid food lures. Comparative responses to attractants by 7 species were studied in field cage experiments.

Twenty-three of the known Australian species did not respond to male attractants. No species was attracted to both cue-lure and methyl eugenol. Closely related species within species complexes responded to the same attractant. The attractant responses of species within the supra specific groups corresponded with the conclusions from a previous South Pacific study (Drew 1974).

Introduction

There is considerable interest in the compounds cue-lure, methyl eugenol and trimedlure which act as parapheromones and attract males of many species of fruit flies of the subfamily Dacinae. When used in suitable traps these attractants can be used for (i) population detection to assist with the timing of spray control programmes in orchards, (ii) the assessment of populations in ecological studies and (iii) quarantine surveys aimed at the detection of introduced exotic pest species. Their use in large-area suppression and eradication programmes is well established (Steiner *et al.* 1970; Bateman *et al.* 1973).

Drew (1974) documented the history of the development of fruit fly attractants and the attractant responses of 79 species occurring on islands in the South Pacific area. It was shown that the species fall into 2 groups on the basis of their response to attractants and that no species was attracted to both cue-lure and methyl eugenol.

This paper presents data on the responses of Australian fruit fly species to male attractants.

Methods and materials

Three separate studies were carried out.

(1) Steiner type traps (Hooper and Drew 1978) were set at 43 localities along the east coast of Queensland between Brisbane in the south and Mossman in the north. Four traps baited with cue-lure, Willison's lure, methyl eugenol and trimedlure respectively were set at each locality for a period of 2-3 weeks during the mid-summer season when fruit fly populations were at their peak. The traps were hung in broad leaf forest (rainforest). A mercury vapour light trap hanging against a vertical white sheet was used at some of the localities in conjunction with the attractant traps.

In addition, trapping data were available from survey work carried out in localities throughout Cape York Peninsula, the Torres Strait Islands, north-west Queensland and the Northern Territory. Traps in these regions were established on a permanent basis for quarantine purposes.

All traps were baited with 4 mL of a 4:1 mixture of attractant and 50% w/v dichlorvos insecticide on a cotton wick.

(2) Two Steiner traps (1 cue-lure and 1 methyl eugenol baited as in study 1) were set together with 2 McPhail traps (1 baited with 50 mL Lane protein hydrolysate in 400 mL water and 1 with orange-ammonia solution (May, 1958)) in each of 10 localities in south-eastern Queensland for 18 months from October 1975. The localities were—Cunningham's Gap, Heifer Creek (2 sites), Gatton, Toowoomba, Ravensbourne, Brisbane River at Kilcoy, Somerset Dam, Glasshouse Mountains (2 sites). The traps were serviced at 2-week intervals.

A similar study was carried out at 4 localities in north Queensland for 3 months from 1st December, 1976. The localities were—Lake Placid, Kuranda, Mission Beach, Milla Milla Falls.

(3) Infested fruit was collected in both southern and northern Queensland and held at ambient conditions for emergence of fruit flies. Species obtained from these fruit which had not been collected at male attractant traps were allowed to develop to sexual maturity (*ca* 30 d old) and then tested to determine their responses to the male attractants in a large field cage (3.1 × 3.1 × 2.1 m). The responses of these species were compared with those of *Dacus tryoni* (Froggatt) and *Dacus cacuminatus* (Hering) which are known to

respond to cue-lure and methyl eugenol respectively. In each experiment, 30 flies of each species were released in the cage. Four Steiner traps (2 baited with 0.3 mL cue-lure and 2 baited with 0.3 mL methyl eugenol) were hung from the ceiling of the cage adjacent to the centre point of each wall. The traps were rotated every hour and each experiment lasted for 7 h.

Results

Study 1—Some 25,000 specimens were collected of which 39 species responded to both cue-lure and Willison's lure and 16 species to methyl eugenol. These are listed in Tables 1-2. In both Tables, members of the subgenus *Bactrocera* are arranged in groups of closely related species except for the final 7 in Table 1 and 3 in Table 2, which show no close relationships to other species and are arranged alphabetically. One specimen of *Dacus exiguus* (May) was collected at the light trap at Wallaman Falls, North Queensland but none were captured at male attractants that were exposed at the same time. Specimens of *D. tryoni* and *D. neohumeralis* Hardy were collected at the light trap in several localities in addition to responding to cue-lure. No species responded to trimedlure.

TABLE 1
SPECIES RESPONDING TO BOTH CUE-LURE AND WILLISON'S LURE

Genus *Callantra* Walker
  C. aequalis (Coquillett)
  C. smieroides Walker
Genus *Dacus* F.
Subgenus *Didacus* Collart
  D. hardyi Drew
Subgenus *Pacifodacus* Drew
  D. salamander Drew and Hancock
  D. strigifinis Walker
Subgenus *Dacus* F.
  D. absonifacies (May)
  D. bellulus Drew and Hancock
  D. newmani (Perkins)
  D. signatifrons (May)
Subgenus *Zeugodacus* Hendel
  D. choristus (May)
  D. fallacis Drew
Subgenus *Bactrocera* Macquart
alyxiae complex
  D. alyxiae (May)
  D. recurrens (Hering)
bidentatus complex
  D. aeroginosus Drew and Hancock
  D. bidentatus (May)
fagraea complex
  D. fagraea (Tryon)
  D. kraussi Hardy
  D. rufescens (May)
  D. russeolus Drew and Hancock
quadratus complex
  D. antigone Drew and Hancock
  D. aurantiacus Drew and Hancock
  D. erubescentis Drew and Hancock
  D. peninsularis Drew and Hancock
  D. quadratus (May)
silvicola complex
  D. absconditus Drew and Hancock
  D. breviaculeus Hardy
  D. rufofusculus Drew and Hancock
  D. silvicola (May)
tryoni complex
  D. aquilonis (May)
  D. melas (Perkins and May)
  D. neohumeralis Hardy
  D. tryoni (Froggatt)
Ungrouped species
  D. allwoodi Drew
  D. barringtoniae (Tryon)
  D. bryoniae (Tryon)
  D. frauenfeldi Schiner
  D. fuliginus Drew and Hancock
  D. perkinsi Drew and Hancock
  D. robiginosus (May)

TABLE 2
SPECIES RESPONDING TO METHYL EUGENOL

Genus *Callantra* Walker
  C. pusilla May
Genus *Dacus* F.
  Subgenus *Polistomimetes* Enderlein
    D. decurtans (May)
    D. visendus Hardy
  Subgenus *Bactrocera* Macquart
  dorsalis complex
    D. bancrofti (Tryon)
    D. cacuminatus (Hering)
    D. endiandrae (Perkins and May)
    D. musae (Tryon)
    D. opiliae Drew and Hardy
mayi complex
  D. mayi Hardy
  D. pallidus (Perkins and May)
  D. tenuifascia (May)
notatagena complex
  D. notatagena (May)
  D. romigae Drew and Hancock
Ungrouped species
  D. amplexiseta (May)
  D. humilis Drew and Hancock
  D. laticaudus Hardy

Study 2—Table 3 shows the species collected at the McPhail traps charged with liquid food lures, which did not respond to the male attractants and Table 4 shows the species collected with food lures which did respond to male attractants.

TABLE 3
SPECIES AND NUMBERS OF MALES AND FEMALES RESPONDING TO LIQUID FOOD LURES BUT NOT THE MALE ATTRACTANTS

Species	orange-ammonia		protein hydrolysate	
	♂	♀	♂	♀
Callantra petioliforma May		1		
Dacus (Afrodacus) jarvisi (Tryon)		1		
Dacus (Afrodacus) tigrinus (May)		3		1
Dacus (Austrodacus) cucumis French	1	1		4
Dacus (Bactrocera) bancrofti (Tryon)	4	7	8	6

TABLE 4
SPECIES AND NUMBERS OF MALES AND FEMALES RESPONDING TO LIQUID FOOD LURES WHICH ALSO RESPONDED TO MALE ATTRACTANTS

Species	orange-ammonia		protein hydrolysate	
	♂	♀	♂	♀
Dacus (Bactrocera) cacuminatus (Hering)	22	9	7	10
Dacus (Bactrocera) tryoni (Froggatt)	33	38	6	22

The following species collected at male attractants also responded to orange-ammonia lure—*Dacus (Pacifodacus) strigifinis* Walker, *Dacus (Zeugodacus) fallacis* Drew, *Dacus (Bactrocera) breviaculeus* Hardy, *Dacus (Bactrocera) endiandrae* (Perkins and May), *Dacus (Bactrocera) musae* (Tryon), *Dacus (Bactrocera) neohumeralis* Hardy. Numbers of males and females which responded are not available for these species.

Study 3—Seven species were reared from infested fruit and tested for responses to male attractants. These species and their mean percent response (estimated from the number of individuals collected in baited Steiner traps out of 30 released in each of 5 experiments) to both cue-lure and methyl eugenol are listed in Table 5.

TABLE 5
MEAN PERCENT OF SPECIMENS WHICH RESPONDED TO CUE-LURE AND METHYL EUGENOL IN THE FIELD CAGE EXPERIMENTS

Species	Mean percent response	
	cue-lure	methyl eugenol
D. aglaiae Hardy	0	0
D. cacuminatus (Hering)	0	75.8
D. jarvisi (Tryon)	3.3	3.3
D. musae (Tryon)	0	22.9
D. neohumeralis Hardy	35.0	0
D. signatifer Tryon	0	0
D. tryoni (Froggatt)	71.7	0

Twenty-three of the known Australian species were not collected at male attractant traps in the present survey and are listed in Table 6. Collecting records (May 1953) indicate that the species occur in the survey area at the time of year when the experiments were carried out.

Discussion

Dacus (Bactrocera) pulcher (Tryon) was not collected during the study and an examination of the type specimen has revealed that the species possesses characters typical of South Pacific species occurring in Papua New Guinea and the Bismark Archipelago and not characters common to Australian species. The type locality, Glasshouse Mountains, was used as a collecting site for these studies. It is doubtful if *D. pulcher* is an Australian species and probably the designated type locality is incorrect.

TABLE 6
SPECIES NOT COLLECTED AT MALE ATTRACTANTS

Genus *Callantra* Walker
C. petioliforma May
Genus *Dacus* F.
Subgenus *Afrodacus* Bezzi
D. aberrans Hardy
D. brunneus (Perkins and May)
D. flavinotus (May)
D. furvus (May)
D. jarvisi (Tryon)
D. mesoniger (May)
D. tigrinus (May)
Subgenus *Austrodacus* Perkins
D. cucumis French
Subgenus *Diplodacus* May
D. signatifer Tryon
Subgenus *Gymnodacus* Munro
D. calophylli (Perkins and May)
D. exiguus (May)
Subgenus *Hemizeugodacus* Hardy
D. aglaiae Hardy
D. aureus (May)
Subgenus *Paratridacus* Shiraki
D. expandens Walker
D. niger Tryon
Subgenus *Polistomimetes* Enderlein
D. murrayi (Perkins)
Subgenus *Bactrocera* Macquart
D. halfordiae (Tryon)
D. hispidulus (May)
D. mendosus (May)
D. mutabilis (May)
D. phaleriae (May)
D. strigatus (Perkins)

The Australian species are specific in their response to the attractants as are the South Pacific species occurring outside Australia (Drew 1974).

Cue-lure and methyl eugenol attracted species of both genera, viz., *Callantra* and *Dacus*. The genus *Dacus* has been divided into 2 groups of subgenera, viz., the *Dacus* group and the *Bactrocera* group (Drew 1972). Cue-lure attracted species belonging to both groups of subgenera while methyl eugenol only attracted species of the *Bactrocera* group.

No species belonging to the subgenera *Afrodacus*, *Austrodacus*, *Diplodacus*, *Gymnodacus*, *Hemizeugodacus* and *Paratridacus* responded to the male attractants.

Differing response within a supra-specific group, i.e. some species responding to cue-lure with others responding to methyl eugenol, only occurred in the genus *Callantra* and the subgenus *Bactrocera* of the genus *Dacus*.

Only the genus *Callantra* and subgenera *Bactrocera* and *Polistomimetes* possess some species which did not respond to male attractants while most species within these 3 supra-specific groups did respond.

All major economic species in Australia respond to male attractants except *D. cucumis* and *D. jarvisi*.

The species listed in Table 3 did not respond to the male attractants which were exposed at the same time as the liquid attractants. However, *D. bancrofti* was collected in small numbers at methyl eugenol in the absence of the liquid lures. This indicates a rather weak response of this species to methyl eugenol.

Results of the field cage experiments (Table 5) support the field collection data for the species listed. In particular *D. aglaiae*, *D. jarvisi* and *D. signatifer* which have never been collected at male attractant traps in the field, showed either no or an insignificant response in the field cages.

All species within each complex of closely related species were found to respond to the same attractant, which corresponds with the conclusions from the South Pacific trapping programme (Drew 1974).

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Population Studies of Fruit Flies (Diptera:Tephritidae) in South-East Queensland

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Summary. Weekly fruit fly captures for a 12-month period on Mt Glorious (south-east Queensland) suggested that at higher altitudes very few flies survived the winter and that there was an annual colonisation of the higher altitudes by flies from the lower altitudes. The peak trap captures of *Dacus tryoni* (Froggatt) and *Dacus neohumeralis* Hardy corresponded with the fruiting times of their major hosts. The fly populations increased with the onset of higher temperatures and the beginning of the summer rain period and decreased with the decline in temperature and rainfall in autumn. Studies on *Dacus cacuminatus* (Hering) showed that when environmental conditions are suitable this species efficiently exploits its host resulting in rapid population increases.

Introduction

Several native tropical tephritid species have become pests of cultivated fruits and vegetables in coastal, eastern Australia. Bateman (1968) studied the most important pest species, *Dacus tryoni* (Froggatt), in an orchard in southern New South Wales (Wilton) and found that the population size was primarily determined by weather. While temperature played a major role in the timing of seasonal events, the size of the population was primarily determined by summer rainfall, given the availability of suitable hosts.

There have been virtually no studies of these tropical tephritids in their natural environment – the rain forests of eastern Australia. In south-east Queensland such a study with *D. tryoni* would face severe problems given the broad range of hosts, both native and exotic, that it can exploit. Consequently we initiated a study with *Dacus cacuminatus* (Hering) because in coastal Queensland it breeds primarily in one host, *Solanum mauritianum* Scop. (wild tobacco), which grows from sea level to altitudes of over 700 m and fruits throughout the year.

The paper reports data on the seasonal abundance of *D. cacuminatus* in relation to the phenology of fruiting of its host and to temperature. Data are also presented on the abundance of *D. cacuminatus*, *D. tryoni* and *D. neohumeralis* Hardy at various altitudes, and the relationship between seasonal activity and abundance and temperature and rainfall is explored.

Offprint requests to: R.A.I. Drew

Materials and Methods

This work was carried out at Mt. Glorious (27°20′ S, 152°46′ E, altitude 730 m) in south-east Queensland. The suburbs of Brisbane extend to the base of this mountain, the upper levels of which are covered by open eucalypt and rain forests interspersed with some residential areas and small farms.

Fruit fly populations were monitored at altitudes of 100, 200, 300, 400, 500, 600 and 700 m. At each altitude there were 2 Steiner traps, 1 containing methyl eugenol (4 mL + 1 mL 50% w/v dichlorvos concentrate) and the other containing cuelure (4 mL + 1 mL 50% w/v dichlorvos concentrate). The pairs of traps were located in open eucalypt forest at 100 to 400 m, in rain forest at 600 and 700 m, and in a transitional zone comprising a mixture of these vegetational types at 500 m. This experiment was carried out for 2 years from July 1978 to July 1980. There was also 1 methyl eugenol trap in the wild tobacco study area at 650 m. All traps were cleared of flies weekly and the lure + insecticide wicks were changed at 4-weekly intervals.

Three McPhail traps, 1 charged with orange-ammonia solution (May 1958), 1 with Dribarm yeast (5 g/200 mL water) and 1 with a 1:1 mixture of orange-ammonia solution and Dribarm yeast were set in the grove of *S. mauritianum*. Sodium metabisulphite (2 g/200 mL) and sorbic acid (2 g/200 mL) were used instead of mercuric chloride as the preservative in the orange-ammonia solution. No preservative was used in the yeast solution. These traps were cleared, cleaned and filled with new bait weekly, and the trapped flies collected were identified and sexed.

As part of the investigation into the relationship between *D. cacuminatus* and its host, an established plant within a grove of *S. mauritianum* at an altitude of 650 m was selected for study. Three large branches were marked and the total number of flower heads and fruit heads were counted each week for a period of 50 w from mid-winter 1978. These heads were categorised into flowers, immature green fruit and mature fruit (green to yellow), the latter stage being susceptible to fruit fly oviposition. Six samples of fruit heads were collected each week. For each sample the individual berries (which varied from immature to ripe) were cut from the head, mixed thoroughly and 6 lots of 100 randomly selected berries were weighed and held in a laboratory in Brisbane until fruit fly pupae developed. The pupae were held until the flies emerged and all flies identified.

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Thermohygrographs were used to record temperatures at the 100, 400 and 700 m altitudes and the mean weekly maximum and minimum temperatures were calculated from the corresponding daily temperatures. Rainfall data for the area were obtained from the Bureau of Meteorology.

The flight threshold was established with 2-week old *D. cacuminatus* adults which had developed from infested fruit collected in the Brisbane area and held in ambient conditions (spring) until tested. Approximately 300 flies were confined in a 0.05 m^3 cage and placed in a cabinet in which temperatures from 10 to 22° C could be established. The cage of flies was placed in the desired temperature and after 5 min the cage was inverted and vibrated. The ensuing activity of the flies was noted. Between each test the flies were kept at 25° C until the cabinet achieved the next desired temperature. The test was replicated 3 times.

Results

Host Relationships

The inflorescence of *S. mauritianum* is a dichotomous, branched corymb bearing blue flowers. The fruit (berries) which are produced in a bunch, are globular, pubescent but become almost glabrous with age and are 1–1.5 cm in diameter when mature. Young berries are hard and green, becoming soft and dull yellow when mature. The berries at the centre of the bunch mature first and most bunches bear fruit in various stages of maturity. *D. cacuminatus* will oviposit in the berries at the mature green stage just before they begin to soften and change colour.

Flowers and fruit were present throughout the year (Fig. 1c). As temperatures increased in spring (Fig. 1d) flowering increased and peak production of fruit occurred

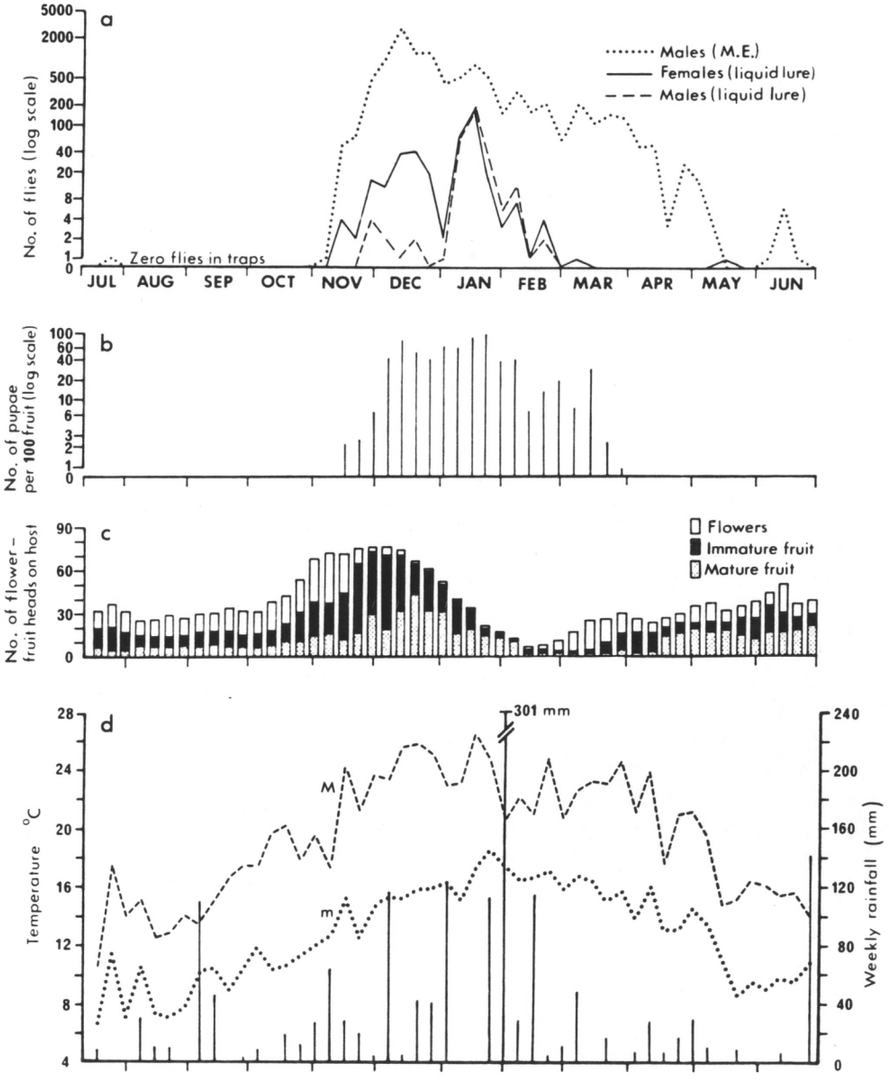

Fig. 1 a–d. Study of *Dacus cacuminatus* (Hering) in its host plant *Solanum mauritianum* Scop., **a** numbers of flies collected in liquid lure and methyl eugenol traps, **b** number of *D. cacuminatus* reared ex *S. mauritianum* fruit, **c** developmental stages of *S. mauritianum* flowers and fruit, **d** weekly rainfall and weekly mean minimum (*m*) and maximum (*M*) temperatures. Note: Spring: September–November; Summer: December–February; Autumn: March–May; Winter: June–August

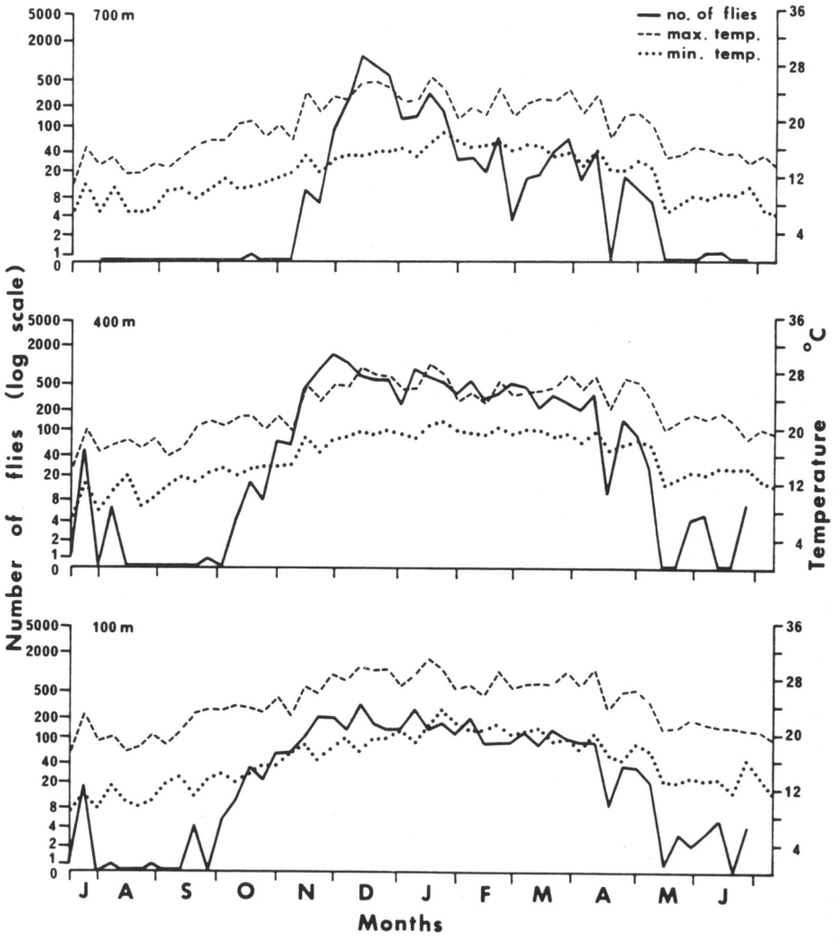

Fig. 2. Number of *Dacus cacuminatus* (Hering) per trap week and weekly mean minimum (*m*) and maximum (*M*) temperatures at altitudes of 100 m, 400 m and 700 m on Mt. Glorious, 1978–1979

in late November – mid-December. Both flowering and fruit availability then declined until mid-February. At this point flowering recommenced but little fruit suitable for oviposition was available until late April.

Figure 1 b shows the number of pupae obtained from the weekly samples of fruit plotted for the week in which the fruits were collected. Thus the Figure indicates the time of ovipositional activity of *D. cacuminatus* as well as the number of pupae per 100 fruits. Oviposition commenced in mid-November and ceased in late March. For most of that 20 week period pupal production was ca. 100 pupae/100 fruit but in some samples 138 pupae were obtained. The mean weight of the 100 fruit samples was 85.4 g, which gives an approximate yield of 1.2 pupae/g fruit. This Figure probably underestimates host utilisation since the fruit samples were randomly selected and each sample would have contained some fruits too immature for oviposition. The decline in pupal production in autumn is probably a reflection of reduced fruit availability (Fig. 1 c) since temperatures at this time were similar to those at the commencement of the breeding season (Fig. 1 d).

Methyl eugenol attracts only mature male flies and one fly was caught in July during a week in which the temperature was abnormally high (2 days > 20° C, Fig. 1 d). No further flies were caught until early November, and the trap captures thereafter increased rapidly to peak in mid-December. The population then gradually declined during the summer and autumn. During this period when the weekly mean maximum temperature exceeded 20° C fluctuations in the trap data appear to be correlated with fluctuations in the weekly temperatures. The main period of fruit fly activity (October – March) coincided with the period of summer rainfall. During this period a total of 1167 mm of rain fell (Fig. 1 d).

The liquid lure traps will capture both males and females and the first females were caught one week after males were first caught in the methyl eugenol traps (Fig. 1 a). Probably this is simply a function of the relative attractiveness of the two kinds of traps. The liquid lure trap data show 2 peaks of fly abundance. In the first peak mature flies were captured and females outnumbered males. The second peak comprised equal numbers of males and females and the majority of these flies were teneral. The time difference between the 2 peaks (4 weeks) approximates the time required for development of adults from eggs at the prevailing temperatures.

When exposed in the laboratory to temperatures of 10 and 12° C the flies ceased activity within 2.5 min, and when disturbed remained immobile on the base of the cage. At 14 and 15° C flies were not completely immobilised but activity was minimal. As the temperature increased (16, 17 and 18° C) so did activity with a small number of individ-

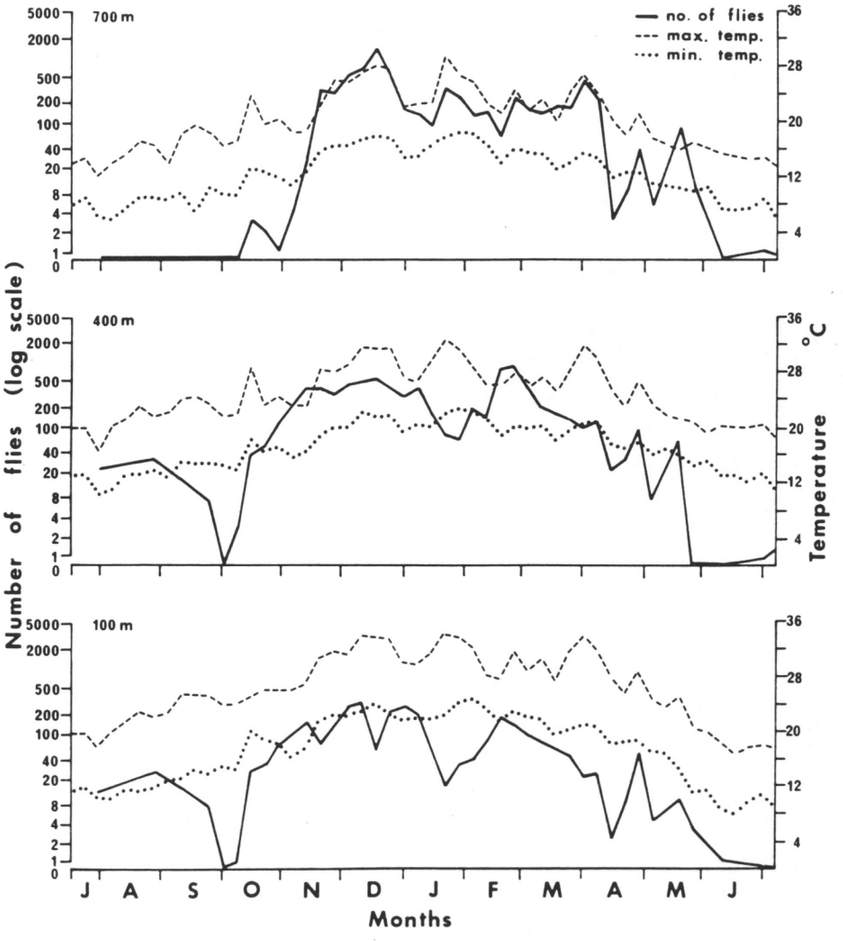

Fig. 3. Number of *Dacus cacuminatus* (Hering) per trap week and weekly mean minimum (*m*) and maximum (*M*) temperatures at altitudes of 100 m, 400 m and 700 m on Mt. Glorious, 1979–1980

uals flying if disturbed but not spontaneously. At 20 and 22° C the flies were normally active and spontaneous flight occurred. For the purpose of this study the flight tolerance temperature is defined as that at which spontaneous flight occurred. From the above data this is taken to be 20° C.

Altitude Trapping

While we collected flies at 100 m intervals between 100 and 700 m we are only presenting data in Figs. 2–5 for 100, 400 and 700 m to illustrate the patterns of abundance. The data for the other altitudes support the conclusions drawn from the data presented.

In the 1978–79 season the abundance of *D. cacuminatus* at 100 m began to increase in late September – early October while at 500–700 m the increase in population began 6 weeks later (Fig. 2). At all altitudes the populations declined in autumn. In the following year a similar pattern occurred (Fig. 3); the populations began to increase at 100–400 m in early October and 2–3 weeks later at 500–700 m. While at 700 m no flies were caught in winter, at 100–400 m when the temperature was less severe flies could be captured in small numbers throughout this period. At 700 m the number of flies caught per week correlated with the weekly mean maximum temperatures. As a rule whenever this temperature reached or exceeded the flight tolerance temperature of 20° C, flies were captured, while flies were rarely captured when the weekly mean maximum temperature was less than 20° C.

D. tryoni and *D. neohumeralis* infest the same cultivated and wild hosts and were present in approximately equal numbers in the trap collections. As a consequence the data presented in Figs. 4 and 5 are the total number of flies of these 2 species. At 100 m these species were caught in numbers >4 flies/trap week throughout the season and population peaks could be identified in September, November, January-February and March. At 400 m the 4 population peaks were present and at 700 m the first 2 peaks were present. At 700 m no flies were caught from May to September and at this time temperature obviously was a major determinant of abundance and/or activity. The flight tolerance temperature was not estimated for *D. tryoni* and *D. neohumeralis* but, as with *D. cacuminatus*, the capture of flies shows a correlation with a temperature of 20° C.

Discussion

The larger populations of *D. tryoni* and *D. neohumeralis* are maintained at the 100 m (Brisbane region) site by late-winter breeding in loquats, mid-spring breeding in mulberries, early summer breeding in peaches, mid-summer breed-

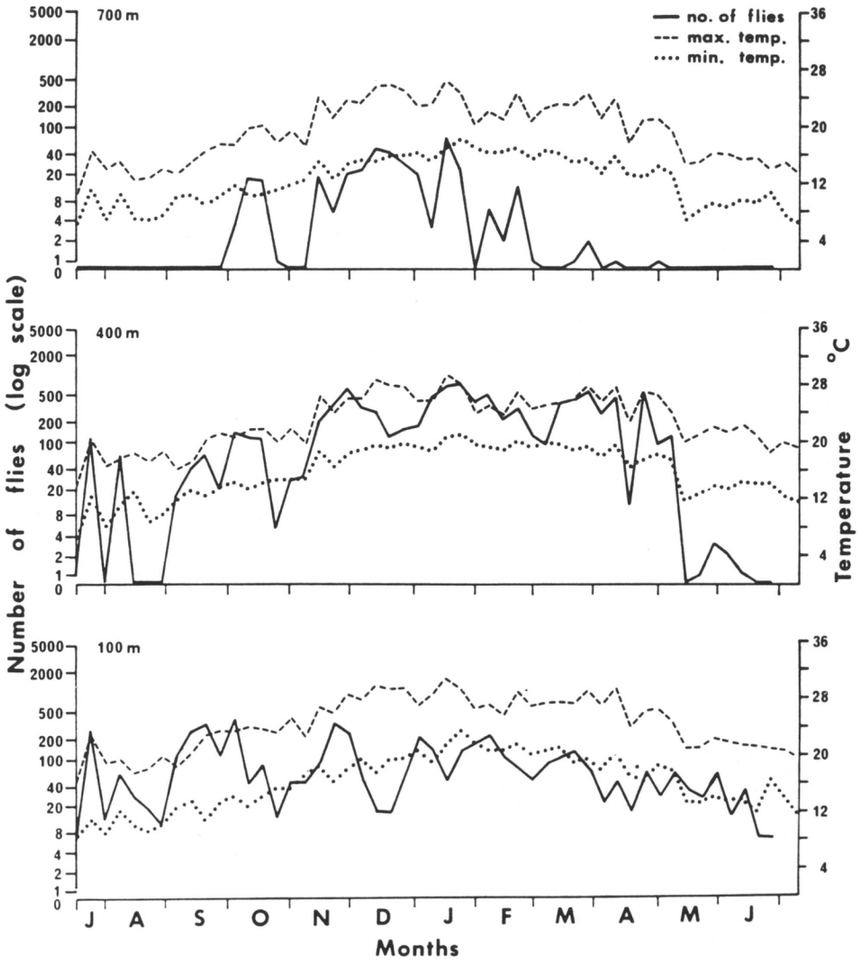

Fig. 4. Number of *Dacus tryoni* (Froggatt) plus *Dacus neohumeralis* Hardy per trap week and weekly mean minimum (*m*) and maximum (*M*) temperatures at altitudes of 100 m, 400 m and 700 m on Mt. Glorious, 1978–1979

ing in mangoes and early to mid-autumn breeding in guavas. In the 100 and 400 m cuelure trapping data (Figs. 4, 5), peaks are present that coincide with these breeding times while in the 700 m cuelure data peaks are present that coincide with the loquat and mulberry fruiting. Mangoes and guavas do not grow at 700 m.

At 100 m, *D. tryoni* and *D. neohumeralis* could be captured throughout the year. No flies were captured at 200 m during a number of weeks in July and this period increased with increasing altitude until at 700 m flies were captured only in very low numbers after early April and were not captured from late May to late August. While it is known that low temperatures will inhibit the response of *D. tryoni* to cuelure traps (Fletcher 1974b) we believe the increase in capture of *D. tryoni* and *D. neohumeralis* at the higher altitudes at Mt. Glorious in October probably represents an influx of flies from lower altitudes. These immigrant flies then breed in native and cultivated fruits in the November–January period before populations start to decline due to a decline in host fruit and decreasing temperatures. It seems reasonable to postulate annual colonisation of the higher altitudes by immigrants from what is known of the behaviour of *D. tryoni* in southern New South Wales. Teneral *D. tryoni* have a dispersive phase and the distance moved can be up to 24 km in 3 weeks (Fletcher 1974a). In the Mt Glorious area we have captured marked *D. tryoni* up to 20 km from the release point in 3 weeks. The distance between the 100 m and 700 m trapping sites was 20 km.

At Wilton, New South Wales, where the temperatures in winter and spring are similar to those at 700 m at Mt. Glorious, Fletcher (1974b) found that the weekly mortality rate of *D. tryoni* adults in spring was about 0.19. This, together with the observations that no flies were captured for about 10 weeks in midwinter at 700 m suggest that very few flies from the summer breeding population would survive to the following spring.

D. tryoni and *D. neohumeralis* have a wide host range involving both introduced and endemic plants (May 1958). On the other hand *D. cacuminatus*, which is endemic to, and only known from Australia, breeds primarily in *Solanum mauritianum* and *S. erianthum* D. Don., although there are a few records of *D. cacuminatus* from tomato and capsicum (May 1963). Symon (1981) believes that both these *Solanum* species originated from tropical South America, and the earliest record of *S. mauritianum* in Australia is 1881 and of *S. erianthum* is 1802. Hence it would appear that prior to the introduction of these two species in Australia, *D. cacuminatus* bred on endemic but unknown, solanaceous plants. In Queensland, *S. erianthum* has a subcoastal distribution and does not occur at Mt. Glorious.

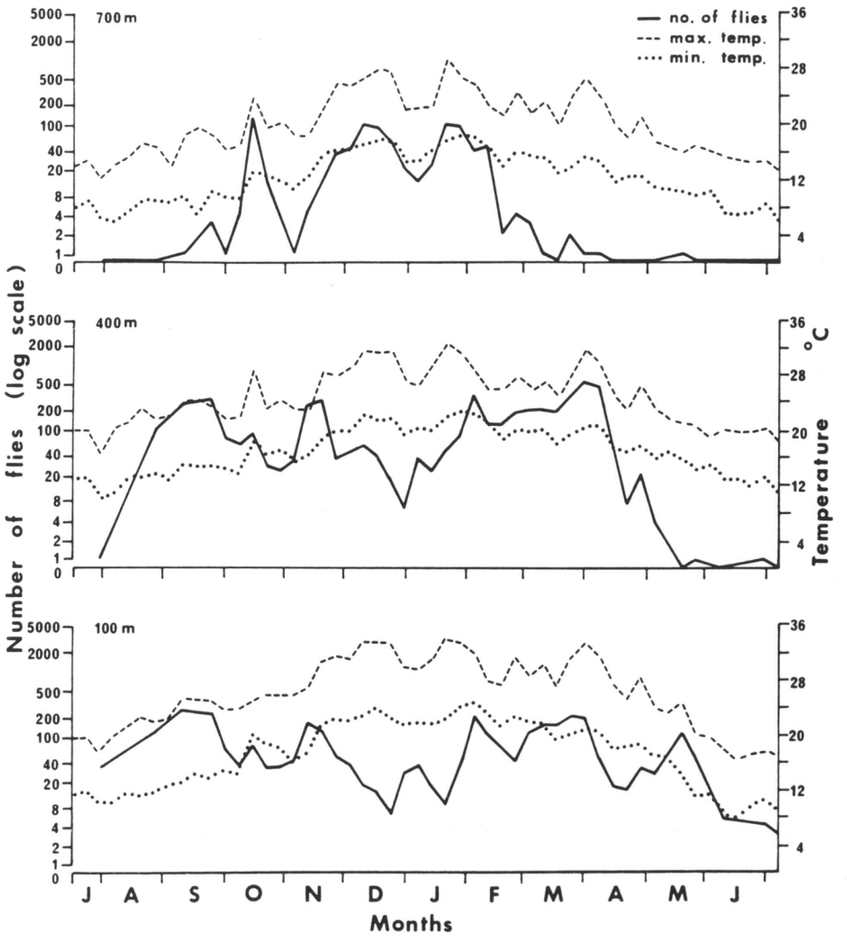

Fig. 5. Number of *Dacus tryoni* (Froggatt) plus *Dacus neohumeralis* Hardy per trap week and weekly mean minimum (*m*) and maximum (*M*) temperatures at altitudes of 100 m, 400 m and 700 m on Mt. Glorious, 1979–1980

S. mauritianum grows in disturbed places along the margins of rain forest which is comprised principally of trees and lianes of the Indo-Malay flora in coastal to subcoastal areas of eastern Australia. In Papua New Guinea there is an undescribed endemic species of *Dacus* which is closely related to *D. cacuminatus* and which breeds in *S. mauritianum* (Drew unpub. data).

At 100 m *D. cacuminatus* could usually be collected throughout the year and an earlier extensive study of *D. cacuminatus* populations in the Brisbane suburban area gave similar results (Hooper unpub. data). *S. mauritianum* produces fruit throughout the year at altitudes up to 700 m and small numbers of larvae were reared from fruit collected during the winter at 100 m. Thus at low altitudes *D. cacuminatus* can breed throughout the year but populations increase rapidly in October in response to increased fruit production by *S. mauritianum* and increasing temperature. With increasing altitude the spring rise in population was delayed – at 700 m the delay was ca. 5 weeks. At this altitude no, or very few, flies were captured in the June–October period. These results suggest that, as with *D. tryoni* and *D. neohumeralis*, the higher altitudes of Mt. Glorious are repopulated by immigrant *D. cacuminatus* from lower altitudes where temperatures are mild enough to permit breeding throughout the year.

At the host study site (650 m) one fly was caught in late July during a week in which the temperature was abnormally high. In October similar temperatures prevailed but no flies were caught. These facts coupled with the findings that no pupae were recovered from fruit, despite the availability of suitable fruit for oviposition, suggest that at this altitude few if any *D. cacuminatus* survive the winter to reproduce in spring.

The first males were captured at methyl eugenol in early November while males and females were recorded in liquid lure traps (more females than males) one week later. This event coincided with the first recovery of pupae from fruit. At this time also *S. mauritianum* fruit production was increasing.

Approximately 4 weeks after the peak fly numbers in December, a peak of teneral flies (1:1 sex ratio) was recorded in the liquid lure traps which would represent the adults of the first generation. From mid-January numbers of *D. cacuminatus* declined despite the fact that oviposition in the wild tobacco fruit continued until late March and temperatures at that time would appear to have been high enough to permit the development of adults. However, during this period rainfall decreased and this could have adversely affected pupal and adult survival (Bateman 1972). Continuing capture of males in methyl eugenol traps at temperatures well below 20° C in the May-June period could perhaps be a consequence of acclimatisation of the flies

to declining temperatures as Meats (1981) has found to occur in *D. tryoni*.

Some care has to be taken in interpreting the pupal production data. After collection at Mt. Glorious the fruits were held in a laboratory at Brisbane, so some pupal development late in the season may not have occurred in the field. Nevertheless neither minimum nor maximum temperatures were lower at the end (March) than at the beginning of the period of breeding. Pupal production then declined quite rapidly-probably in response to scarcity of *S. mauritianum* fruits in March–April. Bateman and Sonleitner (1967) found that scarcity of fruit was the major factor involved in the decline of *D. tryoni* at Wilton, and as a result there was a rapid dispersal of both teneral and mature flies. A similar relationship in *D. cacuminatus* would explain the decline in the adult population shown by the methyl eugenol traps.

Bateman and Sonleitner (1967) found the mean number of *D. tryoni* pupae/fruit to be no greater than 1/30 g in apples while a density of 1 larva/g is optimal in laboratory cultures. On the other hand Fitt (1981) recorded densities of 0.5–2.5 adults/g for 4 northern tephritid species in native hosts. It would appear that for most of the season the *S. mauritianum* fruits were efficiently utilised with pupal production of 1.2 pupae/g fruit. Dissection of fruit revealed that on average a berry could have up to 7 1st instar larvae, 4–5 2nd instar larvae or 3 final instar larvae. Thus towards the end of the season (February–March) it is likely that there was high larval mortality due to competition as fruit production declined while the adult population remained high.

Bateman (1968) found that moisture was the primary determinant of numbers of *D. tryoni* at Wilton by affecting survival of pupae and newly emerged adults, the fecundity of females and immigration. The increase in population and period of maximum activity corresponded with the period of summer rainfall while the decline of the population in autumn corresponded with the time of decreasing rainfall.

The seasonal activity of *D. cacuminatus* was dependent upon temperature, rainfall and the state of development of the host plant. This species shows an ability to exploit its host and to increase rapidly in numbers when environmental conditions permit. In this way it conforms with the concept of an r selected species which Bateman (1972) reported was characteristic of tropical fruit flies.

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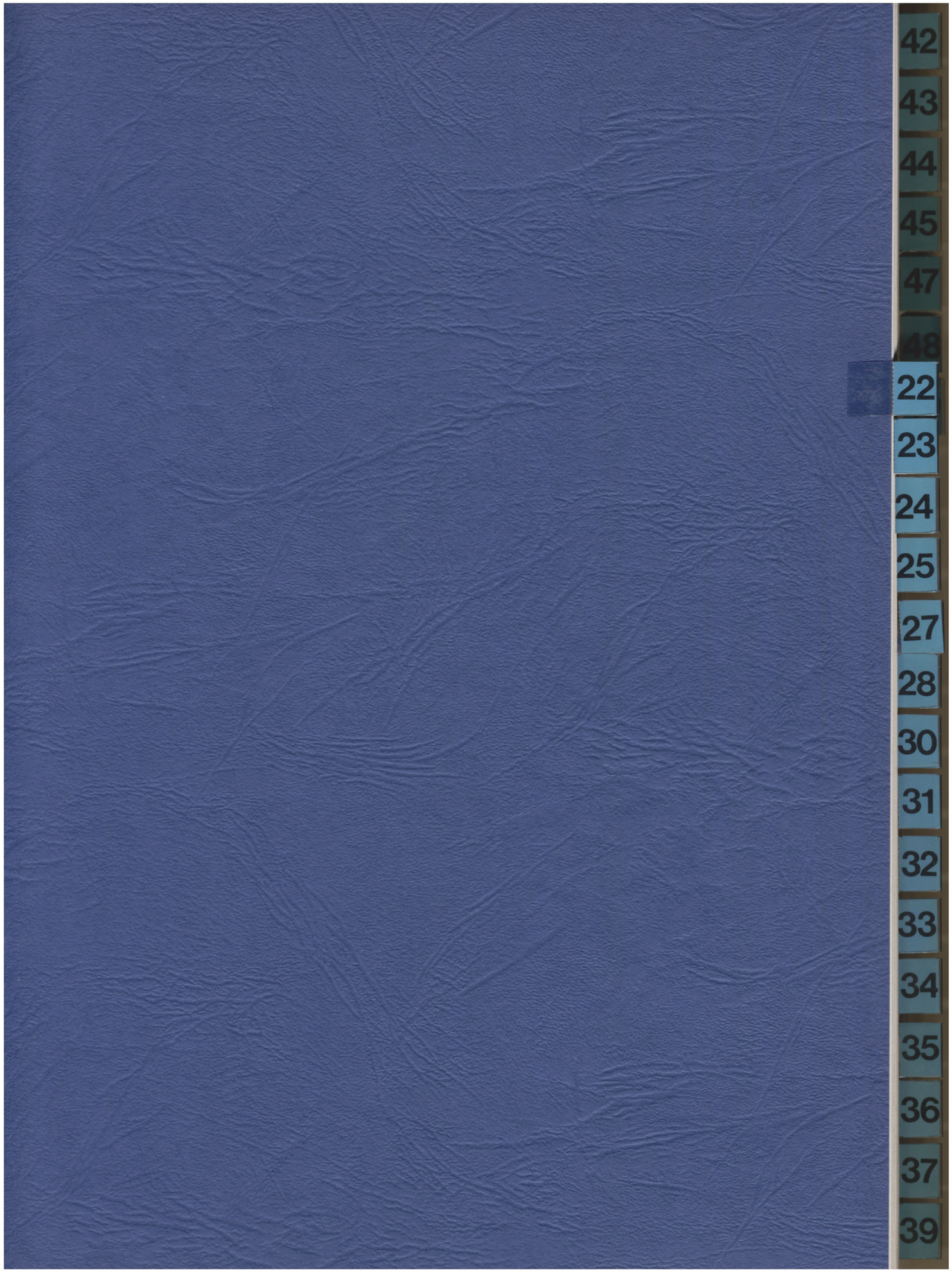
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Original Papers

Bacteria as a natural source of food for adult fruit flies (Diptera: Tephritidae)

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Summary. Bacteria isolated from crops and stomachs of adult fruit flies feeding on mulberry fruit and leaf surfaces were cultured on agar and proved highly attractive to adult fruit flies and provided them with virtually a complete breeding diet. Diets of bacteria, sugar and water gave equal longevity and increased fecundity in *Dacus tryoni* (Froggatt) compared with the conventional diet of autolysed brewer's yeast, sugar and water. The type and abundance of leaf and fruit surface bacteria appears to be an important factor in the life history of tropical fruit flies.

Introduction

Fruit flies of the tephritid subfamily Dacinae occur widely in the tropical and sub-tropical areas of the world where rainforest is their primary habitat.

Little is known about the natural regulation of numbers of those fruit flies which plague horticulture although some workers (Birch 1965, Meats 1981) have investigated the influences of temperature. Our work suggests that nutrition, and particularly adult nutrition, is of overriding importance to the activity and numbers of fruit flies.

A great deal is known about adult nutritional requirements of some species reared in the laboratory (Hagen 1953) but little is known about the source of these nutrients in nature. Adult fruit flies have been observed feeding on leaf and fruit surfaces by means of a rapidly pulsating action of their probosces (Tryon 1889; Boyce 1934). It was also suggested that fungal spores and yeasts might provide nutrients for adult fruit flies (Boyce 1934). Modern workers (Hagen 1953, 1958; Boush et al. 1969; Neilson and Wood 1966; Yasumatsu and Nagatomi 1959; Varley 1947) have proposed that the adult food in nature is primarily honeydew.

Courtice (1982) first proposed that adult fruit flies were dependent on high protein phyllosphere yeasts and bacteria and Courtice and Drew (1983) suggested that bacteria introduced into the host fruit with the egg were nutritionally important to the fruit fly larvae.

This paper reports data on the anatomy of the alimentary canal of *Dacus tryoni* (Froggatt), isolation of bacteria from the crop and stomach of four *Dacus* species collected in a mulberry tree, and the effect of feeding six of these bacteria and a fluorescent pseudomonad bacterium from lettuce leaves on the fecundity and longevity of *Dacus cacuminatus* (Hering) and *D. tryoni*.

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Materials and methods

Isolation of microorganisms from field collected flies

Dacus (*Afrodacus*) *brunneus* (Perkins and May), *Dacus* (*Bactrocera*) *neohumeralis* Hardy, *D. cacuminatus* and *D. tryoni* adults were observed feeding on the surfaces of mulberry (*Morus nigra* L.) leaves and fruit during early Spring 1982 in Brisbane, Queensland. Specimens were collected and held singly in glass tubes until each had produced faecal droppings, after which time they were dissected under sterile water following the method by Martignoni and Steinhaus (1961) to eliminate contamination by external microorganisms. During dissection the quantity and colour of crop and stomach contents and the state of ovarian development in females were noted. Then the crop and stomach contents and faeces of each fly were streaked on King-B medium (King et al. 1954) for bacteria culturing and potato dextrose agar (PDA; Gibco Diagnostics, Madison, Wisconsin) for yeast culturing.

After inoculation, the plates were incubated at 28° C and observed daily. An assessment of the microorganisms isolated was made and pure cultures of certain of the microorganisms were subsequently produced for use in feeding trials.

The dissection/isolation technique was tested by feeding newly-emerged *D. tryoni* on sugar, water and an easily identified fluorescent bacterium (*Pseudomonas fluorescens – putida* group) isolated from a lettuce leaf; after 24 h access, crops and stomachs of three flies were used to inoculate PDA and King-B media. After inoculation, the plates were incubated at 28° C for 3 days.

Isolation of microorganisms from leaf and fruit surfaces

Mulberry fruits and leaves, upon which the dissected flies were feeding, were shaken for one minute with 20 ml sterile water in a sterile plastic bag. This was then held for 10 min

before the solution was used as inoculum. The inoculated plates were incubated at 28° C and observed daily. The colony characteristics of the microorganisms were compared with those isolated from the feeding flies.

Feeding tests with microorganisms

Six bacteria isolated from crops and stomachs of field collected flies (UQM Nos. 2509–2514, Table 1) and the fluorescent bacterium (*P. fluorescens – putida* group; UQM No. 2515) isolated from a lettuce leaf were used in feeding tests on *D. tryoni* and *D. cacuminatus*. The bacteria were fed to the flies as either washed or unwashed preparations of cells.

Washed preparations were obtained from 2- to 3-day-old cultures on peptone yeast extract agar (10 g peptone, 5 g yeast extract, 5 g NaCl, 15 g agar, 1,000 ml distilled water) incubated at 24–26° C. The bacteria were suspended by adding 10–15 ml phosphate buffered saline (PBS: 0.1 M $Na_2HPO_4 - KH_2PO_4$, pH 7, plus 0.14 M NaCl) per 90 mm diameter petri dish culture and gently emulsifying the bacterial growth on the agar surface with a glass rod spreader. The bacterial suspension was then removed and centrifuged to pellet the cells. After the supernatant liquid was decanted, the cells were resuspended in an equal volume of PBS using a vortex mixer and again centrifuged. The resuspension and pelleting of cells in PBS was again repeated and the cells left in a small amount of PBS. This washing system ensured that free nutrients from the agar medium were not fed to flies.

Unwashed cells of the bacteria were obtained by gently scraping the lawn of bacteria off the surface of the agar using a glass rod spreader.

Usually, freshly prepared washed or unwashed cells were fed to the flies but occasionally refrigerated preparations were used.

Five cages each with 200 pupae of *D. tryoni* ex laboratory colony, Dept. Primary Industries, Brisbane, were each provided with sugar and water until one week after emergence. At this time an additional nutrient source was added to four cages – one with 1.5 ml of unwashed fluorescent bacterium (*P. fluorescens – putida* group; UQM No. 2515) one with 0.25 ml of each of fruit fly bacteria UQM Nos. 2509–2514 (unwashed), one with 0.25 ml of each of UQM Nos. 2509–2515 (washed), one with 2.0 ml autolysed brewer's yeast fraction (Amber – BYF®, Amber Laboratories, Wisconsin, U.S.A.) (the latter is the standard nutrient source for the laboratory colony). This food was fed to flies on 150 mm × 12 mm strips of filter paper suspended from the roof of each cage three times per week for 40 days, then twice per week for 100 days and thereafter once per week. The strips were moistened with distilled water several times per week.

Colonies of *D. cacuminatus*, ex *Solanum mauritianum* Scop. fruit, Brisbane, were set up and fed as for *D. tryoni* except that the diet containing autolysed brewer's yeast fraction was not included.

When 16 days old, three *D. tryoni* females fed each diet were dissected for assessment of ovarian development. At 26 days an egg collection test was carried out. A hollowed apple dome was punched with pin holes, sealed to a glass plate with wax, thoroughly washed in 0.1% alkyldimethylbenzylammonium chloride (Zephiran) solution and placed in each cage for 5 h ($6^1/_2$ h for cage with sugar and water diet). The eggs laid were counted and percent hatch determined.

Because of the difficulty in inducing *D. cacuminatus* to oviposit under laboratory conditions, three females fed each diet were dissected at 20 days old and eight from each cage at 33 days for assessment of ovarian development.

At each feeding time, the dead flies were removed and counted to assess longevity under each diet.

Anatomy of alimentary canal

Adult male and female *D. tryoni* were dissected immediately after killing and their alimentary canals studied. The sections of each canal were measured using an eyepiece micrometer and subsequently illustrated.

Estimation of pH of crop and stomach

Adult *D. tryoni* were fed on a gel diet containing reversible pH indicator (BDH chemicals Ltd., England, range 1 to 14). The gel was 0.5% agarose containing 10 g sugar and 2 ml pH indicator in 100 ml of double distilled water. After 2 and 3 days of active feeding, 7 males and 7 females were anesthetised and dissected and the pH estimated. Agarose gel was used to avoid possible buffering effects that could occur with protein based gels. Crop contents of some flies were placed on pH indicator paper (E. Merck, Darmstadt) to provide an additional estimate.

Results

When isolations on PDA and King-B media were made from the crops, stomachs and faeces of fruit flies found in the mulberry tree, yeasts and fungi were absent. In contrast, bacteria were usually isolated in large numbers from the flies, except from the empty crops of some specimens. These results, at least with respect to bacteria and yeasts, paralleled the results of isolations from the surfaces of leaves or fruit of the mulberry tree where bacteria and fungi were more numerous than yeasts.

Since many different bacterial colony types were present on plates used in isolations from the flies, it is apparent that many different bacteria were involved.

On the basis of colony type, bacteria common in the stomach of a fly were usually also common in the crop of the same fly, and either absent or present in low numbers in the faeces. Often more than one bacterium was common in the one fly. Bacteria with a similar colony type were often isolated from different species of fruit fly.

Six of the bacteria, which on the basis of colony type appeared to be different and to be isolated abundantly from at least one fly, were purified by repeated single colony transfer. These pure cultures were then Gram-stained and examined microscopically. All six were Gram-negative (Table 1). All showed different microscopic characters, and thus were each assumed to be a distinct species.

Bacteria isolated from mulberry fruit or leaves also showed a range of colony types, including some similar to those obtained from the flies.

In preliminary tests seven yeasts isolated from either banana or persimmon leaves, including four tentatively identified as *Aureobasidium* sp. and two as *Torulopsis holmii*, were compared with the fluorescent bacterium from lettuce as supplementary components of the diet of

Table 1. Bacteria isolated from *Dacus* species feeding in mulberry tree, Brisbane. (UQM = Culture collection number, Dept. of Microbiology, University of Queensland)

Accession no.	Origin	Colony and cell characteristics	Notes
UQM 2509	*D. cacuminatus* (♀)	Bluish colony, Gram negative rod	Numerous similar colonies isolated from crops and stomachs of *D. brunneus*, *D. neohumeralis*, and *D. tryoni* that had fed on mulberry fruit. Not isolated from faeces
UQM 2510	*D. cacuminatus* (♀)	Cream-yellow colony, Gram negative rod	Numerous similar colonies isolated from stomachs and some crops of *D. neohumeralis*, and *D. tryoni* that had fed on mulberry fruit. Isolated in low numbers from faeces, only when purple
UQM 2511	*D. tryoni* (♀)	Cream colony, Gram negative rod	Numerous similar colonies isolated from crops and stomachs of some flies that had fed on mulberry fruit. Only occasionally isolated from faeces and in very low numbers
UQM 2512	*D. tryoni* (♀)	Cream translucent colony, Gram negative rod	Numerous similar colonies isolated from crop and smaller numbers from stomach of one fly that had not fed on mulberry fruit. Not isolated from faeces
UQM 2513	*D. neohumeralis* (♀)	Cream opaque colony, Gram negative rod	Numerous similar colonies isolated from crop and smaller numbers from stomach of one fly that had not fed on mulberry fruit. Large numbers isolated from faeces
UQM 2514	*D. neohumeralis* (♀)	Cream-yellow colony, Gram negative rod	Numerous similar colonies isolated from crop of one fly that had not fed on mulberry fruit. Not isolated from faeces

D. tryoni. Although the flies fed actively on the fluorescent bacterium, and the bacterium was readily isolated from the alimentary canals of three such flies, the flies showed little interest in the yeast cultures and the yeasts were not isolated from the flies.

The six bacteria isolated from fruit flies resembled the fluorescent lettuce bacterium in strongly attracting adults of *D. tryoni* and *D. cacuminatus*. Feeding swarms formed on the bacteria placed in the cages (Fig. 1) and the flies fed vigorously.

In an extended feeding test *D. tryoni* and *D. cacuminatus* were allowed to feed on sugar and water supplemented with either washed or unwashed bacteria or autolysed brewer's yeast (Table 2). *D. tryoni* fed on the diet containing washed or unwashed bacteria isolated from flies (Table 1) had half-formed ovaries with some mature eggs at 16 days old. At 16 days flies fed on the sugar and water diet without bacteria, or supplemented with only the lettuce fluorescent pseudomonad, had immature ovaries. At 19 days and thereafter females were ovipositing into bacteria UQM 2511, 2512 and 2514 on the suspended paper sheets.

At 26 days the egg production test with *D. tryoni* was made. It was found that compared with the sugar and water diet (Nil diet), the diets containing supplements greatly enhanced the rate of oviposition. Addition of the lettuce fluorescent pseudomonad increased the oviposition rate 75 times, the autolysed brewer's yeast 212 times, the unwashed fruit fly bacteria 425 times, and the washed fruit fly bacteria plus the lettuce fluorescent pseudomonad 900 times (Table 2).

At 20 days old, *D. cacuminatus* fed on diets containing either washed or unwashed fruit fly bacteria had ovaries about one-quarter full size with many immature eggs and an occasional mature egg. At 33 days, 40 percent of flies of this species fed on the diets containing washed or unwashed fruit fly bacteria had reasonably well developed ovaries with mature eggs, with 25 percent more eggs where the diet contained washed bacteria than where the diet contained unwashed bacteria. In contrast, flies fed on the diets containing the fluorescent pseudomonad or unsupplemented with bacteria had undeveloped ovaries at both 20 and 33 days.

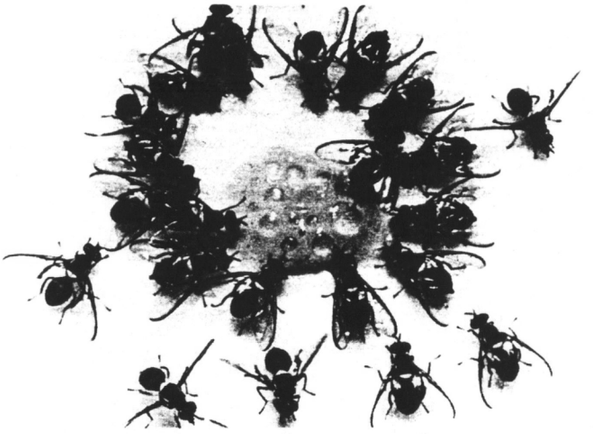

Fig. 1. Swarm of *Dacus tryoni* (Froggatt) feeding on bacteria isolated from field collected flies

Longevity of *D. tryoni* and *D. cacuminatus* was also affected by diet. *D. tryoni* survived equally well on diets containing bacteria and autolysed brewer's yeast; survival on sugar and water alone was relatively poor (Table 3). *D. cacuminatus* survived better on the diets containing the fruit fly bacteria than on the sugar and water alone, but survival on the lettuce fluorescent pseudomonad was poorest of all (Table 4).

The alimentary canal of *D. tryoni* (Fig. 2) consists of a crop located in the anterior region of the abdomen and which is connected to the posterior end of the oesophagus by a long slender duct, a long coiled stomach, two long bifurcated malpighian tubules, and a short intestine ending in an enlarged rectum. The oesophagus measures 1.5 mm

Table 2. Egg production and percent hatch at 26 days for *Dacus tryoni* (Froggatt), fed on diets of either bacteria or autolysed brewer's yeast plus sugar and water

Diet supplement[a]	No. of females	Duration of test (h)	No. of eggs	Oviposition rate (eggs/♀/h)	% Egg hatch
1. Fruit fly bacteria UQM 2509–2514 (unwashed)	84	5	1430	3.4	90
2. Lettuce fluorescent pseudomonad UQM 2515 (unwashed)	80	5	240	0.6	89
3. UQM 2509–2515 (washed)	84	5	3018	7.2	97
4. Autolysed brewer's yeast	80	5	697	1.7	75
5. Nil	79	6.5	4	0.008	25

[a] All diets (including Nil) contained sugar and water

Table 3. Number of *Dacus tryoni* (Froggatt) alive at times (weeks) after emergence from 200 pupae, given diet supplements of either bacteria or autolysed brewer's yeast

Age (weeks)	Diet supplement[a]				
	Fruit fly bacteria UQM 2509–2514 (unwashed)	Lettuce fluorescent pseudomonad UQM 2515 (unwashed)	UQM 2509–2515 (washed)	Autolysed brewer's yeast	Nil
2	177	165	172	170	170
4	164	155	165	159	154
8	103	115	120	110	41
12	43	65	75	52	5
16	14	30	38	22	0
20	3	12	14	15	0

[a] All diets (including Nil) contained sugar and water

Table 4. Number of *Dacus cacuminatus* (Hering) alive at times (weeks) after emergence from 200 pupae, given diet supplements of bacteria

Age (weeks)	Diet supplement[a]			
	Fruit fly bacteria UQM 2509–2514 (unwashed)	Lettuce fluorescent pseudomonad UQM 2515 (unwashed)	UQM 2509–2515 (washed)	Nil
2	159	156	165	100
4	91	42	120	57
8	23	2	38	4
12	18	0	22	0
16	14	0	14	0
20	7	0	9	0

[a] All diets (including Nil) contained sugar and water

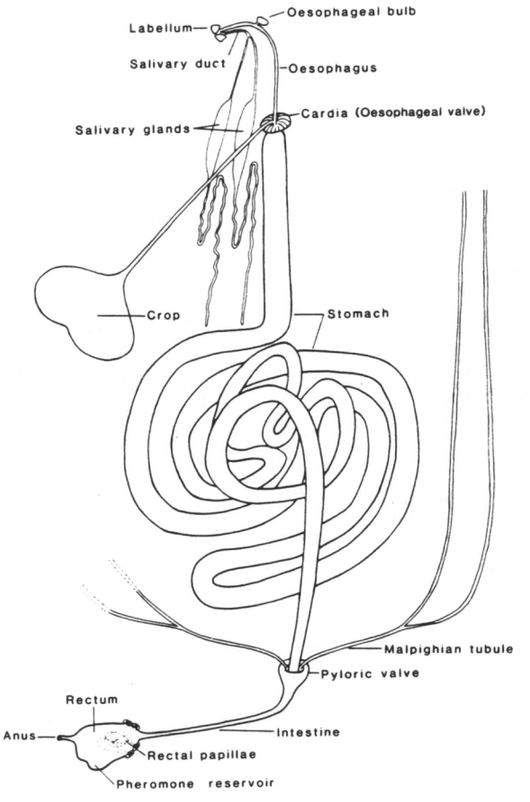

Fig. 2. Alimentary canal of *Dacus tryoni* (Froggatt)

long, stomach 28 mm, intestine (including rectum) 4 mm, and the malpighian tubules 10 mm.

When the insect feeds, the crop becomes extremely enlarged and it distends the abdomen when full. Flies collected after feeding in mulberry trees had the purple dye characteristic of mulberry fruit in the crop and stomach.

The *D. brunneus* were males and had empty crops and some pale reddish food in the stomach. *D. cacuminatus* were mostly females with immature ovaries and were actively feeding; their crops and stomachs were full and contents and faeces were dark purple; the few males had half filled crops with the contents of crops and stomachs being clear. *D. neohumeralis* and *D. tryoni* were all females with mature ovaries full of well developed eggs. They were not feeding very actively immediately prior to collection, having either empty or partly filled crops and with either clear or dilute purple crop and stomach contents.

In each specimen dissected, the crop and stomach contents were always the same colour and when there was some purple colouring from mulberry fruit in evidence, then this also showed in the faeces.

The agarose gel fed to the flies had a pH of 6. Colour changes after ingestion showed *D. tryoni* had a crop pH of 3 and a stomach pH of 3 to 3.5. Crop contents placed on pH indicator paper had a pH of 3.

When the fruit fly bacteria and the fluorescent pseudomonad (UQM 2509–2515) were inoculated onto peptone yeast extract agar adjusted to various pH levels with hydrochloric acid, none grew at pH 3.0 or pH 3.5 and only UQM 2510, 2511 and 2513 grew at pH 4.0.

Discussion

In the work reported above bacteria were isolated in large numbers from adult fruit flies, particularly from those with full crops and stomachs. It is most likely that many of these originated from the mulberry tree on which the flies were feeding. Evidence that the bacteria were ingested rather than being symbiotic inhabitants of the upper alimentary canal is as follows – (1) The crop and stomach of *D. tryoni* were found to be acid (pH 3–3.5). Many bacteria are unable to grow at pH values below 5, and only a few rare bacteria are able to grow at pH values below 4 (Brock and Brock 1978). The diversity of bacteria isolated from the alimentary tract of the flies does not indicate a restricted bacterial flora, which would be expected to develop in such an acid environment. Further, a test of six bacteria isolated from fruit flies showed that none grew at pH 3–3.5, the pH of the crop and stomach of *D. tryoni*. (2) A general similarity was observed between bacteria isolated from the fruit flies and from the surfaces of mulberry fruit or leaves. (3) *D. cacuminatus* and *D. tryoni* showed a strong feeding response (Fig. 1) to pure bacteria isolated from the crops and stomachs of flies collected in the mulberry tree, and *D. tryoni* females oviposited in smears of these bacteria. (4) We successfully fed and subsequently isolated the fluorescent pseudomonad (UQM 2515) from laboratory flies.

The fact that the bacteria occurred in large quantities in crops and stomachs but were either absent or in low numbers in faeces (Table 1) indicates that they were being digested. Further, the measured egg production in the laboratory experiments could not have resulted from any other food source.

The feeding trials demonstrated that bacteria vary in their nutritional value. For example, the fluorescent bacterium from lettuce was less useful at increasing longevity and fecundity than the mixed bacteria obtained from fruit flies. Presumably, under the acid conditions of the crop and stomach, bacteria autolyse and release their cell contents in the form of amino acids, vitamins, and other nutrients. Because of the acidity (pH 3–3.5) of the upper alimentary tract it is unlikely that the flies possess enzymes which hydrolyse ingested proteins into amino acids, since most insect proteinases are active under neutral or alkaline conditions (Gilmour 1961). Whatever the mechanism, we have shown that a diet of bacteria supplies the high concentration of amino acids known to be required for egg production (Hagen 1953).

The structure and large size of the crop and stomach (Fig. 2) and the purple-blue contents of both organs in flies feeding in mulberry trees, indicate the ingestion of as much food as possible when it is available. The crop is used for storage. Thus fruit flies can utilise leaf and fruit surface bacteria which are available in intermittent growth flushes (Blakeman and Fokkema 1982) on fruit and leaf surfaces.

The coloured crop contents of female flies collected in the mulberry tree, especially those with immature ovaries, indicated that they were actively feeding. At that stage of development they require a protein-rich source of nutrients (including hydrolysed protein). Two of the species, *D. brunneus* and *D. cacuminatus* do not oviposit in mulberry fruit but were using the plant as an adult food source.

The importance of bacteria to adult fruit flies appears to be parallelled by their importance to larvae. Our observations (Courtice and Drew 1983) indicate that, at oviposition, microorganisms are introduced which cause the fruit to decay and subsequently the larvae feed in the decaying fruit and not in fresh fruit. It is probable that the larvae are ingesting bacteria growing in the decaying fruit and that the numerous bacteria found in the alimentary canal of larvae (G. Fitt, pers. comm.) are as important nutritionally as in the adults. This nutritional interpretation of the role of ingested bacteria in larvae and adult fruit flies may be contrasted with the current popular belief that such microorganisms are symbionts (Rossiter et al. 1982). Further studies on larval feeding are in progress.

Flies of the tropical subfamily Dacinae require a large and rapid egg development in order to survive among the numerous frugivorous animals of the rainforest. Rapid development to sexual maturity and increased egg production in *Dacus cucurbitae* Coquillett and *Dacus dorsalis* Hendel occur when the diet contains a high concentration of free amino acids (Hagen 1958). It must be assumed that other *Dacus* species are equally attracted to and utilise a rich source of hydrolysed protein in nature. The attraction of *Dacus* species to hydrolysed yeast protein in bait sprays (Steiner 1952) has long been a commonplace of horticultural practice.

The source of hydrolysed protein in nature has not before been established. While honeydew from homopterous insects may be an important part of the diet of some fruit fly species, and certainly may be a maintenance ration for *D. tryoni* in dry weather (Courtice, unpub. data), it is doubtful that it can provide the quantity and variety of amino acids required for reproduction by the highly fecund tropical Dacinae. Craig (1960) found that some essential amino acids are absent or in low concentrations in common insect honeydew, which might be expected when one considers that honeydew is the surplus or reject matter discarded after successful egg production by other highly fecund insects. The bacteria discussed in this paper develop in fruit and leaf surface leachates following wetting (Ruinen 1961; Tukey 1971). These leachates are probably of similar composition to material derived from phloem by sucking Homoptera. It is more reasonable to assume an equality of nutritional opportunity between these two unrelated but equally fecund groups of insects, rather than that one depends upon the reject material of the other.

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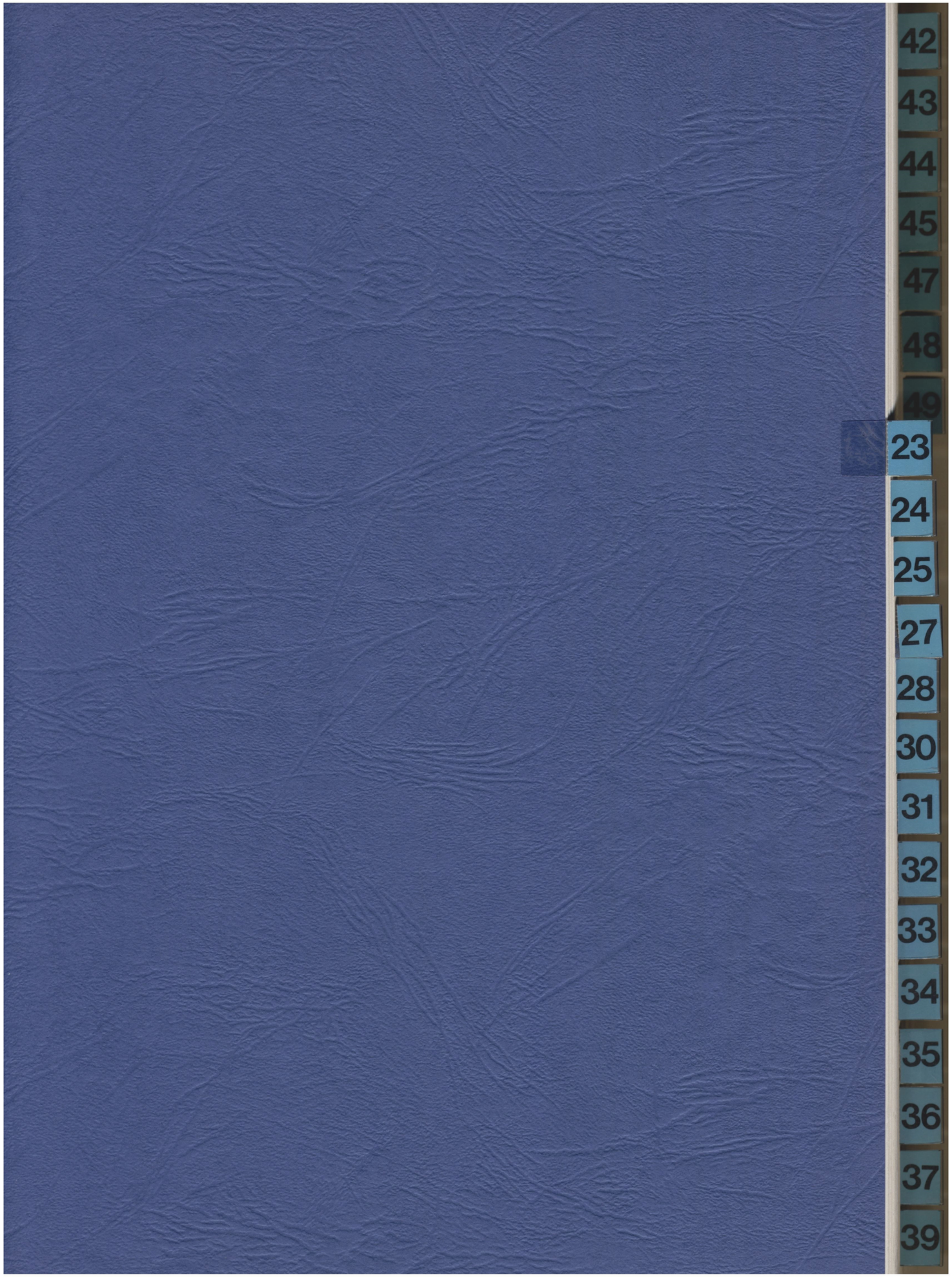
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Bacterial regulation of abundance in tropical fruit flies (Diptera: Tephritidae)

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ABSTRACT

Protein bait trap and male lure trap estimates of seasonal numbers and studies on movements in several fruit fly species in southeast Queensland have led to a new understanding of the natural regulation of fruit fly abundance. Teneral female flies were observed to disperse in the company of mature males, feeding *en route* on growth flushes of highly specific leaf surface bacteria. The erratic supply of specific leaf surface bacteria in nature governs fruit fly numbers. Rainfall and temperature play only indirect roles. The supply of bacterial food for larval growth is comparatively independent of environmental parameters.

INTRODUCTION

Tephritid fruit flies devastate horticultural crops in both temperate and warmer regions of the world. In tropical and sub-tropical orchards, where most pest Tephritidae belong to the sub-family Dacinae, population outbreaks occur erratically in time and intensity. Tryon (1889) first reported increased numbers of Queensland fruit fly, *Dacus tryoni* (Froggatt), in the wake of wet summer weather. Bateman (1968) found that while temperature played a major role in the timing of stages in the life cycle of this species, the size of the resultant population was primarily a function of summer rainfall. Nishida (1963) observed a similar pattern for the melon fly *Dacus cucurbitae* (Coquillett), in India. Fitt (1981) reported a highly significant correlation between increasing rainfall and temperature and increasing trap catches of the univoltine (one generation per annum) *Dacus opiliae* Drew and Hardy in the Northern Territory during the increasing phase of the population. He explained this correlation by suggesting that flies emerging in the wet season develop a response to the male lure used in trapping. He suggested that they lose this response in the dry season, to recover it again only at the beginning of the next wet season, and that the climatic variable most likely to be involved is humidity. His trap catches of *Dacus tenuifascia* (May), however, were not correlated with temperature and rainfall. *Dacus newmani* (Perkins) of semi-arid Australia has been observed responding to male lures immediately after, and only after, significant rainfall (Courtice, unpubl. data).

Two factors have generally been employed to account for the size ot wild fruit fly populations. In the first place singular emphasis has been placed on the effects of temperature on both survival and rates of development of the various stages of the life cycle. This emphasis represents the continuing influence of the work of James Davidson [1885-1945] in South Ausralia where extremes of temperature have an over-riding influence on insect numbers. In the second place destruction of fruit and vegetables by Tephritid larvae is always conspicuous. Thus the availability of larval host material as a factor regulating fruit fly abundance has not been neglected. These two factors were employed by Fletcher (1974). In a study of the seasonal abundance of *D. tryoni* south of Sydney, he explained population size differences between seasons and locations in terms of temperature extremes and the availability of larval hosts. As Drew and Hooper (1983) have done, he notes, but does not explain, the influence of summer rainfall.

Fruit fly numbers, however, do not always increase in the wake of summer rain. Whereas Fletcher (1974) consistently found a large peak in numbers of *D. tryoni* in autumn at all altitudes at 34°15′ South Latitude, Drew and Hooper (1983), working in the Brisbane hinterland at 27°25′S found a steady decline in numbers of both *D. tryoni* and *Dacus neohumeralis* Hardy during the same months of the year. This decline occurs during the regular late summer wet season in the montane hinterland behind Brisbane. The observed decline in fruit fly numbers was greatest at an altitude of 700 m on Mt. Glorious where rainfall for the period February-April is also the greatest. At Mt. Glorious rainfall averages 647 mm for this period compared to 394 mm at Drew and Hooper's site at 100 m elevation, and compared to 226 mm and 252 mm for Fletcher's Campbelltown (55 m elevation) and Picton (168 m elevation) sites respectively.

This autumn decline in fruit fly numbers calls into question the "drinking ration" theory (Meats 1981) to account for the relation between population size and summer rainfall. Drew and Hooper's (1983) explanation in terms of the absence of larval hosts on Mt. Glorious is equally unsatisfactory. In late summer and autumn many of the rainforest trees fruit prolifically at 700 m altitude, some of them being susceptible to minor infestation by *D. tryoni* and *D. neohumeralis* (May 1953, 1957). More important, however, Golden Delicious apples in Mt. Glorious orchards ripen each year at this time and unprotected fruit is usually free from infestation. These major pest species are almost entirely dependent on exotic cultivated fruits south of the 19th Parallel of Latitude in eastern Australia (Courtice and Drew 1982).

Temperatures remain favourable for fruit fly activity on Mt. Glorious until approximately the middle of May. Food for egg production by adult fruit flies remains the variable in need of further consideration. This food requirement has been investigated primarily in relation to diets for laboratory colonies. The possibility that a shortage of adult food may influence fruit fly numbers in the field has not been investigated (Bateman 1972). Wild fruit flies have been reported

feeding on a variety of natural products, but a high protein diet commensurate in supply with the prolific egg production observed in multi-voltine pest species of the Dacinae has not been identified.

Much work has been done on fruit fly attractants, but the connection between response to these substances and the fruit fly's search for food is seldom made. Bateman (1972) treated "food" and "attractants" under different headings. Gow (1954) noted the urgent need for a more powerful attractant for females of the Oriental fruit fly, *Dacus dorsalis* (Hendel) and for flies of both sexes of *D. cucurbitae* and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) [sub-family Trypetinae]. Neither *D. dorsalis* nor *D. cucurbitae* occur yet in Australia. Gow found that specific bacteria in the genus *Proteus* (Enterobacteriaceae) which he cultured in soy bean extract were highly attractive to these major pest species of fruit fly. Despite the fact that hydrolysed yeast protein (Steiner 1952) is the major ingredient in baits applied to orchard foliage for fruit fly control in most parts of the world, the connection between the attractancy of *Proteus* bacteria and food or other fruit fly requirements has not been further investigated. Similarly ammonia has long been used in some fruit fly lures (Perkins and Hines 1933), but even in very recent work (Bateman and Moreton 1981) the biological significance of its attractancy has remained obscure.

Gow's work was not continued and later research has been dominated by the theory that fruit flies obtain their reproductive food requirements from aphid honeydew (Hagen 1958, Neilson and Wood 1966, Bateman 1972). Recent work, however, on the feeding behaviour of *Anastrepha fraterculus* (Wiedemann) [sub-family Trypetinae] in Brazil (Malavasi *et al.*, 1983), has shown that honeydew is not a major food source for this species. Indeed the majority of the world's Tephritid fruit fly species occur in the humid tropics and sub-tropics where sooty moulds rapidly cover all homopterous secretions. The honeydew theory goes hand in hand with the theory that bacteria found in the alimentary tract of fruit flies are symbiotic. There is a large literature on the subject (Hagen 1966, Bateman 1972, Rossiter *et al.* 1982) all following Petri's (1910) interpretation of bacteria found in the oesophageal bulb of the olive fruit fly, *Dacus oleae* (Gmelin).

Although Dacine pest fruit flies occur through all but the Neotropical warmer latitudes of the world, most population studies have been carried out in Australia. It is a significant weakness of these studies that, apart from some use of sweep nets by Fletcher (1973), they have relied on data provided by the use of lures which attract only sexually mature males during seasonal periods of sexual activity. Furthermore until very recently (Drew and Courtice, in prep.) the biological significance of these lures has not been understood.

The movements of sexually mature flies have become comparatively well known. They primarily seek larval host material for their progeny and congregate in appropriate areas. Using traps (Steiner 1957) baited with cuelure (4-[p-acetoxyphenyl]-2-butanone) Courtice (unpubl. data) has repeatedly observed some

congregation of mature male *D. tryoni* and *D. neohumeralis* in peach orchards where there is ripening fruit; such congregation occurs at the expense of adjacent areas without ripening fruit. The females are readily observed among the ripening fruit. Fletcher (1973) has made similar observations at Wilton south of Sydney and the subject is well documented (Bateman 1972). In the absence of larval host material, Fitt (1981) has shown congregations of the univoltine *D. opiliae* in "dry season refuges" along forested water courses of the Northern Territory.

However the movements and congregations of teneral (immature adult) fruit flies have received little attention. They are known to disperse soon after emergence from the soil (Bateman 1972) and require food for maturation (Christenson and Foote 1960) but neither has this food been identified nor has the pattern and scale of migration been studied.

This paper presents new data on the seasonal abundance of several species of fruit fly, contradicting some aspects of current theory. Initially these data were collected in the course of observations on leaf diseases of stone fruits in the humid climate of Mt. Glorious (Courtice 1982a).

Observations on the phenomena of "succession" (Ruinen 1961) and "antagonism" (Baker and Cook 1974, Blakeman and Fokkema 1982) among leaf surface micro-organisms provided an indispensable background against which the present study was initiated. Although current observations are not pertinent to the present work, the two horticultural problems of fruit fly outbreaks and summer defoliation of stone fruits have proved to be the outcome of the same sequence of leaf surface microbial events.

MATERIALS AND METHODS

This work was carried out at Mt. Glorious (27°20'S, 152°46'E, altitude 700 m in the D'Aguilar Range of south-east Queensland. At its southern limit the suburbs of Brisbane extend to the base of this range, the upper levels of which are covered by open eucalypt and rain forests. There are some residential areas and small farms on fertile basaltic loams at Mt. Glorious. The principal experimental site was located in orchards in a rainforest clearing. This clearing occupies an isolated 20 ha plateau standing 1 km east of the main range at Mt. Glorious. Temperatures at the experimental site were measured 1 m above the ground in the total shade of a large tree on this plateau. The daily maximum temperature is normally 4-7°C lower than that recorded on the coastal plain below.

Protein bait trapping

The undersides of the leaves of a section of one grapefruit tree and one sweet orange tree were sprayed with a commercial preparation of hydrolysed protein (Roche-Maag Ltd., Sydney) [11g solids/1] plus maldison as emulsifiable concentrate [11.4g/1]. Beneath the sprayed leaves of each tree a sheet of unbleached

calico of area 2 m^2 was spread. In spring 1982 these two traps were set up early in the morning of 4 September following the observation of very large numbers of *D. tryoni* and *D. neohumeralis* in a row of grapefruit trees on the previous day. On 3 September temperatures on the plateau had considerably exceeded the flight threshold of 20°C (Drew and Hooper 1983) for these species for the first time that season. In spring 1983 the same traps were set up in advance of temperatures permitting fruit fly activity at Mt. Glorious. In both years the spray was repeated at weekly intervals, or more often if rain in excess of 25 mm fell, in accordance with conventional horticultural practice for fruit fly control. During a period of dry westerly winds in October 1982 this routine was varied and foliage sprayed twice daily for five days. All fruit flies collected on the calico sheets were identified, counted and sexed. From 14 September 1983 most collections were preserved in 50% ethanol to faciliate examination of the sexual organs.

Cuelure trapping

In mid-winter 1980 four traps each consisting of a horizontal 1 l cylinder of clear perspex with entrance funnels at each end (Steiner 1957) housing a wick impregated with 4 ml cuelure + 1 ml 50% w/v dichlorvos insecticide concentrate were set up to monitor adult male numbers of those species which respond to this lure. The traps were suspended in the shade in orchard and rainforest trees approximately 200 m apart on the plateau. They were emptied daily at 700 hrs or less often when fruit fly activity was low. The traps were maintained all the year round during the period of the experiments. Occasionally in summer traps were also maintained for periods of a few weeks on Maiala Creek and on Cedar Creek above Greene's Falls at 140 m and 110 m respectively below the elevation of the plateau. All flies collected were identified and counted.

Mark and re-capture experiment

On 13 November 1980, 250,000 pupae of a laboratory strain of *D. tryoni* were placed in ten 3-l plastic *jardinières*. 5 cm of sawdust mixed with rocket red fluorescent pigment (Dayglo Color Corp., Cleveland, Ohio) at the rate 10 g pigment/70 g sawdust was poured on top of the pupae. The *jardinières* were then suspended above head height from trees in dense eucalyptus forest at 100 m elevation below the eastern lip of the plateau. 1 cm wire mesh prevented interference by birds and a sticky ant barrier (Rentokil Ltd., Sydney) was smeared on the suspending wire. Many twigs were inserted through the wire mesh to enable emerging flies to climb free from their fellows and so avoid death by crowding. At emergence the flies take pigment into their head cavity on retraction of the ptelinum, a balloon-like membrane which expands to break open the pupal case. The heads of re-captured flies are squashed in acetone. When it is present the pigment fluoresces under ultra-violet light. In addition to the four cuelure traps on the plateau at Mt. Glorious, 30 were set up along watercourses leading from the base of the range below the release point 25 km into the suburbs of

Brisbane. Four traps were set up on England Creek on the western side of the D'Aguilar Range to monitor flies that crossed the range.

Mulberry feeding observations

D. tryoni were hand collected while they were feeding on mulberry fruit in the field. They were held in glass containers, fed on brown autolysed yeast, and the time taken for the blue-purple colour of the fruit to cease in their droppings was noted. Ripe mulberry fruit were presented to caged *D. tryoni* in the laboratory. Their behaviour was observed and the time taken for blue-purple colour to appear in their droppings was noted.

Micro-organism feeding trials

Bacteria and yeasts were isolated from leaf surfaces and from the crops and stomachs of field collected fruit flies, and cultured on agar in the laboratory. Various preparations of these micro-organisms were then fed to caged *D. tryoni* and *Dacus cacuminatus* (Hering). The egg production and longevity of these fruit flies was then noted in comparison with the performance of flies fed on the conventional laboratory diet of autolysed yeast protein. This work is being presented as a separate paper (Drew *et al.*, 1983) although some of the results are referred to in the discussion below.

RESULTS

Protein bait trapping

A variety of insects were collected on calico sheets spread beneath baited citrus foliage. Eight species of Dacinae were represented, and one species, *Rioxa pornia* (Walker), of the Tephritid sub-family Trypetinae. Among other Diptera the families Lauxaniidae and Drosophilidae were well represented. On two occasions in spring 1982 the diversity of each day's collection was completely overshadowed by the appearance of extremely large numbers of Dacine fruit flies. These events coincided with north-west winds and temperatures on the plateau well in excess of the Dacine flight threshold of 20°C. The fruit flies were so numerous and so much confined to certain citrus trees irrespective of the presence of bait, that they assumed the character of discrete swarms. The swarm in the citrus orchard on 3 September 1982 may have comprised over 30,000 individuals. Although there was some flight from leaf to leaf and tree to tree, most individuals were preoccupied with feeding behaviour on fruit and leaf surfaces. The orchard stands in an open kikuyu grass paddock and continuous observation from the time of their arrival at about 1000 hrs through until dusk left little doubt that their sole source of food on that day lay on these fruit and leaf surfaces. Scale insects and aphids were absent. The presence of baited foliage did not appear to influence the distribution of the swarm, indicating that food as acceptable as hydrolysed yeast protein was generally available.

The disappearance of neither swarm in spring 1982 coincided precisely with adverse weather conditions, although from 7-25 September 1982 daily maximum temperatures were well below flight threshold, falling as low as 10.5°C on 22 Sepember. The second swarm occurred under similar conditions on 27 September 1982. Five millimetres of rain fell in a thunder shower that afternoon, followed by a dry south-west gale early on the following day. Despite favourable temperatures on 29 September the swarm was not seen again. Many of the flies collected on the calico sheets during the 1982 swarms were apparently sexually immature, as their undeveloped abdomens collapsed shortly after death. A total of 107 mm of rain was well distributed throughout September 1982. The results for this season are presented in Tables 1 and 2. Cuelure catches for the same day are given for comparison. Since the traps and sheets are cleared at 700 hrs, flies collected are always recorded as belonging to the previous day.

In winter 1983, 904 mm of rain were recorded at the experimental site for the period May-August compared with 169 mm in the same period in 1982. Only one swarm, on 14 September, was observed in spring 1983, followed by a thunder storm from the north-west at 300 hrs on the following day. Mt. Glorious was then engulfed in cloud above 600 m until a cool south-easterly change at 700 hrs caused temperatures to remain below flight threshold for several days. The swarm, however, disappeared late in the afternoon of the same day that it had arrived, more than 24 hours before the cool south-easterly change. Temperatures of 23-25°C, corresponding with 28-32°C on the coastal plain, occurred several times but no second swarm appeared. High temperatures on 3-4 October

TABLE 1. Total numbers of *Dacus tryoni* (Froggatt) plus *Dacus neohumeralis* Hardy and *Callantra aequalis* (Coquillett) collected at two protein bait traps and four cuelure traps at Mt. Glorious, August-September 1982. The protein bait traps were not set up until first light on 4 September.

Date	Daily Maximum T°C	Two Protein Bait Sheet Traps	Four cuelure traps	
			D. tryoni plus *D. neohumeralis*	*Callantra aequalis*
30 Aug.	18	—	0	0
31	19	—	6	6
1 Sep.	19.5	—	8	4
2	20	—	2	10
3	23	—	170	13
4	22.5	75	55	2
5	17	4	9	0
6	20.5	41	18	6
7	14	0	0	0
26	21	6	35	5
27	26	507	49	26
28	20.5	2	0	0
29	21	0	11	1
30	12	0	0	0

TABLE 2. Total number by sex of fruit flies collected at two protein bait and four cuelure traps at Mt. Glorious on 26th and 27th September 1982.

Trap	Species	No. males	No. females
Cuelure	*C. aequalis*	31	0
	D. absonifacies	5	0
	D. choristus	1	0
	D. neohumeralis	32	0
	D. tryoni	46	0
Protein on sweet orange	*D. neohumeralis*	92	57
	D. tryoni	52	39
Protein on grapefruit	*D. choristus*	1	0
	D. neohumeralis	86	49
	D. tryoni	73	64

1983 were terminated by cold wet weather for nine days during which temperatures on the plateau did not reach flight threshold. Very small numbers of fruit flies were collected after the resumption of favourable conditions on 14 October. A total of 26 mm of rain were recorded at the experimental site in September 1983 and 118 mm during the nine days commencing 5 October 1983. Results for the 1983 season are presented in Tables 3 and 4 and include the results of dissections to examine reproductive organs. Females were classed as mature if most or all of the 40-42 ovarioles which comprise each ovary contained an egg. Dissection also permitted examination of the crop and stomach which were a deep purple-blue colour when the fly had recently fed on ripe mulberry fruit surfaces. Mulberries ripen in Brisbane from the beginning of September, but not until the second half of October on Mt. Glorious, so that flies with blue-purple matter in their stomachs (Tables 3 and 4) were very recent arrivals. During the 1983 collections on the plateau, the nearest mulberry tree with ripe fruit was 2.4 km away and 350 m below the elevation of the experimental site. The range of occurrence and larval host fruits of all fruit flies collected are described by May (1963).

Feeding swarms of a small fly in the family Lauxaniidae (Queensland Department of Primary Industries Entomology Collection) were observed on several occasions in spring 1982 and 1983 and they were caught in very large numbers on the calico sheets. These Lauxaniid swarms persisted for several days and although they shared the coherence of the Tephritid swarms, they lacked the dramatic appearance and disappearance characteristic of the latter.

Cuelure trapping

Figure I shows cumulative numbers of *D. tryoni* plus *D. neohumeralis* caught in four cuelure traps during three spring-summer seasons. These two species use exactly the same range of fruits for their larval hosts (May 1953, 1957). Some daily results of cuelure trapping in spring 1982 and 1983 are given in Tables 1

and 3, although it should be noted that catches of *D. tryoni* and *D. neohumeralis* at this time are small compared to summer catches (November and December) while summer orchard fruits are ripening. During the wet season (January-March) each year numbers of these two major pest species decline rapidly. *Dacus bryoniae* (Tryon) and *Dacus choristus* (May) generally appear in increasing but still small numbers in autumn when the wet season has passed, although after a very wet winter *D. bryoniae* was relatively abundant in spring 1983. *Callantra aequalis* apparently has a lower flight threshold than the *Dacus* species observed and was caught consistently throughout all seasons whenever temperatures permitted. Cue-lure catches in dense rainforest on Maiala Creek and Cedar Creek at Greene's Falls indicated a heavy traffic of fruit flies along these water courses. Catches in these traps in January were often 4-10 times greater than catches on the plateau, probably indicating a downstream movement from suburban gardens on the main ridge of the D'Aguilar Range at Mt. Glorious.

Mark and re-capture experiment

The winter-spring dry season of south-east Queensland varies greatly in its intensity from one year to another. Spring 1980 was exceptionally dry and no rain was recorded at the experimental site in September that year. Light falls averaging 3 mm fell on eight occasions in October before the dry season broke on 25 October with a fall of 178 mm. Of the 125,000 male *D. tryoni* released on 8 November 1980, 123 were re-captured in the four cuelure traps on the plateau above, only 200-300 metres distant from the release point. One hectare of early season peaches on the plateau were ripe enough to attract attention from fruit flies. Nevertheless 2,127 marked flies, or 95% of all recaptures, were taken along water courses below the release point. The temporal pattern of recaptures indicated that the majority of marked flies passed 25 km down these water courses and dispersed into the suburbs of Brisbane within 3 weeks of emergence. A few were caught along the same water courses up to five months later. Only 3 marked flies were taken in the western drainage system on England Creek. Teneral flies do not respond to cuelure. No method for monitoring their movements was available in 1980 and it is assumed that the pattern of mature adult recaptures reflects the earlier movement of tenerals. Those recaptured on the plateau may be regarded as those that did not migrate at all. (cf. Fletcher 1974).

Mulberry feeding observations

D. tryoni caught by hand on ripe mulberry fruit continued to pass blue-purple droppings for five hours. When ripe fruit was presented to caged *D. tryoni* blue-purple droppings appeared after two hours. The flies do not puncture the fruit. Soft fruits such as raspberry and mulberry are susceptible to leaching, especially just prior to harvest (Tukey 1971). In both cases the flies regurgitated blue-purple liquid in a series of drops on the side of the jar or cage. After 30-60 minutes had elapsed they returned to re-ingest these drops. This was followed by further regurgitation by the same fly. The process was repeated several times.

TABLE 3. Numbers of Dacine fruit flies collected at two protein bait traps, and four cuelure traps at Mt. Glorious in Spring 1983. After 13 September the number of flies containing blue mulberry dye (B) are given in parentheses. (1) *Dacus absonifacies* (May), (2) *Dacus bryoniae* (Tryon), (3) *Dacus neohumeralis* Hardy, (4) *Dacus tryoni* (Frogatt) and (5) *Callantra aequalis* (Coquillette).

Date	Daily Max. T°C	Protein Bait	Cuelure 1	2	3	4	5
31 Aug	17	0	0	0	0	0	2
1 Sep.	16.5	0	0	0	0	0	4
2	17	0	0	0	0	0	4
3	18.5	0	0	0	0	0	6
4	19.5	0	0	0	3	1	29
5	18.5	0	0	0	0	0	1
6	19.5	0	0	0	0	0	12
7	22.5	0	0	0	8	4	24
8	25	12	0	0	9	8	19
9	20	1	0	0	1	1	0
10	17	0	0	0	0	0	0
11	18	0	0	0	1	3	0
12	20.5	0	0	0	0	4	2
13	23	7	0	0	5	3	3
14	25	110(4B)	0	2	12	25	14(5B)
15	20	6	0	0	2	13	2
16	17.5	0	0	0	0	0	0
17	14	0	0	0	0	0	0
18	16.5	1	0	0	1	4	0
19	18	0	0	0	0	0	0
20	20.5	3	0	0	0	0	6
21	24	0	0	6	5	3	17
22	20	0	0	0	1	5	0
23	23	4	2	14	7	8	12(4B)
24	25.5	4	1(1B)	28(1B)	7	7	11(3B)
25	18.5	2	0	0	0	2	0
26	16	0	0	0	0	0	0
27	16.5	0	0	0	0	0	0
28	20	4	0	0	0	1	0
29	22	0	1	5	6	2	3
30	23	0	3	6	2	2	6(1B)
1 Oct.	19	0	2	6	1	4	0
2	22.5	0	2	4	1	1	5(3B)
3	23	1	3	4	4	2	4
4	25.5	5(2B)	0	3	4	10	6(1B)

DISCUSSION

In the course of two spring seasons three large swarms of fruit flies were observed at Mt. Glorious. On each occasion, despite favourable temperatures and ripe citrus fruit, the swarm disappeared as suddenly as it had arrived. This phenomenon has not been observed before in the Tephritidae. Under uniform conditions male and female *D. tryoni* each take the same time to reach sexual maturity (Drew 1969). Thus the swarms, being composed of mature males and predominantly immature females, could not have resulted from a peak emergence period during exceptionally hot weather. The seasonal sequence of larval host

TABLE 4. Total numbers of fruit flies of each sex indicating both mature and immature forms collected at two protein bait traps at Mt. Glorious on various dates in Spring 1983. Flies were preserved in spirit and flies containing blue mulberry dye are indicated (B).

Species	Date	Immature ♂	Mature ♂	Immature ♀	Mature ♀
D. halfordiae	14 Sep.	0	0	1	1
D. neohumeralis		0	31(1B)	17	9(1B)
D. tryoni		0	26(1B)	16	8
C. aequalis		0	0	1(B)	0
D. halfordiae	23 Sep.	0	0	0	1
D. neohumeralis		0	1	0	0
D. tryoni		0	1	0	1
D. neohumeralis	24 Sep.	0	0	0	1
D. tryoni		0	1	0	0
D. neohumeralis	25 Sep.	0	1	0	0
D. tryoni		0	0	0	1
D. tryoni	3 Oct.	0	0	0	1
D. tryoni	4 Oct.	0	2(1B)	1	2(1B)

fruits for *D. tryoni* and *D. neohumeralis* in the Brisbane region has been described by Drew and Hooper (1983). Fruit flies in the 1982 swarms most likely emerged under loquat and mulberry trees respectively, and those in the 1983 swarm under loquat trees. Both fruit trees are numerous on the coastal plain below Mt. Glorious. Thus, although it is probable that the majority of fruit flies in each swarm emerged under one kind of fruit tree, some deliberate aggregation of mature males and immature females must have taken place to permit their arrival together on the plateau by 1000 hrs. The swarms coincided with short periods of increasing and above average temperatures. The absence of immature males in the swarm is noteworthy, and the presence of some mature females requires comment. There is little doubt that these females had been mated well before the day of the swarm. They occur in protein bait catches in small numbers throughout the season, always in roughly the same proportion to the number of males caught in cuelure traps. It is therefore suggested that mature females caught on the same day as the swarm were local flies already present on the plateau. The precise definition of sexual maturity may require further attention.

During studies on summer defoliation of stone fruit trees by fungal pathogens, Courtice (1982b) proposed that fruit flies feed on colonies of bacteria or yeasts which occur early in the seasonal succession of micro-organisms which takes place on the leaf surface. Progress in this succession, from bacteria to yeasts and then filamentous fungi, is governed largely by the age and nutritional status of the leaf (Ruinen 1956, 1961). The nutritional status of foliage generally follows an annual rhythm of accumulation and exhaustion. Whereas accumulation is largely a function of photosynthesis in the leaf and soluble nutrient accumulation in the soil, exhaustion follows growth and fruiting on the one hand, and leaching on the other.

The accumulation of soil nitrogen in regions experiencing a marked alternation between wet and dry seasons has been well documented (Birch 1958, 1959, 1960). Rapid mineralisation of soil nitrogen under a montane (seasonal) rainforest in south-east Queensland has been reported by Ian Fergus (pers. comm.). Mineralisation here takes place in concert with rising spring temperatures which permit fruit fly activity in these mountains and which possibly trigger the assembly and departure of swarms from the coastal plain. Early spring mists and thunder storms which break up the winter-spring dry season occur at the same time. Fergus found an increase from 5 to 230 ppm nitrate nitrogen in Beechmont district rainforest soil following wetting and incubation at 25°C. The bulk of the increase occurred within a few hours.

Loss of soluble nitrogen and other compounds from leaf tissue to the leaf surface, without loss to the soil below, occurs optimally in very light rain or mist (Tukey 1971). These conditions occur almost daily in some spring seasons at Mt. Glorious. Carroll (1981) found that fluxes of dissolved nitrogen on leaf surfaces were high when the tree had been exposed to substantial rainfall (more than 200 mm) during the preceeding two weeks. This condition is perhaps unnecessary at Mt. Glorious where the soil profile normally remains wet throughout the cold winter months. Carroll found that an initial pulse of leaching released dissolved nitrogen into rainwater on the leaf surface, and that important changes in microbial populations on leaf surfaces occur during the transition from a dry to a wet canopy. He estimated that the production of leaf surface micro-organisms in temperate forest was up to 175 kg/ha/year.

Bacteria occupy the first position in the leaf surface succession (Ruinen 1956). Bacterial isolation and subsequent feeding trials (Drew *et al.*, 1983) amply demonstrated that a high nitrogen leaf surface substrate can produce the normal food for Dacine, and perhaps all Tephritid, egg production. Although yeasts provoke little interest, *D. tryoni* fed vigorously on washed preparations of pure cultures of bacteria belonging to the genus *Proteus* (Enterobacteriaceae). Their egg production rose to four times that on a conventional laboratory diet of autolysed protein, and hatch rate rose from 75% to 97%. Longevity remained high on this diet of natural bacteria.

Rapid bacterial growth on a high nitrogen substrate normally entails some loss of ammonia gas. Ammonia and other volatile products of bacterial metabolism enable fruit flies to locate this high protein bacterial food necessary for egg production. Each species of bacterium has a specific profile of volatile metabolic emissions (Lee *et al.* 1979) and each species of fruit fly appears to seek specific bacteria. Thus some fruit flies, such as *D. bryoniae* and *D. choristus,* are more abundant in autumn than in spring on Mt. Glorious. Similarly the banana fruit fly, *Dacus musae* (Tryon), may be restricted to tropical latitudes in eastern Australia by the restricted range of its specific bacterial food. *D. neohumeralis* and *D. tryoni,* both "cuckoo" fruit flies without specific larval host fruits of their own (Courtice

and Drew 1982), differ in their ranges of occurrence in a manner which may prove explicable in terms of different adult food choices resulting from their different centres of evolution. Whereas *D. neohumeralis* inhabits New Guinea and those coastal regions of eastern Australia with most reliable humidity, *D. tryoni,* like the closely related *Dacus aquilonis* (May) of the Northern Territory, is common where an acute dry season prevails for some part of most years.

Whereas leaf surface acidity (pH 6-6.5) generally favours bacterial growth, fruit surfaces are usually more acid (pH 3-4) and provide a suitable substrate for yeasts and fungi (Dennis 1976). The means by which female fruit flies locate their larval host fruits is not yet known. Once the fruit has been discovered, however, female *D. tryoni* and *D. neohumeralis* have been observed "feeding" on the host fruit surface in the same place that the ovipositor is then inserted (Tryon 1889). Norman Jones (pers. comm.) has observed *D. tryoni* "spitting" on fruit prior to oviposition.

We submit that there are two kinds of bacterium used by Tephritid fruit flies. One kind feeds the adult and the other feeds the larvae. Larval food bacteria have been shown to cause fruit rotting (Rossiter *et al.* 1982) and these bacteria may be isolated from the oesophageal bulb of the adult. This small appendage to the oesophagus of Tephritid fruit flies has been illustrated in Drew *et al.* (in press). By means of regurgitation onto fruit surfaces and subsequent oviposition through the droplet of "spittle" observed by Jones, the female introduces these bacteria with her eggs into the host fruit. The events of fruit rotting and egg hatch may be triggered by pH changes in the ripening fruit. Newly hatched larvae tunnel to the centre of the fruit, no doubt spreading bacteria as they go, and then feed their way back towards the outside again. They feed upon bacteria and not, as commonly supposed, upon fruit tissue. The brown bacterial "soup" familiar in infested fruit is always in front of them as they feed, not behind them. It has been demonstrated that these bacteria are retained from the larval stage in the oesophageal bulb of the pupa and are thus passed on to the newly emerged adult (Tsiropoulos 1976). Petri (1910) believed mistakenly that the bacteria found in the oesophageal bulb of adult *D. oleae* were symbionts rather than food for their larval projeny. This belief has persisted (Rossiter *et al.* 1982). Fitt (1983) has fed and raised fruit fly larvae on one such bacterium. The repeated regurgitation and re-ingestion of mulberry juice by *D. tryoni* suggests the means by which the supply of oesophageal bulb bacteria is maintained. Thus the numerous observations of fruit flies feeding on leaf surfaces on the one hand, and fruit surfaces on the other, may be understood.

Bacteria hydrolyse leaf surface proteins for adult fruit flies and fruit tissue proteins for larvae. Drew (unpubl. data) has shown that fruit tissue infested with fruit fly larvae contains at least twice the amount of each amino acid, essential to these fruit flies, as is found in uninfested fruit tissue. Hydrolysed protein is essential in the diet of both larval and adult fruit flies (Bateman 1972, Hagen 1953). The crop and stomach of larval and adult fruit flies is very acid (pH 3)

(Drew *et al.* 1983). The acid conditions not only confirm that bacteria cannot grow in these organs, as symbiotic bacteria would need to do, but also indicate that the flies do not contain proteinase enzymes to hydrolyse ingested protein. Most insect proteinases are active under neutral or alkaline conditions (Gilmour 1961). Fitt (1983) has shown that bacteria that secrete proteinases, when fed to fruit fly larvae, are pathogenic and destroy the stomach wall. Since hydrolysed protein is essential in the diets of both adults and larvae, it seems most likely that these are ingested through a diet of bacteria which autolyse in the acid conditions and release their cell contents into the alimentary canal.

The conditions which promote the growth of leaf surface bacteria at Mt. Glorious are clearly transitory. By mid-summer filamentous fungi become dominant on leaf surfaces of stone fruit trees and foliar applications of inorganic nitrogen are required if susceptible cultivars are not to succumb to pathogens which mark the end point of the succession on these trees. Although ornamental peach trees are very numerous in the Brisbane region, and are always heavily infested by *D. tryoni* and *D. neohumeralis,* increases in fruit fly numbers at Mt. Glorious, following their emergence in January, are usually small (Fig. 1). Both the movement of marked flies away from the mountain and the absence of a second spring swarm after the very wet winter of 1983 suggest that teneral fruit flies migrate towards regions having a recent history of drought and concomitant accumulation of soil nitrogen.

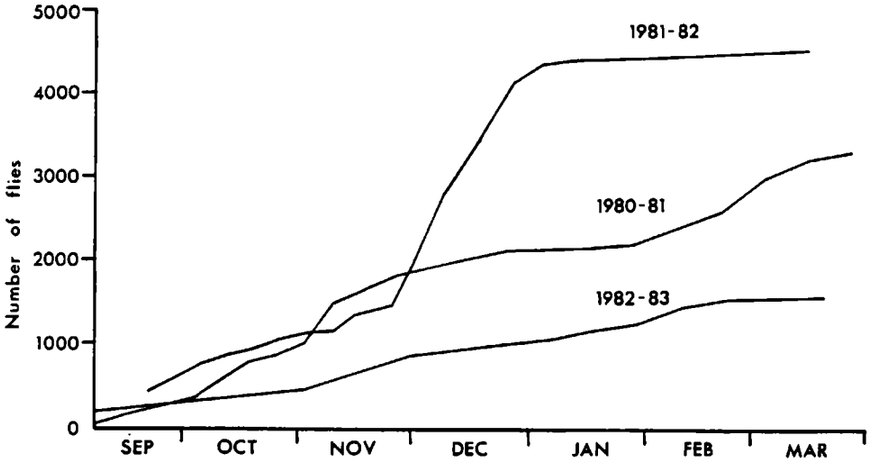

Fig. 1. Cumulative totals of *Dacus tryoni* (Froggatt) plus *Dacus neohumeralis* Hardy caught in four cuelure traps on Mt. Glorious during the 1980-1, 1981-2 and 1982-3 spring-summer seasons.

It is unreasonable to expect multi-voltine fruit flies such as *D. tryoni, D. neohumeralis,* or *D. dorsalis* to be sedentary. Just as the multi-voltine fruit fly relies upon a sequence of host fruits through the season, such species also rely on a sequence of high nitrogen feeding conditions for each cycle of egg production. In the humid tropics leaf surface nitrogen fixing bacteria in the genus *Beijerinckia* are widespread and constitute the principal nitrogen source for tropical rainforest (Ruinen 1956). In Australia, away from affluent suburban conditions where soil and plant nitrogen are sustained at high levels for long periods by artificial means, a high nitrogen leaf surface substrate depends on soil fertility and a prior history of even short-term drought followed by rainfall and humidity (Birch 1958 *et passim.*). Erratic rainfall and disastrous drought are ever-recurring themes over most of Australia (Leeper 1960), and a capacity for long distance migration is characteristic of much of the fauna of the continent.

The repeated occurrence of swarms of the small Lauxaniid fly (D.P.I. Entomology Collection) throughout spring suggested that the brief passage of fruit fly swarms on Mt. Glorious was not immediately related to the exhaustion of their food supply. It is suggested that they moved on as discrete swarms along a migration route to drier places, perhaps breaking up only as the females reach sexual maturity, then to continue individually until larval host fruits are discovered. Fruit flies may travel considerable distances down the western rivers of Queensland and New South Wales (Courtice and Drew 1983, J. R. MacFarlane unpub. data) and may be sustained on these journeys by homopterous secretions in the *Eucalyptus* flora which lines the river banks all the way to South Australia. *Callantra aequalis* frequently appeared on Mt. Glorious early in the day after feeding on the surface of mulberry fruit on the coastal plain a short time before. Although the larval host of this species (May 1957) is confined to rainforests on the eastern side of the Great Dividing Range, one specimen was taken (Courtice) in Autumn 1983 near Goondiwindi, 240 km down the MacIntyre River west of the watershed of the Great Dividing Range. Two specimens of *D. cacuminatus,* almost equally remote from their nearest larval host fruit, were taken at the same place and time. Specimens of *D. cacuminatus* have been collected in male lure traps on the Murray River at Albury, 250 km due west of the nearest larval host plant. Specimens of *Dacus jarvisi* (Tryon) were collected on 6 April 1983 in a station garden citrus tree 400 km south of Katherine in the Northern Territory (Allan Allwood, pers. comm.). These flies were perhaps 500 km from their nearest larval host tree.

CONCLUSION

Adult food for fruit flies occurs on leaf surfaces in erratic supply according to periodic accumulations of soil nitrogen and subsequent conditions which favour the growth of leaf surface micro-organisms. Although it may influence the number of generations in a season (Meats 1981), temperature cannot provide a guide to the size of the resultant population. The East Australian Current, flowing south from equatorial regions at 4 knots, maintains equitable temperatures for fruit

fly activity throughout much of the year in coastal regions of the eastern continent. The temperature extremes which dominate insect life in South Australia are generally absent. Apart, then, from some seasonal regulation of generation times, and given the present-day widespread occurrence of exotic larval host trees together with the fruit fly's capacity for rapid long distance migration, these studies indicate that a food supply for egg production is the factor primarily responsible for fluctuations in numbers of *D. tryoni* and *D. neohumeralis,* the two major pest species in eastern Australia.

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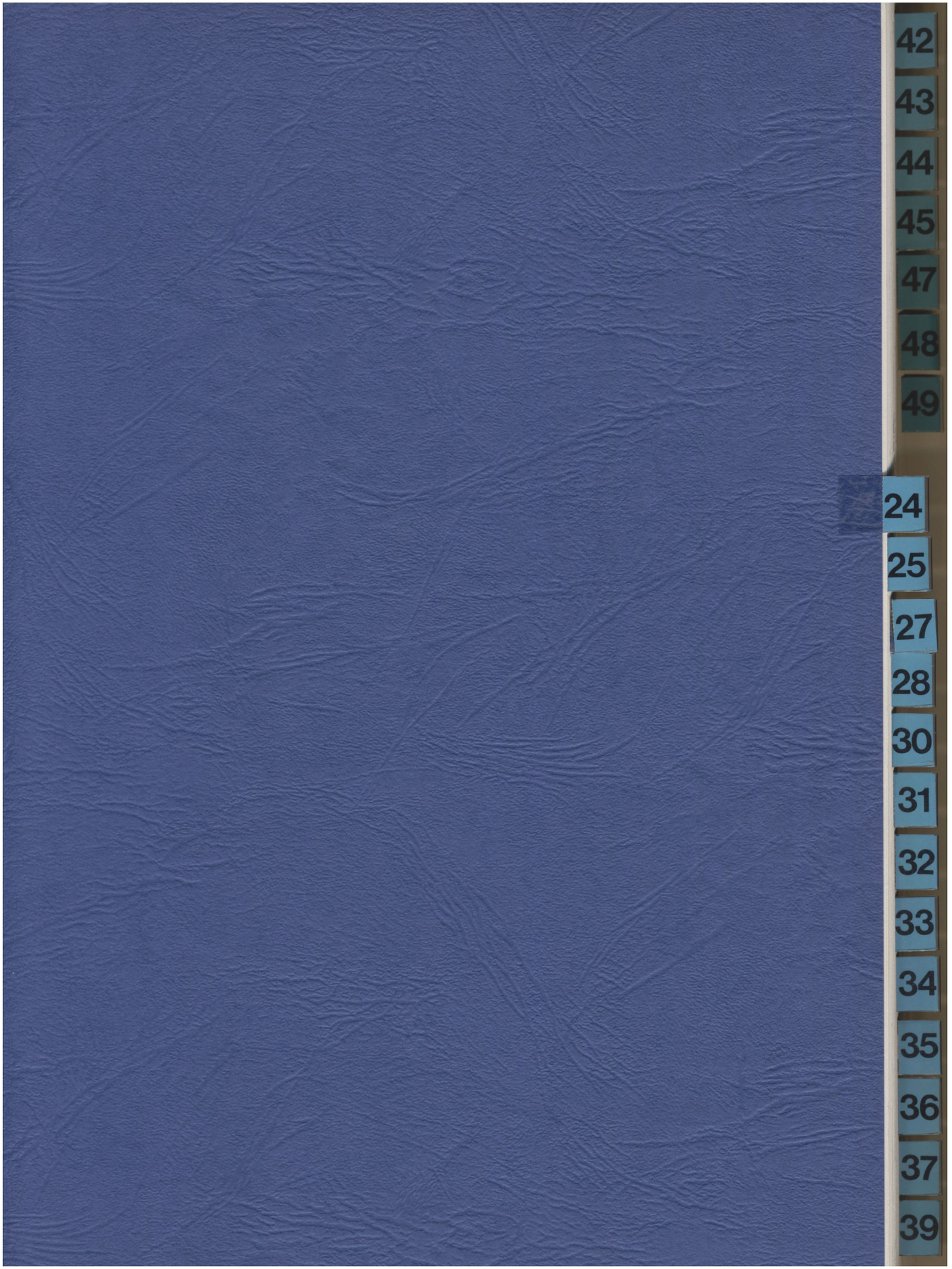
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Ecological studies of Eastern Australian fruit flies (*Diptera: Tephritidae*) in their endemic habitat

I. Temporal variation in abundance

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Abstract. Fortnightly fruit fly captures for a 2-year period at Cooloola (south-east Queensland) contained 11 species. Three species, viz., *D. tryoni*, *D. neohumeralis* and *D. endiandrae* predominated. The peak trap catches of 7 species corresponded with the peak fruiting times of their major hosts. There was no direct relationship between temperature and rainfall and the variations in population numbers. The host plants of some species do not grow in the Cooloola area and there is evidence that large numbers of flies migrate into the region from other breeding areas up to 100 km away. Pockets of tropical rainforest such as Cooloola could be important adult fruit fly feeding areas even in the absence of larval host plants.

Introduction

Ecological studies of tropical fruit flies in Australia have been confined primarily to cultivated orchard situations (Sonleitner and Bateman 1963; Bateman 1968; Fletcher 1973, 1974). Before European settlement, however, most species of Dacinae inhabited the tropical rainforests of eastern Australia (Courtice and Drew, in preparation). In order to understand the factors influencing the abundance of fruit flies, it is necessary to study them in their endemic rainforest habitat.

This paper reports data on the seasonal abundance of 11 species of Dacinae in a rainforest area of south-east Queensland and the relationship of abundance to various environmental factors.

Material and methods

The work was carried out at Cooloola, south-east Queensland (25°58′S, 153°07′E) in an area of rainforest (ca. 2000 ha) surrounded by open *Eucalyptus* forest (Fig. 1), growing on coastal siliceous sand. The climate is sub-tropical, with a high summer and low winter rainfall. While the soils in the area are generally of low fertility, there are realtively high levels of nutrients in the rainforest surface soil (Webb and Tracey 1975).

Fruit fly populations were monitored at 16 sites in the rainforest area and 31 sites in the surrounding open *Eucalyptus* forest (Fig. 1). At each site there were two Steiner traps, one containing methyl eugenol (4 mL + 1 mL 50% w/v dichlorvos concentrate) and the other containing cue-lure (4 mL + 1 mL 50% w/v dichlorvos concentrate). This study was carried out for 2 years starting in June 1976. All traps were cleared of flies at ca. 2-weekly intervals and the lure plus insecticide wicks were changed at 4-weekly intervals. The trapped flies were identified and counted. Concurrently, available fallen fruit was collected and held until fruit flies emerged.

Daily maximum and minimum temperatures, rainfall, wind speed and direction were obtained from the Double Island Point weather recording station adjacent to the study area (Fig. 1).

As lure traps catch only mature male flies and little is known about fruit fly generation times no attempt has been made to calculate rates of population increase. Instead data is presented on the log average abundances (+1) per trap per 2 weeks of the 11 species over 2 years (cf. Wolda 1980). An attempt has been made to correlate trap catches with weather conditions during the intervening 2 week period between each trap clearance (cf. Fitt 1981 b).

Results

During the 2 year study a total of 341799 fruit flies representing 11 species were trapped. Assuming that the lure traps sample all species with equal efficiency then the distribution of flies between the 11 species provides a measure of their relative abundance (Fig. 2). Three species, *Dacus tryoni* (Froggatt), *Dacus neohumeralis* Hardy and *Dacus endiandrae* (Perkins and May), predominated, accounting for 39%, 26% and 23% respectively of the entire catch. The relationship between ln abundance versus rank is approximately linear (coefficient of determination = 0.9716, $F_{1,9} = 307.4$, $P < 0.0001$) indicating a log series distribution (Fig. 2).

The relative overall abundance of species (Fig. 2) is also reflected in the 2-weekly catches/site over the study period. Fruit flies are not equally abundant at all times of the year, rather they display distinct trends in the size, timing and patterns of population changes (Fig. 3a, b, c). Some species abundances are highly correlated with each other (Table 1). *D. tryoni* and *D. neohumeralis* trap catches are highly correlated (Table 1), showing similar levels of abundance (Fig. 3a) and timing of both their population peaks (mid October, 1976 and late September, 1977). Similarly, *Dacus*

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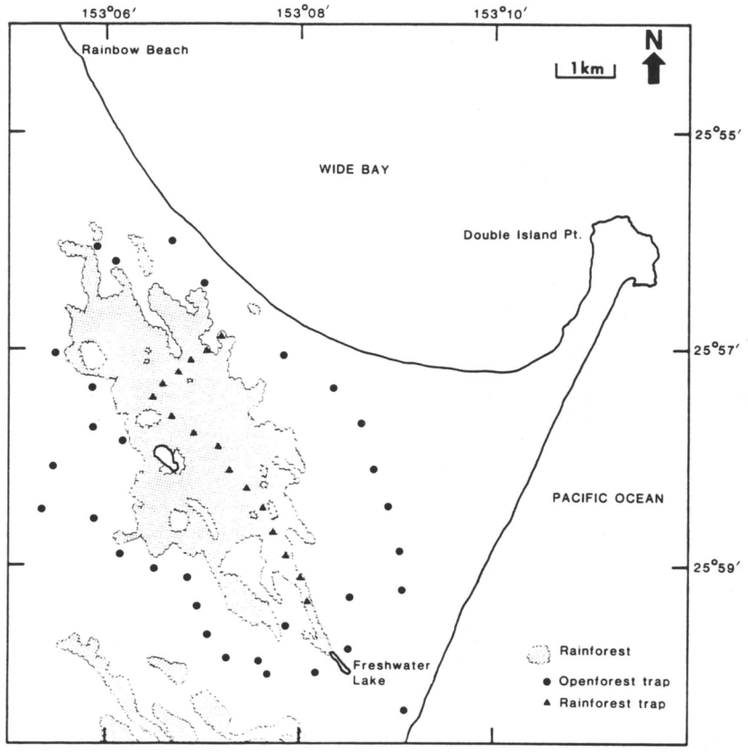

Fig. 1. Study area showing location of trap sites in relation to forest type

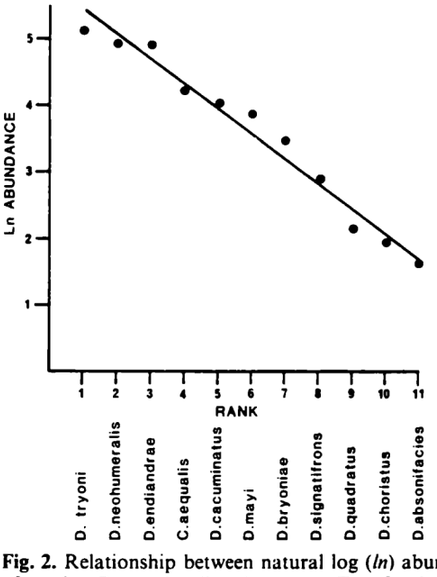

Fig. 2. Relationship between natural log (*ln*) abundance and rank of species. Regression line shown (see Text for details)

cacuminatus (Hering) and *Dacus mayi* Hardy are highly correlated (Table 1) and show similar abundance and timing of population peaks (Fig. 3b). On the other hand although *Dacus bryoniae* (Tryon) and *Dacus choristus* (May) are highly positively correlated (Table 1) and show similar timing of population peaks (Fig. 3c), *D. bryoniae* is much more abundant (Figs. 2, 3c). Similarly *Callantra aequalis* (Coquillett) – *Dacus absonifacies* (May), *D. absonifacies* – *D. mayi* and *Dacus signatifrons* (May) – *D. endiandrae* are positively related (Table 1), have similarly timed population peaks (Fig. 3a, b, c) but have different levels of abundance relative to one another.

Most species, however, are not correlated (Table 1) and show very different levels of abundances and timing of population peaks (Fig. 3a, b, c) suggesting a partitioning of time by fruit flies. Despite these differences it is possible to identify three broad, though arbitrary, types of population dynamics:

(1) Relatively smooth changes in population size;
(2) Jagged, discrete changes in abundance;
(3) erratic changes.

Type 1 species include *D. tryoni*, *D. neohumeralis*, *C. aequalis* and *D. endiandrae* (Fig. 3a) which were caught at all times of the year (except *C. aequalis* for a short time in mid-winter). All species show a rapid increase to peak levels in spring and early summer (September to December). Population levels decline during summer and autumn. Although these species have many smaller population peaks (Fig. 3a) indicating discrete breeding periods, these fluctuations are smaller than those shown for type 2 species. This suggests there is considerable overlap in breeding of type 1 species (i.e. continuous breeding and/or movement) and a range of breeding host plants (Table 4). Type 2 species, *D. cacuminatus* and *D. mayi*, are also virtually present at all times of the year, but show very rapid changes in population size at regular intervals (Fig. 3b) indicating discrete breeding periods with little overlap between generations. Numbers are low in late autumn to winter (April to July) and peak in late summer – early autumn. Type 3 species (*D. bryoniae*, *D. choristus*, *D. signatifrons*, *D. absonifacies* and *D. quadratus*) are rare when present and absent altogether at some time during the year (Fig. 3c). *D. quadratus*,

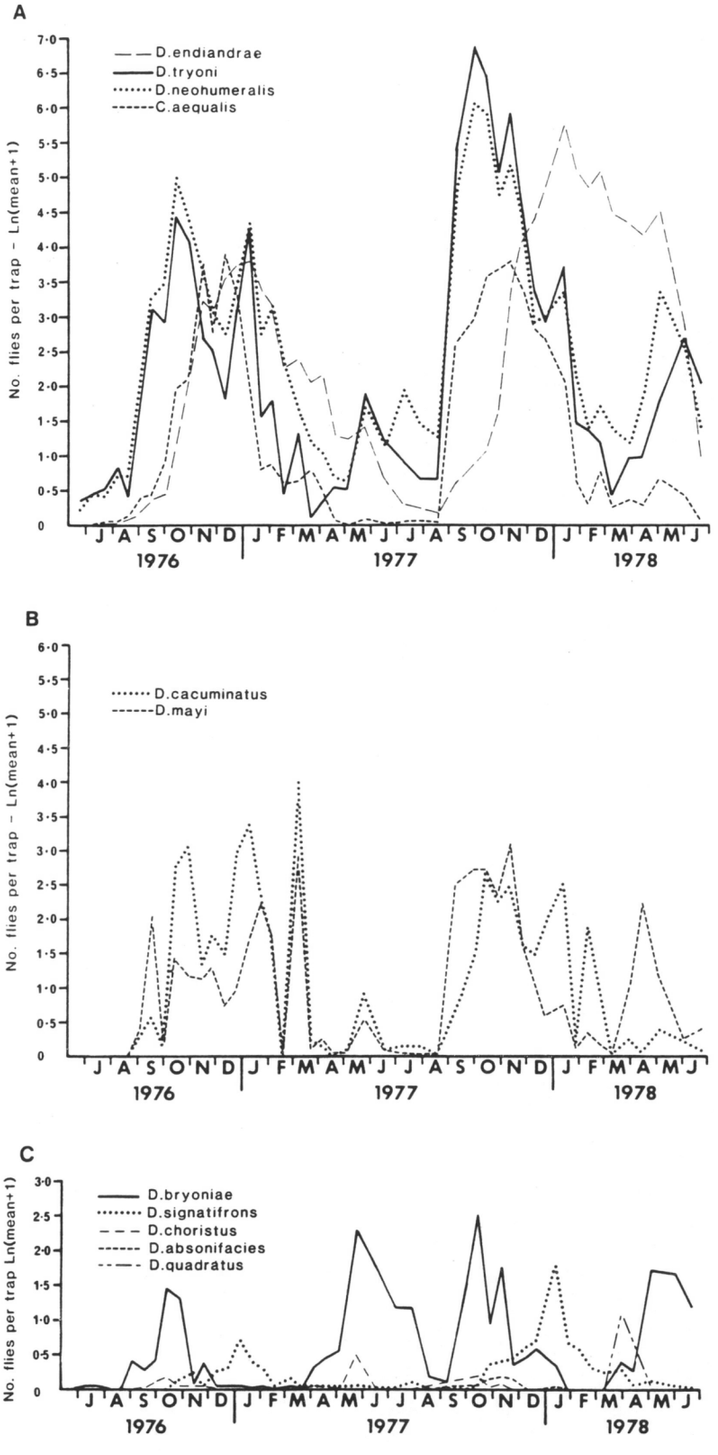

Fig. 3A–C. Log mean abundance (+1) of flies per trap per sampling interval (ca 2 week) for 11 fruit fly species over 2 years. Species have been classified as: abundant, continuously present with "smooth" population changes (**A**): abundant, absent for short periods with discrete changes in abundance (**B**) and rare with variable abundance (**C**)

for example, was only caught for a brief period (March–April) late in the study.

Changes in rainfall and maximum temperatures during each trapping period are shown in Fig. 4. There was no direct relationship between temperature and rainfall and the population sizes of each species (Table 2). In correlating weather conditions with population levels during periods of increase and decrease in population size there was a weak temperature effect on some species (Table 3), but no effect of rainfall.

Host plants are known for 7 of the 11 fruit fly species collected during the study (May 1953). Plants of the Coo-

Table 1. Partial correlation matrix between species abundance levels over a 2 year period

D. neo-humeralis	*D. endi-andrae*	*C. aequa-lis*	*D. cucu-minatus*	*D. mayi*	*D. bryo-niae*	*D. signa-tifrons*	*D. quadra-tus*	*D. chori-stus*	*D. absoni-facies*	
0.941***	−0.187	0.101	−0.017	−0.133	−0.052	−0.071	0.103	−0.373	0.332	*D. tryoni*
	0.281	−0.079	0.02	0.181	0.082	0.044	−0.086	0.334	−0.218	*D. neohumeralis*
		0.631***	−0.156	0.045	−0.061	−0.019	0.184	−0.043	0.115	*D. endiandrae*
			0.148	−0.104	0.038	−0.019	−0.209	−0.039	−0.08	*C. aequalis*
				0.179	0.049	−0.139	0.877***	0.304	−0.034	*D. cacuminatus*
					0.561***	−0.018	−0.205	0.085	−0.212	*D. mayi*
						−0.196	0.027	−0.53***	0.673***	*D. bryoniae*
							0.158	−0.263	0.30	*D. signatifrons*
								−0.202	−0.118	*D. quadratus*
									0.713***	*D. choristus*

*** $P<0.01$

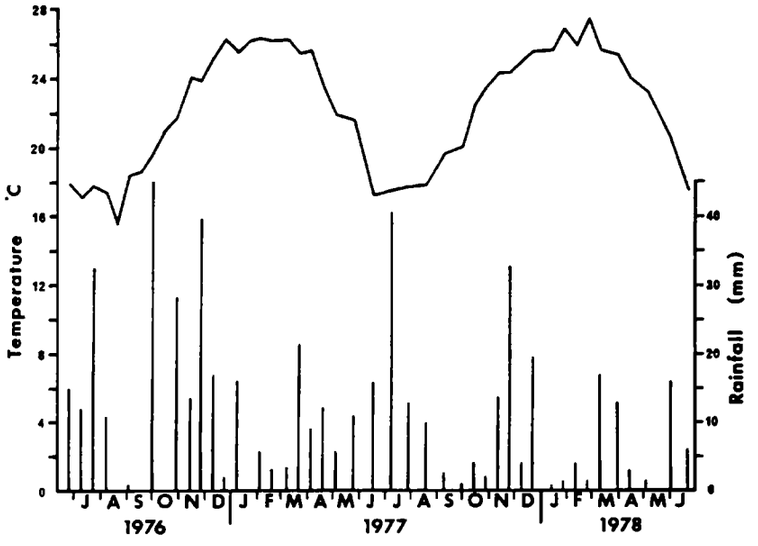

Fig. 4. Mean daily maximum temperature and rainfall recorded at Double Island Point in the period preceeding trap clearance

Table 2. Correlation matrix of species abundance levels against rainfall and temperature

	Temperature	Rainfall
D. tryoni	−0.127	0.041
D. neohumeralis	0.079	−0.068
D. endiandrae	−0.269	0.052
C. aequalis	0.265	−0.022
D. cacuminatus	−0.401**	0.01
D. mayi	0.323	−0.073
D. bryoniae	−0.01	0.444**
D. signatifrons	0.097	0.151
D. quadratus	0.578**	−0.115
D. choristus	0.267	0.318
D. absonifacies	0.076	−0.465**

** $P<0.01$

loola rainforests have been recorded by Webb and Tracey (1975). The fruit fly species, their hosts, host fruiting times and peak trapping times during the study are listed in Table 4. The major hosts of only three species occur in the forest of the study area i.e. *C. aequalis*, *D. endiandrae* and *D. mayi*. May (1953) lists 27 species of rainforest plants as hosts of *D. tryoni*, 9 of these grow in the Cooloola region but 6 comprise incidental host records. The remaining 3 host plant species are recognised as minor hosts. During the 2-year study searches were conducted for fallen fruit on the forest floor. Generally, fruit was scarce but when collected it was held in the laboratory. Only one species was reared – *Dacus halfordiae* (Tryon) from *Schizomeria ovata* D. Don. It appears that fruit fly breeding in the forest fruits in the Cooloola areas is at a very low level.

Discussion

Large numbers of fruit flies (11 species) were captured during the study. Three species, *D. tryoni*, *D. neohumeralis* and *D. endiandrae* predominated in the collections and occurred throughout the year. The other 8 species, *D. bryoniae*, *D. choristus*, *D. signatifrons*, *D. absonifacies*, *D. quadratus*, *D. cacuminatus*, *D. mayi* and *C. aequalis*, occurred in much smaller numbers and could not be captured throughout the year. The flies showed seasonal fluctuations in abundance similar to those recorded for other tropical insects (Wolda 1978, 1979).

Table 3. Correlation of selected species abundance levels against temperature and rainfall during periods of population increase and decrease

	Period of population increase			Period of population decrease	
D. tryoni	24/6/76–13/10/76	Temp.	0.7987**	13/10/76–4/4/77	0.6526*
		Rain	0.2409		0.0461
	18/4/77–29/9/77	Temp.	0.0574	29/9/77–30/3/78	0.9089****
		Rain	0.4422		0.2206
D. neohumeralis	24/6/76–13/10/76	Temp.	0.7958*	13/10/76–4/4/77	0.7143***
		Rain	0.2164		0.0390
	18/4/77–29/9/77	Temp.	0.0510	29/9/77–30/3/78	0.9142****
		Rain	0.4483		0.1914
C. aequalis	19/8/76–10/12/76	Temp.	0.8306**	10/12/76–18/4/77	0.0209
		Rain	0.1242		0.2199
	18/8/77–10/11/77	Temp.	0.9938****	10/11/77–21/6/78	0.0787
		Rain	0.1047		0.5012
D. endiandrae	19/8/76–7/1/77	Temp.	0.9106****	7/1/77–28/7/77	0.5924*
		Rain	0.0604		0.2641
	18/8/77–12/1/78	Temp.	0.6027	12/1/77–21/6/78	0.6304
		Rain	0.0449		0.5222

*$P<0.05$ **$P<0.01$ ***$P<0.005$ ****$P<0.001$

Table 4. The host phenology of some fruit fly species collected during the study (Records from May 1953; Drew and Hooper 1983)

Species	Hosts	Fruiting time	Peak trapping time(s) during study
Dacus tryoni (Froggatt)	*Major hosts*: Loquat[a]	July–August	early August
	Mulberry[a]	October	October
	Peach[a]	December	early January
	Mango[a]	January	early February
	Guava[a]	March–April	March May
	Minor hosts:		
	Syzygium paniculatum (= *Eugenia australis* Wendl. ex Link)	July	
	Acmena smithii (= *Eugenia smithii* Poir.)		
	Notelaea longifolia Vent.		
Dacus neohumeralis Hardy	*Major hosts*: As for *D. tryoni*	'as above'	October
			early January
			early February
			May
	Minor hosts: Some rainforest plants		
Dacus bryoniae (Tryon)	*Diplocyclos palmatus* (L.)[a] (C. Jeffrey)	November–July	April–December
Dacus endiandrae (Perkins and May)	*Endiandra discolor* Benth.	October–March	October–May
Dacus cacuminatus (Hering)	*Solanum mauritianum* Scop.[a]	October–January	October–March
Dacus mayi Hardy	*Planchonella australis* (R.Br.) Pierre	September–October	September–January
	Planchonella pohlmaniana[a] (F. Muell) Pierre ex Dubard	May	
Callantra aequalis (Coq.)	*Marsdenia rostrata* R.Br.	September–April	September–March

[a] Not growing in study area

Some species were highly correlated with respect to the size, timing and patterns of population peaks as represented by trap numbers. This is particularly the case with *D. tryoni* and *D. neohumeralis* which share the same major fruit hosts and have similar ecological characteristics (Lewontin and Birch 1966). However, most species were not correlated with respect to seasonal abundance, showing different periods of peak trap catch. These different types of population dynamics are due to the ecological characteristics of the species (Southwood 1978), their response to weather conditions, host plant phenology and interspecific interactions.

Little is known about the bionomic/ecological characteristics of the Australian Tephritidae. Females oviposit in mature fruits of various host plants. In Queensland some species are polyphagous (e.g. *D. tryoni* and *D. neohumeralis*) and others are more specific (e.g. *D. endiandrae* and *C. aequalis*) (Table 4). In the Northern Territory *Dacus opiliae* Drew and Hardy and *Dacus tenuifascia* (May) have been

shown to be monophagous and probably univoltine (Fitt 1981a, b). The adult flies generally are long lived and have a teneral movement phase (Bateman 1972; Courtice and Drew 1983).

How the ecological strategy of each species influences its characteristic population dynamics is unknown. Some workers have attempted to relate fruit fly abundance to weather conditions and host plant phenology (Fletcher 1973; Drew and Hooper 1983) while Fitt (1981b) suggested that changing lure response with different seasons influences the measured changes in abundance.

Wolda (1980) found peak abundance of tropical insects to be closely determined by rainfall and Bateman (1968) found that moisture was the primary determinant of numbers of *D. tryoni*. Drew and Hooper (1983) stated that the seasonal activity of *D. cacuminatus* was dependent upon temperature, rainfall and the state of development of the host plant. Fitt (1981b) also noted the importance of moisture to populations of *D. opiliae*.

In this study there was no direct relationship between temperature and rainfall and the variations in population numbers of each species. Most authors reporting a direct climatic effect on fruit fly abundance have worked in marginal areas which are not part of the endemic habitat of the flies e.g. south-eastern Australia. In Cooloola, within the endemic range of the species, rain falls throughout the year (Fig. 4) and moisture would rarely be limiting. Thus, at Cooloola, seasonal fluctuations in male fruit fly abundance could result from the influences of other factors such as host plant phenology, immigration and emigration of adult flies, and availability of adult food.

In the case of migration, abundance levels at Cooloola may reflect weather and food conditions elsewhere, in which case we could not expect correlations with local weather patterns.

For the species where the major host plants are known, the periods of peak trap catches generally coincided with the times of fruiting of these hosts (Table 4). The plants of the Cooloola study area are listed by Webb and Tracey (1975). The major hosts of *D. tryoni*, *D. neohumeralis*, *D. bryoniae* and *D. cacuminatus* do not occur within the study area. The closest locality in which the hosts of *D. tryoni* and *D. neohumeralis* grow is the town of Gympie (60 km west), while the hosts of *D. bryoniae* and *D. cacuminatus* grow in the montane rainforests 100 km west and south-west of the Cooloola area. The peak trapping times for these species (except *D. bryoniae*) were 2–3 weeks after the peak fruting times of the respective hosts. This could indicate that the specimens of *D. tryoni*, *D. neohumeralis*, *D. bryoniae* and *D. cacuminatus* captured in Cooloola were primarily the progeny from distant breeding areas that had completed their teneral dispersal phase. The major hosts of *D. endiandrae*, *D. mayi* and *C. aequalis* are recorded as growing in the Cooloola area (Webb and Tracey 1975) although they were not found during this study. These hosts also grow in the montane rainforests 100 km west and south-west. It is probable that for all species of fruit flies collected in the Cooloola area there is a large number of immigrants that have travelled long distances.

Drew et al. (1983) have shown that leaf surface bacteria provide a rich source of nutrients for adult fruit flies. The supply of this leaf surface microflora is variable, and in greater supply in the tropical rainforests after the onset of summer rains. Courtice and Drew (1984) explained that the seasonal abundance of several *Dacus* species in south east Queenland was influenced by the erratic supply of lea surface bacteria which is the natural food source for adul flies. It is possible that rainforest areas such as Cooloo are important adult fruit fly feeding areas even in the absence of suitable larval host plants.

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Ecological studies of Eastern Australian fruit flies (*Diptera: Tephritidae*) in their endemic habitat

II. The spatial pattern of abundance

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Abstract. 11 fruit fly species captured at 47 sites in a natural forest area at Cooloola (south-east Queensland) revealed specific patterns of spatial abundance. Although all species were collected throughout the study area, *D. bryoniae*, *D. mayi*, *D. neohumeralis* and *D. tryoni* were more prevalent (average number caught per trap) in the open Eucalypt forest than the rainforest, whereas *C. aequalis*, *D. absonifacies* and *D. endiandrae* were more prevalent in the rainforest. *D. cacuminatus*, *D. choristus*, *D. quadratus* and *D. signatifrons* were equally prevalent throughout both forest types. Fly numbers were not distributed randomly throughout the trap sites. The clumped dispersion patterns seemed to be species specific as assessed and summarised by Taylor's Power Law. The exponent (b) relating mean spatial abundance to its variance ranged from 1.6–5.11 for the 11 species captured. Changing patterns of trap catches from one sampling period to another were analysed using correlograms for the 6 most abundant species (*D. tryoni*, *D. neohumeralis*, *D. endiandrae*, *C. aequalis*, *D. cacuminatus* and *D. mayi*). These revealed changing patterns of relative spatial abundance which can be related, in part, to changing population abundance levels. The various spatial patterns recognised are related to each species movement, breeding and feeding behaviour. It is proposed that flies migrate into the rainforest area from distant locations and that the rainforest habitat is an important adult feeding site.

Introduction

In Australia, fruit flies of the subfamily Dacinae are endemic to two geographic regions, north-eastern Australia and north-western Australia. Within these regions the flies breed in a range of cultivated and wild fruits (May 1953) and show a capacity to disperse over large distances in a short time (Courtice and Drew 1984). In some species, e.g. *Dacus tryoni* (Froggatt), breeding in host fruits is widespread geographically but still concentrated in 'hot spots' such as cities and towns (Courtice and Drew, in preparation). Breeding in rainforest fruits is limited in both numbers of fruit host species and progeny per fruit, particularly for the pest species such as *D. tryoni*. Even so, a large number of adult flies occurs in these forests at certain times of the year (Drew et al. 1984a) and it has been suggested that these habitats are important adult feeding sites (Courtice and Drew 1983).

This paper reports data on the spatial pattern of abundance for 11 species of fruit flies in a south-east Queensland rainforest area.

Offprint requests to: R.A.I. Drew

Materials and methods

During an ecological study of fruit flies at Cooloola, south-east Queensland, specimens were collected in cuelure and methyl eugenol baited traps (Drew et al. 1984a). The flies were taken from the traps at 47 study sites at regular intervals (ca. 2 weeks), identified and counted.

Analyses of the data were carried out in order to assess the spatial pattern of abundance (see e.g. Jumars et al. 1977; Sokal and Oden 1978; Taylor et al. 1980; Zalucki et al. 1981).

The relationship between log variance of spatial abundance and the log mean was used to detect non-randomness (Taylor and Woiwod 1982). The methods of spatial autocorrelation (Cliff and Ord 1978) were used to detect any pattern in trap catches, whilst principle component analysis (Williamson 1972) was used to identify relationships between trap catches and other site variables.

Taylor and Woiwod (1982) have shown that the spatial distribution of a species is unique and biological in origin, hence random dispersal patterns are rare. For each fruit fly species the following regression was fitted:

$$\log_{10} S^2 = \log_{10} a + b \log_{10} \hat{X} \qquad \text{(Eq. 1)}$$

where $\hat{X}$ and S^2 are the mean and variance of the 47 trap sites calculated for each of 46 sampling periods, b and a are fitted constants. This method ignores the relative spatial location of trap sites. This limitation can be overcome by using spatial autocorrelation methods (Cliff and Ord 1973) which ask the question: Are variant values correlated for sampling sites which are defined to be neighbours? If there is no a priori means of defining neighbours then correlograms may be used. Correlograms are plots of the autocorrelation coefficient versus euclidean distance between connected points. In the calculations, trap catches at each site were treated as an interval variable. Sites were deemed connected if they fell within annuli originating from each site. The radius of the annulus was systematically increased and the autocorrelation statistic (Moran's I) calculated. The weighting given to any connection was made proportional to the inverse of the distance between connected points,

Table 1. Intercept (a) and slope (b) of Taylor's Power Law (±SE) for eleven species of fruit fly. Spatial densities also shown (all regressions significant at the 0.001% level)

Species	$\log_{10}$a	$\log_{10}$b	r^2	Range of densities		N
				$\log_{10}$ min	$\log_{10}$ max	
D. tryoni	0.382 (0.1235)	2.267 (0.073)	0.9552	1.2024	2.2161	46
D. neohumeralis	0.603 (0.1488)	2.021 (0.094)	0.9117	0.9327	2.1831	46
D. endiandrae	−0.038 (0.1579)	2.331 (0.226)	0.8995	0.9465	1.9445	46
C. aequalis	0.029 (0.1937)	2.435 (0.074)	0.9606	0.0565	1.4224	46
D. cacuminatus	0.602 (0.1953)	1.904 (0.238)	0.5869	0.5516	1.0974	46
D. mayi	0.018 (0.1489)	2.490 (0.203)	0.7690	0.4411	0.9118	46
D. bryoniae	−0.130 (0.127)	2.920 (0.112)	0.9380	0.0931	0.7650	46
D. quadratus	−0.066 (0.054)	5.109 (0.316)	0.9066	0.0093	0.1347	28
D. signatifrons	−0.113 (0.124)	3.299 (0.155)	0.9318	0.0093	0.4944	34
D. choristus	−0.030 (0.0207)	2.824 (0.231)	0.8373	0.0093	0.0810	30
D. absonifacies	−0.007 (0.0056)	1.636 (0.130)	0.8877	0.0093	0.0448	21

squared. Such a weighting system assumes flies disperse via diffusion. (Thus, nearby sites are more likely to have similar trap catches than distant sites.) Correlograms were generated for the six most abundant species (*D. tryoni*, *D. neohumeralis* Hardy, *D. endiandrae* (Perkins and May), *D. cacuminatus* (Hering), *D. mayi* Hardy, and *Callantra aequalis* (Coquillett) on almost every sampling occasion.

As we were seeking any underlying spatial structure in the pattern of fly abundance across the sampling sites the results of the correlogram analysis were condensed by classifying populations as either low, increasing, high or decreasing. Correlograms in each category for each species were combined to produce an average correlogram for each population abundance category. Sokal and Oden (1978) present different spatial patterns of variate values and the correlogram type each would generate. To test if wind direction influenced the spatial structure of fruit flies, all connections (maximally connected graph) were weighted by the cosines of the angles the connections made with an hypothesised test direction. By computing autocorrelations for different test directions, any directional trends in the data which might correlate with wind directions were sought (Sokal and Oden 1978).

Principal component analysis was carried out using the Genstat package and provides a means of ordinating the 47 trap sites on the basis of fly species numbers caught over the study. This analysis provides a means of hypothesising relationships between trap sites with similar classifications and other site variables.

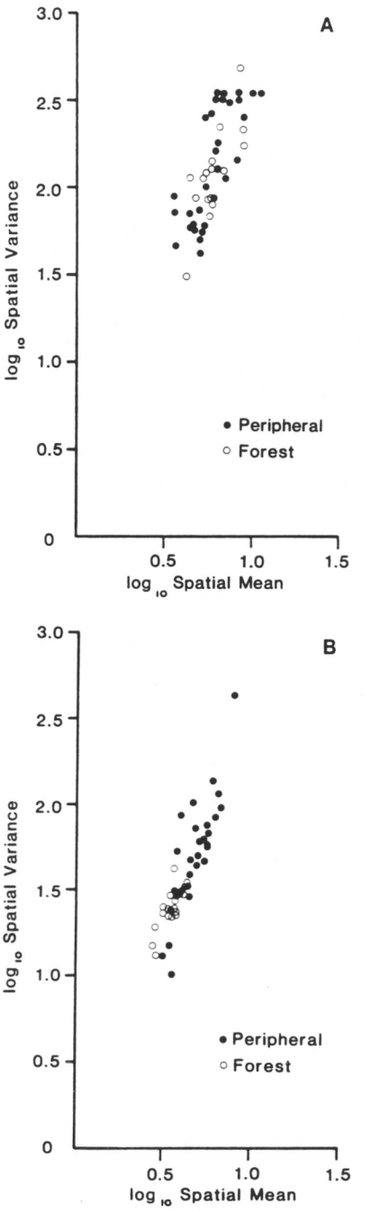

Fig. 1 A, B. $\log_{10}$ Spatial variance plotted against $\log_{10}$ Spatial mean with sites classified in Rainforest (o) or Peripheral (•) for *Dacus cacuminatus* (**A**) and *D. mayi* (**B**)

Results

The log variance of spatial abundance was significantly correlated with the log mean abundance (Table 1). All slopes were greater than 1 (Table 1), indicating non-random clumped dispersion patterns. The dispersion patterns fall into two groups. Abundant species (*D. tryoni*, *D. neohumeralis*, *C. aequalis*, *D. endiandrae*, *D. cacuminatus* and *D. mayi*) had similar b values in the range 1.9 to 2.5. The remaining rarer species were either more clumped with slopes (b) in the range 2.8–5.1 (*D. bryoniae* (Tryon), *D. choristus* (May),

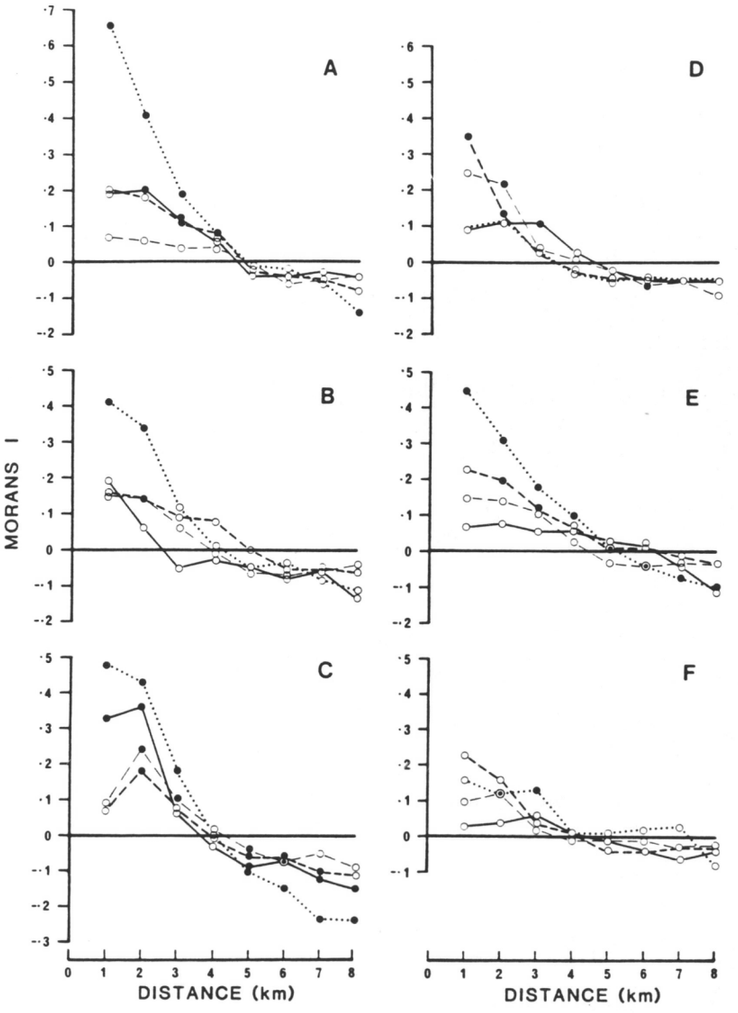

Fig. 2 A–F. Correlogram plots of Morans I versus Euclidian distance between neighbours for 6 common fruit fly species in the Cooloola area: *Dacus tryoni* (**A**), *D. neohumeralis* (**B**), *Callantra aequalis* (**C**), *D. endiandrae* (**D**), *D. cacuminatus* (**E**), *D. mayi* (**F**). Population of each species has been classified as high (....), low (——), increasing (----), decreasing (– – –). Solid symbols (●) indicate significant deviation of Morans I from zero, open symbol (o) no significant deviation from zero

D. signatifrons (May) and *D. quadratus* (May)) or less clumped, b = 1.6 (*D. absonifacies* (May)). The range of characteristic mean sample densities for each species indicated a subdivision of population resource space, with little overlap between the 11 species.

Although most species showed very strong correlations between spatial variance and mean ($r^2 \sim 0.9$; Table 1) two common species, *D. cacuminatus* and *D. mayi*, showed considerably more scatter of points (r^2 of 0.59 and 0.77 respectively). Separating peripheral forest sites from rainforest sites does not account for the scatter. Both site types are intermixed for *D. cacuminatus* (Fig. 1A), whilst *D. mayi* has lower densities in the periphery (Fig. 1B).

The average value for Moran's I is plotted against distance (between connected sites) for the 6 common species (Fig. 2) with populations classified into 4 categories (see Materials and methods). How significantly the average value for Moran's I deviates from a random autocorrelation pattern (i.e. $I \sim 0$) was determined by summing how many of the contributing I values deviated from randomness. If over half were significantly different from 0 then the average was deemed also to differ significantly from 0. Although the pattern of spatial variation showed similarities across all six abundant species, there were sufficient differences for these to be considered separately.

Correlograms for all population abundance categories of *D. tryoni* are similar to the depression pattern of Sokal and Oden (1978). Catches of male *D. tryoni*, when abundance was low, showed significant correlations at distances of 1–3 km, the pattern being random at all other distances (Fig. 2A). Increasing and decreasing populations showed very similar correlograms (Fig. 2A) except increasing populations showed significant correlations at 3 to 4 km (all other autocorrelation coefficients for these 2 population categories were random). During periods of high abundance, trap sites at distances of 1–3 km apart were very similar (significant positive autocorrelation). Figure 3A shows a typical pattern of trap catches during a period of high abundance and clearly shows the depression. Trap catches on the periphery are higher than at the centre, and trap catches nearby are similar.

D. neohumeralis (Fig. 2B) and *D. cacuminatus* (Fig. 2E) showed similar correlogram patterns to *D. tryoni*, except the positive correlation of nearby sites (distances 1–2 km) in *D. neohumeralis* during periods of high abundance is not as pronounced as in *D. tryoni*, whilst *D. cacuminatus*

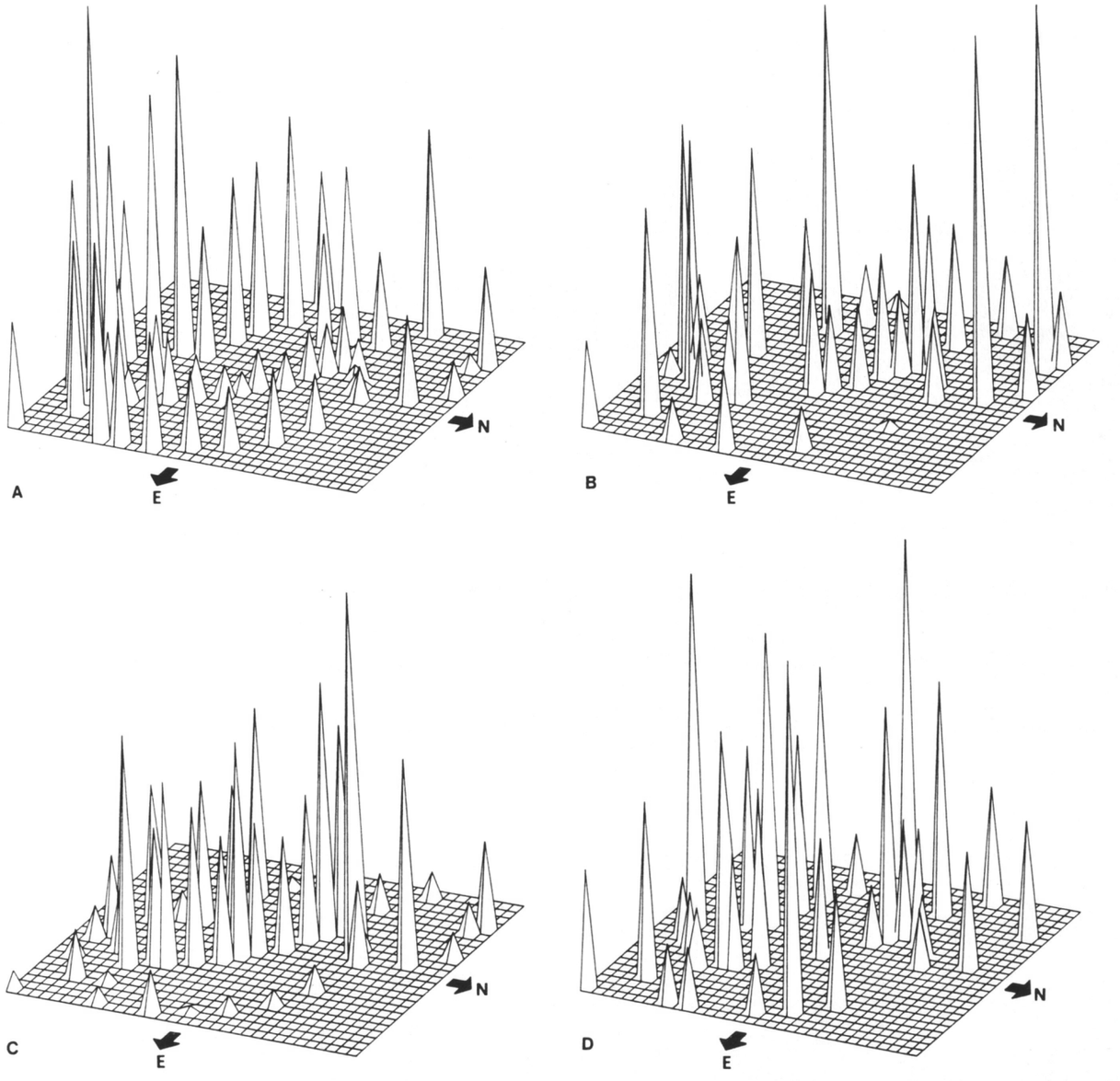

Fig. 3 A–D. Fruit fly abundance on a relative scale recorded at each trap site showing four types of spatial dispersion patterns. **A** Depression pattern for *Dacus tryoni* during a period of high abundance recorded on the 29th October 1977. **B** A random pattern of abundance for an increasing population of *D. neohumeralis* recorded on the 24th May 1977. **C** A reverse depression pattern shown by a high population of *D. cacuminatus* on the 29th September 1977. **D** A random pattern for an increasing population of *D. mayi* recorded on the 13th October 1977

shows a more pronounced depression pattern (significant positive correlation at 1–4 km and significant negative correlation at 6–8 km (see Fig. 3C for a typical reverse depression pattern of abundance). The pattern of catches in both *D. neohumeralis* and *D. cacuminatus* during these periods of high abundance is in fact a reverse depression or hill. The correlograms will be similar to that generated by a depression. For low, increasing and decreasing populations of *D. tryoni*, *D. neohumeralis* and *D. cacuminatus* there was no clearcut significant autocorrelation among trap catches at any spatial scale. Figure 3B shows a typical dispersion pattern during a period of increasing abundance for *D. neohumeralis*.

C. aequalis (Fig. 2C) shows a strong reverse depression pattern at all levels of abundance. This is shown clearly in Fig. 3C for an increasing population. Populations are higher along the central region (rainforest) decreasing to low levels at the peripheral sites.

D. endiandrae (Fig. 2D), unlike the above species, shows a random autocorrelation correlogram during periods of

Table 2. Circular normal statistics for the angular difference between the angle leading to maximal positive autocorrelation among sites and the prevailing wind direction in the period preceding each sample

Species	N[a]	r[b]	ζ°[c]
D. tryoni	37	0.1168^{NS}	16.62°
D. neohumeralis	37	0.1683^{NS}	90.69
C. aequalis	21	0.2151^{NS}	93.18
D. endiandrae	34	0.4631**	31.18^{NS}
D. cacuminatus	20	0.1955^{NS}	17.05
D. mayi	11	0.2832^{NS}	101.07

[a] Number of times a single maximum positive autocorrelation angle could be defined

[b] Mean vector, tested against the null hypothesis of a uniform distribution using Rayleigh's test (see Batschelet 1965)

[c] Mean angle. Need only be tested if the null hypothesis in ([b]) above is rejected. Tested against the null hypothesis that $\zeta° = 0°$

** $P < 0.01$

low and high abundance. During periods of population increase and decrease, significant positive autocorrelation occurs among nearby sites (Fig. 2D).

D. mayi (Fig. 2F) shows a random pattern throughout periods of low, high, increasing and decreasing populations (Fig. 3D).

To determine whether wind had any influence on the pattern of trap catches, we calculated the difference between the angle generating the highest positive autocorrelation among trap sites and the average wind direction in the period preceding the trapping event. If wind direction results in a positive autocorrelation among trap sites then the difference between wind direction and maximal autocorrelation direction would be centred around 0°. We calculated circular normal statistics (Batschelet 1965) for these angular differences. The mean vector (r) measures the tendency of angles to cluster ($r = 0$ coincides to a uniform distribution, whilst $r = 1$ means all angles concide). For 5 out of the 6 most abundant species r did not differ significantly from 0 (Table 2). The exception was *D. endiandrae* which showed a positive association between wind direcion and the direction of positive autocorrelation amongst trap sites. (The mean direction did not differ significantly from 0; Table 2.) A further indication of the lack of any directional tendencies in spatial data was that clear-cut maximum positive (or negative, which was rare) autocorrelations could not be defined for all sampling occasions. The sample size (N) in Table 2 is considerably less than 43 (the number of sampling times when species were reasonably abundant) for most of the species analysed.

The first 3 components of the principal component analysis accounted respectively for 76.8, 15.2, and 7.3% of the variance of numbers of flies caught per site. Trap sites grouped as being similar (lying in the same quadrant of a 3-dimensional plot of the first 3 components) are shown in Fig. 4. Our classification of rainforest sites is largely borne out (9 out of 16 sites were grouped together as being distinct from the peripheral dry sclerophyll sites). Peripheral sites also showed considerable variation. Nearby sites tended to be grouped together (Fig. 4) but there was considerable heterogeneity and sites far apart were also grouped together.

Using our rainforest peripheral classification, we note some species are more abundant in one habitat type than the other (Table 3). *D. absonifacies, D. quadratus, D. endian-*

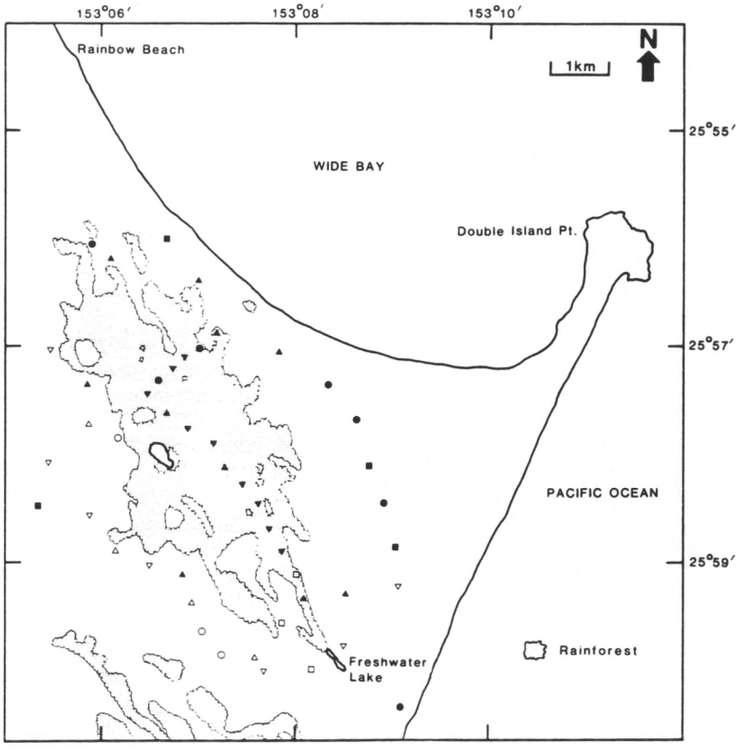

Fig. 4. Cooloola Study area showing trap site location in relation to rainforest and peripheral forest areas. Symbols refer to classification of sites on basis of 3-dimensional plot of the first 3 principal components. Sites with the same symbol have been classified as being similar

Table 3. Average (n ± SE) number of flies caught per trap per sampling interval in rainforest and peripheral forest areas

Species	Trapping area	
	Rainforest ($n = 736$)	Peripheral ($n = 1302$)
D. tryoni	37.04 (3.97)	80.97 (7.20)
D. neohumeralis	36.19 (2.85)	48.86 (3.62)
D. mayi	2.49 (0.179)	3.87 (0.22)
D. bryoniae	0.63 (0.059)	2.00 (0.14)
D. choristus	0.03 (0.008)	0.05 (0.008)
D. signatifrons	0.07 (0.021)	0.50 (0.065)
D. cacuminatus	5.24 (0.433)	5.38 (0.358)
C. aequalis	12.94 (0.947)	6.08 (0.548)
D. absonifacies	0.04 (0.009)	0.01 (0.003)
D. quadratus	0.08 (0.021)	0.06 (0.016)
D. endiandrae	43.41 (3.67)	36.75 (1.96)

drae and *C. aequalis* were more abundant in the rainforest relative to peripheral sites. The remaining species were either caught more frequently in peripheral sites or there was no difference between the two habitats.

Discussion

The major hosts of most species studied (except *D. endiandrae*, *D. mayi* and *C. aequalis*) do not grow in the Cooloola study area and it is most likely that the flies are immigrating in large numbers from breeding grounds 60–100 km west and south-west (Drew et al. 1984a). Early spring swarms of *D. neohumeralis* and *D. tryoni* have been recorded at Mt Glorious (Courtice and Drew 1984). These swarms were found to move from the east coast lowland breeding areas to rainforest areas, feeding en route. While factors influencing the movement of fruit flies are unknown, it is documented that species do move *en mass* over large distances at specific times (Christenson and Foote 1960). Bateman (1972) noted three types of dispersive movements due to different stimuli (a) autumn dispersal due to the disappearance of fruit for oviposition, (b) the commencement of warm weather in spring influencing overwintering adults to disperse, (c) the dispersal of teneral adults.

As a result of recent studies in south-east Queensland, there appears to be a slightly different pattern of movements (a) early spring movement of teneral flies which are the progeny of overwintering adults; this is stimulated by the onset of warm north-westerly winds and is a longdistance movement (Courtice and Drew 1984); sexually mature overwintering adults do not disperse; (b) the disappearance of mature flies from host trees after all fruit has fallen; and (c) the arrival of mature adults at host trees when mature fruit is present. The latter two movements occur intermittently throughout the spring-summer period when different fruit host plants develop fruit (Drew and Hooper 1983). These movements are probably more localised and of much shorter distances than the early spring teneral dispersal. The movements of teneral progenies that are produced during the late spring to autumn season have not been studied.

It is doubtful that the flies that arrive at the Cooloola forest remain there for long periods. It is most likely that they move in and out of the forest and that this habitat is but a segment of their total population range. The large numbers of flies collected in the open Eucalyptus forest surrounding the rainforest must be migrating flies as there are no larval hosts and very limited adult food in this area.

Recent studies on adult feeding (Drew et al. 1983; Courtice and Drew 1984) have shown that certain leaf surface bacteria provide the major source of nutrients for developing flies and that the rainforest areas are very important sources of this food supply. The Cooloola rainforest would probably be a satisfactory feeding site for adult flies and as a result this habitat would play an important role in the life system of the fly populations. The absence of major larval host fruits in the study area means that it is not an important breeding ground and this lends further weight to its importance in adult feeding.

The flies do not treat the peripheral forest and rainforest as a homogeneous unit. Spatial variance was much greater than the mean, indicating clumped dispersion patterns. This presumably reflects interactions between the flies' movement behaviour and their feeding resource base. Taylor and Taylor (1977, 1979) and again Taylor (1981) suggest that a species dispersion pattern is unique and reflects a spatial behavioural solution to competition both within and between species. Certainly, if as we suggest, all the fruit fly species are using the forest as a feeding habitat then competition for leaf surface bacteria may be high. Principal component analysis shows that rainforest areas are basically similar in terms of species composition and number of flies. Areas around watercourses and lakes have also been grouped together suggesting moisture may be another limiting resource.

On a comparative basis, the slope of Taylor's Power Law for spatial variance ranges from 1.6 to 5.1 (mean 2.4) for fruit flies. Although this overlaps considerably with data on aphids (mean 2.14) and moths (2.24) (see Taylor and Woiwod 1982), our fruit flies seem to show a much higher degree of clumping than recorded by Taylor and Woiwod (1982) for other invertebrates. Similar criticisms apply to our data as to attractant and light traps for moths, as our fruit flies were collected using male lure traps. With this caveat in mind, the interpretation of the spatial pattern can only be done on a relative basis assuming flies respond equally to lures. The absolute magnitude of catches may be an artifact of the attractants used.

There is considerably more spatial information on changes in species dispersion in our samples than can be revealed by simple regression models. Our correlogram analysis shows that different species show different spatial patterning as their abundance changes.

For low, increasing and decreasing populations of *D. tryoni*, *D. neohumeralis* and *D. cacuminatus*, there was no clearcut autocorrelation among trap catches at any spatial scale. This suggests the dispersion of these populations at these times is restricted to favourable areas which are themselves randomly distributed relative to each other (see Fig. 3B).

Populations become abundant rapidly (see Drew et al. 1984a) and nearby trap sites show similar trap catches during these times, whereas distant sites are either unrelated (random) or significantly dissimilar (i.e. negative autocorrelation); suggesting (1) a growth in the suitable area for each of these species or overcrowding at each of the favourable sites leading to similar trap catches at sites close to favourable sites. *D. tryoni* at periods of high abundance is much more common in peripheral areas than the rain-

forest leading to a depression effect (Fig. 3A). Are male flies waiting on the edge of rainforests to mate with females that move into such forests to feed and out again to oviposit? Or do *D. tryoni* avoid rainforests? These must remain as hypotheses for further investigation at this stage. *D. cacuminatus* and *D. neohumeralis* on the other hand are more prevalent in rainforest areas (Fig. 3C), similar to *C. aequalis*.

C. aequalis is a rainforest species with some local hosts and breeding. The rainforest is a population source and has high abundance relative to peripheral sites at all times, although this is most pronounced during periods of high abundance (Fig. 3c).

D. endiandrae, also a rainforest breeder, shows a random autocorrelation correlogram during periods of low and high abundance. This may reflect the pattern of breeding and/or feeding sites. During periods of population increase and decrease, nearby sites show similar catches. This suggests highly localised movement away (and to) favourable breeding sites.

D. mayi showed a random dispersion pattern at all abundance categories. This is again a rainforest breeder and suggests that its distribution may be highly localised and tightly tied to its host which may be randomly dispersed?

The lack of any major spatial response to wind direction confirms Taylor's views that a species' spatial dynamics is a biological property of the animal and not just environmental noise.

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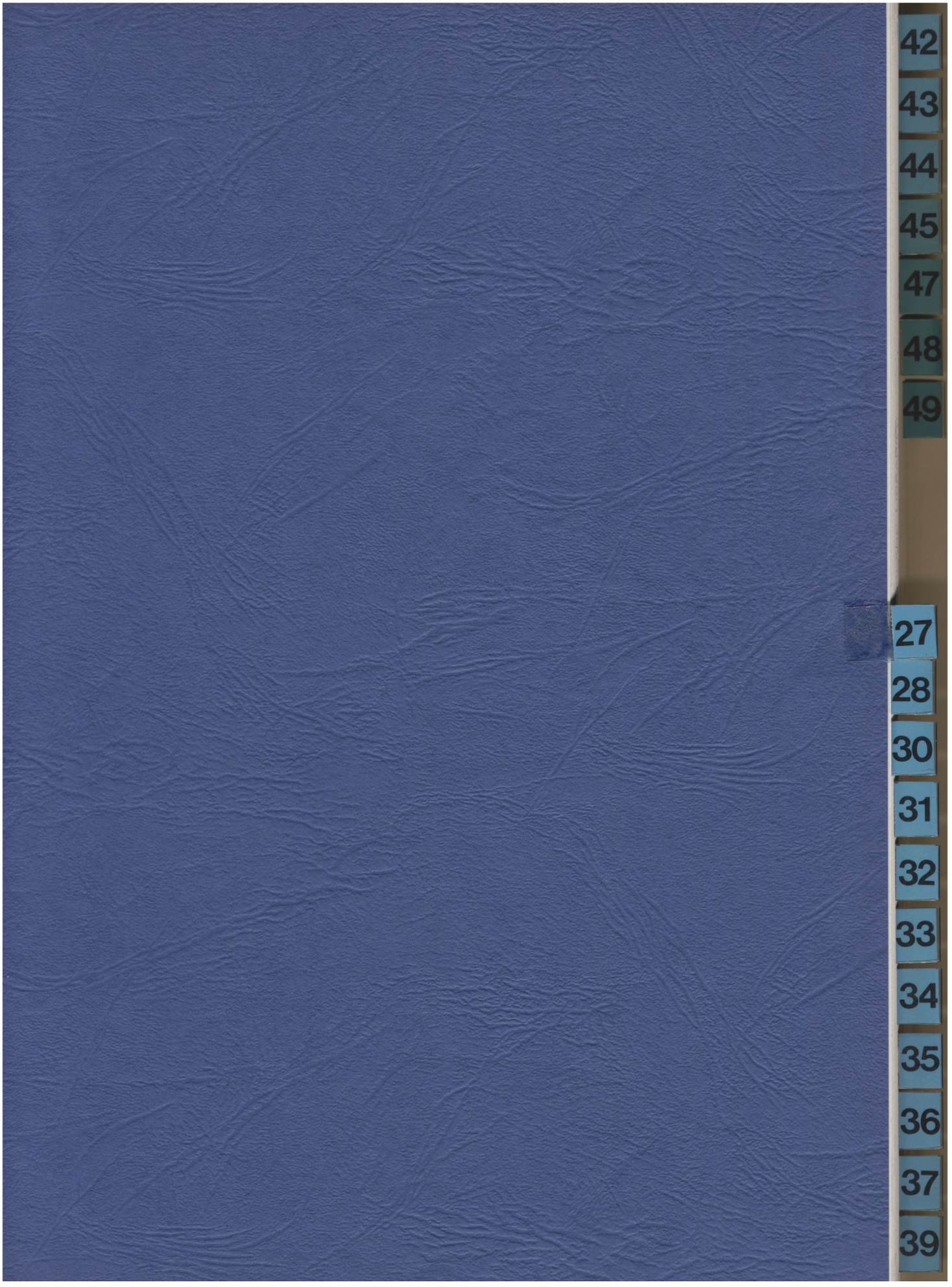
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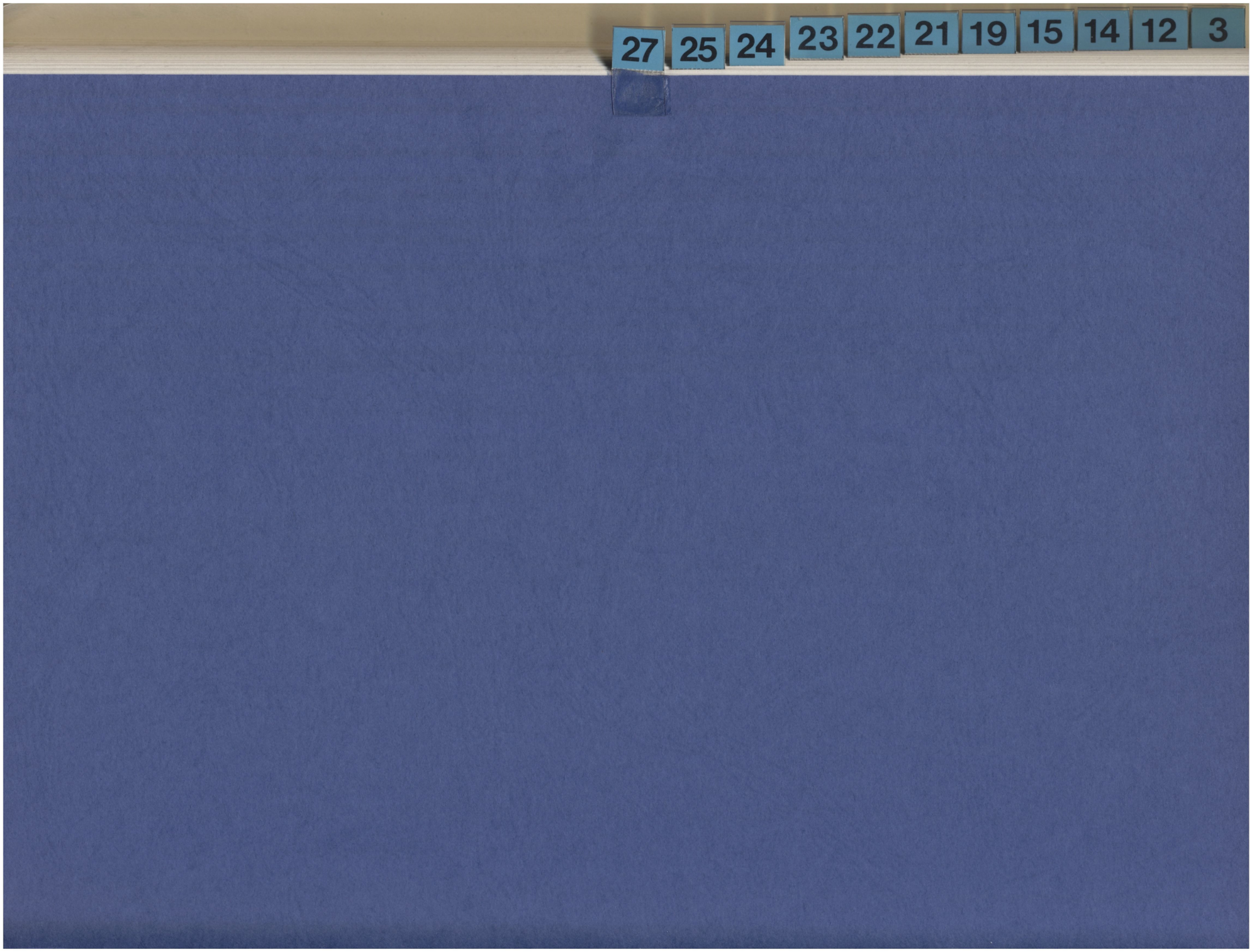
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Spiroacetals in Rectal Gland Secretions of Australasian Fruit Fly Species

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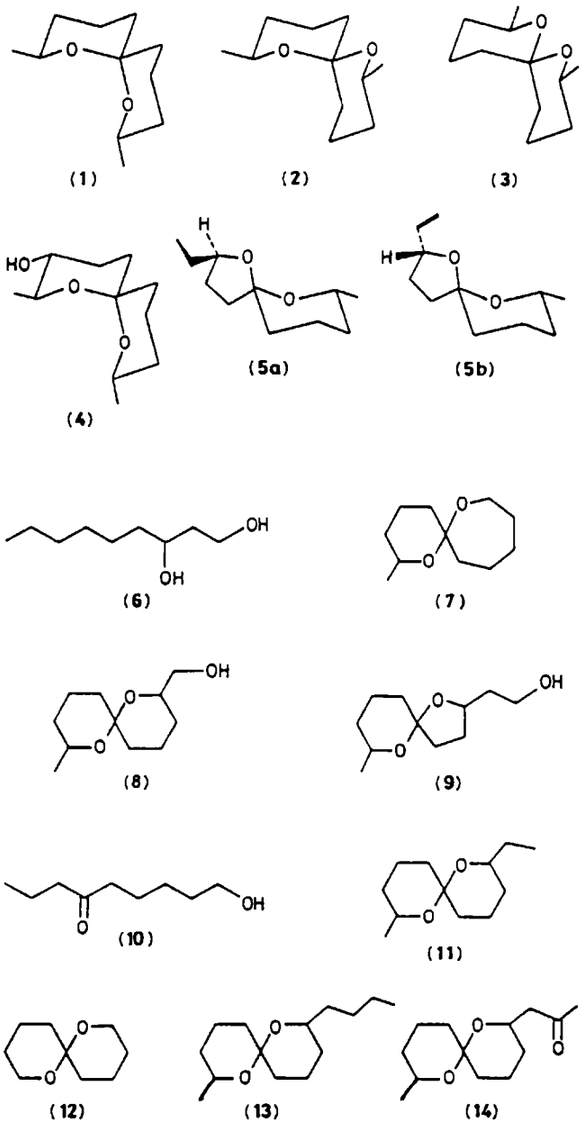
Combined gas chromatography–mass spectrometric examination of the rectal gland secretions of a number of *Dacus* species (Diptera: Tephritidae) having pest status in Australasia, has revealed the presence of a range of spiroacetals.

A large number of fruit fly species of the genus *Dacus* are very serious pests of agricultural produce in Australia and the South Pacific region.[1] Population and species monitoring is generally based on male fly attractants, but some important species, *e.g. D. cucumis* (French) and *D. decipiens* (Drew), do not respond to these lures.[1] This fact encouraged chemical examination of some species in our region in the hope that specific lures may be developed. In the course of our study of taxonomically close species, it emerged that spiroacetals were often present, and in view of recent reports[2] of spiroacetals in *Dacus oleae* Gmelin, and of widespread interest in spiroacetals generally, we report some of our findings in preliminary form. There is considerable evidence[1,3] that some male *Dacus* species secrete and store a pheromone in a sac and reservoir associated with the posterior region of the rectum, and in general, rectal glands were dissected from sexually mature adult male flies (laboratory cultured or field-trapped) and pulverised in pentane and/or acetone, and examined directly by combined gas chromatography–mass spectrometry (g.c.–m.s.).

D. cucumis is a pest of all cucurbits and tomatoes and is distributed along the eastern coast of Australia from Cape York (in the north) to the Queensland–N.S.W. border.[1] The major component of its rectal gland secretion is the stereoisomer (**1**) of 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (M^+ 184), on the basis of v.p.c. and mass spectral comparisons with an authentic sample.[4] There are lesser, but still significant amounts of two components (at longer retention times on OV101) each with M^+ 184, and fragmentation patterns essentially identical with that of (**1**). One is the isomer (**2**),[4] and we conclude the third is the thermodynamically least favourable[5] isomer (**3**),[6] on the basis of its mass spectral behaviour, and presence (2—4%) in the tactically obtained mixture of these stereoisomers.[7]†

A significant level of the 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane[2b,d] (**4**) was also present, along with two diastereoisomers (**5a**) and (**5b**) of 2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane[8] on the basis of g.c.–m.s. comparisons, and synthesis.[7] A very significant component of longer retention time (and extracted more readily into acetone) exhibited a base peak at *m/z* 75 and weak ions at higher *m/z*. However, the presence of *m/z* 159 [$M^+ - 1$ for nonane-1,3-diol (**6**)] was established, and the latter's presence was established by comparison with an authentic sample. Determination of the chirality of the natural diol is proceeding. Other minor spiroacetals [*e.g.* (**7**)—(**9**)] and some pyrazines were also identified.

† One of the present authors (W. F.) has tentatively identified compound (**3**) in a species of solitary bee. In the present case, it is conceivable that the compound (**3**) in question formed under gas-chromatographic conditions (*e.g.* from the ketodiol or hemiacetal), but for several reasons we consider this unlikely.



Dacus halfordiae (Tryon) is taxonomically close to *D. cucumis* (but is of restricted habitat and minor economic importance) and the male rectal gland secretion consisted predominantly of the spiroundecanes (**1**) and (**2**) as for *D. cucumis*. A minor component was shown to be 6-oxononan-1-ol (**10**), on the basis of g.c. comparisons with an authentic sample.[7]

The *Dacus dorsalis* complex[1] of flies [*D. dorsalis* Hendel, *D. occipitalis* (Bezzi), and *D. cacuminatus* (Hering)], will be discussed in detail elsewhere, but there are some points of immediate interest. Although 6-oxononan-1-ol (**10**) is the major component in *D. occipitalis* (65%; 5 μg/fly), the unusual even-carbon-numbered spiroacetal 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (**11**) (M^+ 198) was also present and identified, initially on the basis of mass spectral comparisons with 7-ethyl-2-methyl-1,6-dioxaspiro[4.5]decane,[8] and then by comparisons with a synthesised sample.[7] This spiroacetal is also found in *D. dorsalis* and *D. latifrons* (Hendel). With respect to *D. cacuminatus* males, the major volatile component (72%; ~8 μg/fly) has M^+ 156 and the characteristic spiroacetal fragmentation. This was 1,7-dioxaspiro[5.5]-undecane (**12**), and was shown to be racemic by complexation gas chromatography.‡ Compound (**12**) is also the major component in *D. oleae* (females)[2] and has been demonstrated to be racemic in this fly also.[9] A very minor component of *D. latifrons* (M^+ 226) exhibited a mass spectral fragmentation pattern characteristic of a 2,8-dialkyl-1,7-dioxaspiro[5.5]-undecane[10] (dominant *m/z* at 115, 112, 97, 69, 55, and 41) and with an initial loss of 44 mass units to give *m/z* 182. Structures (**13**) and (**14**) were considered and both compounds were synthesised.[7] However g.c.–m.s. comparisons established (**13**), another even-carbon-numbered spiroacetal from an insect,[11] as the natural material. Long-chain fatty acids were also identified in most of the *Dacus* secretions. From a chemotaxonomic viewpoint, it is of interest that the members of the *D. dorsalis* complex show substantial differences in the nature of their secretions, whereas the taxonomically close *Dacus tryoni* (Froggatt),[12] *D. neohumeralis* (Hardy),[12] and *D. aquilonis* (May)[13] all secrete a very similar blend of relatively simple amides.

Trials to assess the biological activity of these compounds, and investigations of other aspects of this chemistry are continuing.

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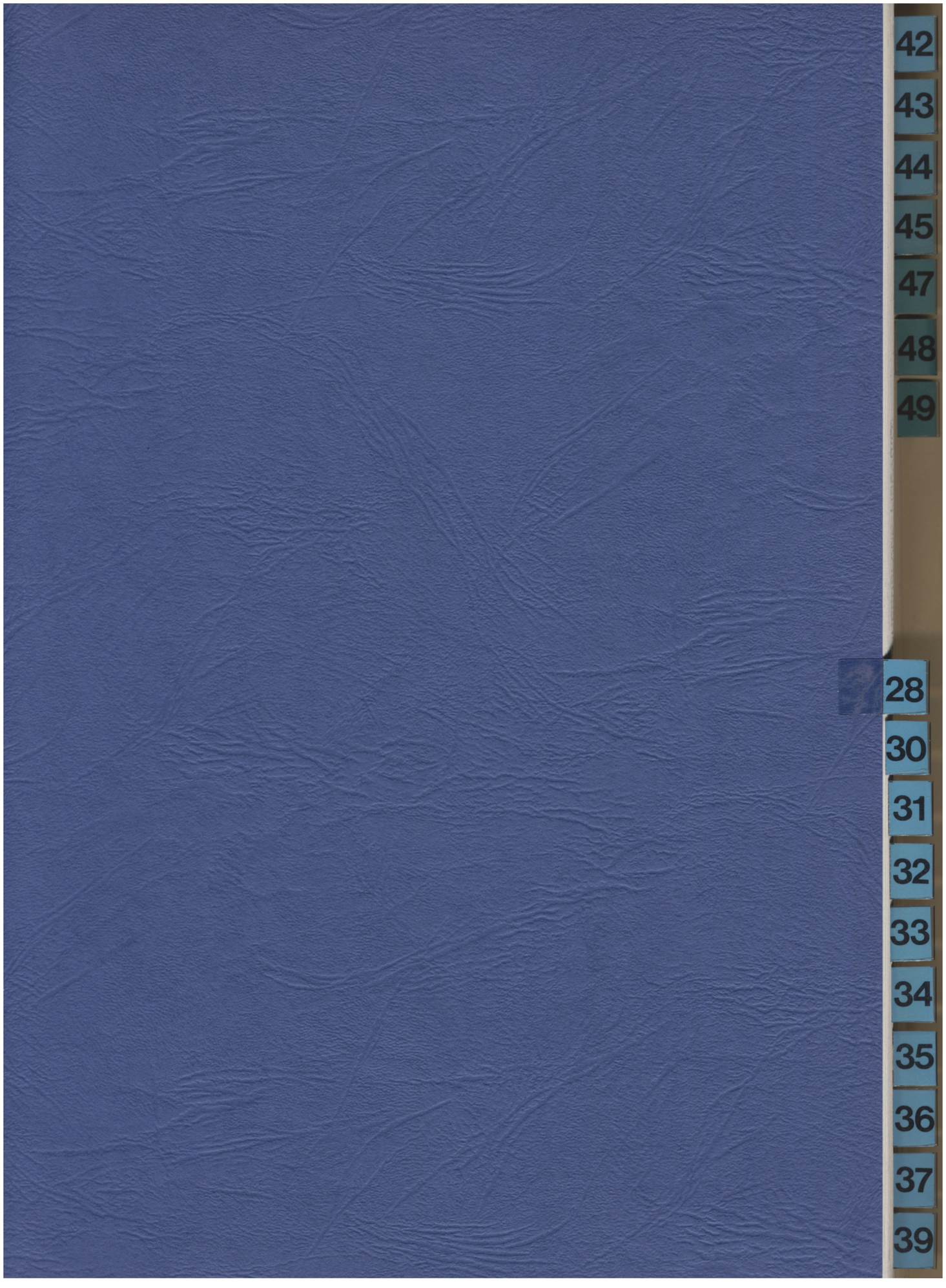
‡ Our sample was kindly examined by Prof. Dr. V. Schurig (Tübingen).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Spiroacetals from Dienones and Hydroxyenones by Mercury(II) Cyclisation

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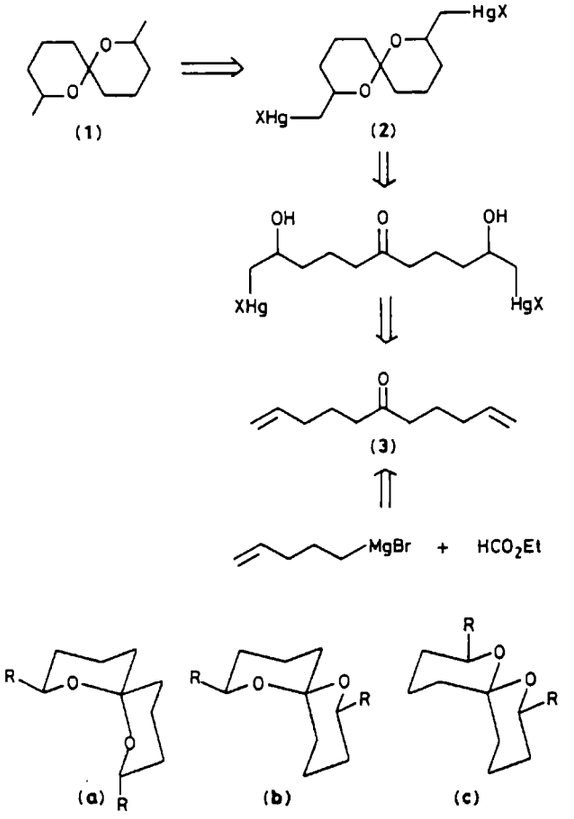
Dienones and hydroxyenones are converted efficiently into spiroacetals by hydroxymercuration–cyclisation followed by either reductive or oxidative removal of mercury.

Certain dialkyl- and hydroxy-substituted spiroacetals are components of the rectal gland secretions of various *Dacus* species (fruit flies) in Australasia.[1] To provide samples for comparison with the natural components, synthesis of a number of these spiroacetals was necessary, and we report efficient routes based on organomercury chemistry. With respect to the isomeric 2,8-dimethyl-1,7-dioxaspiro[5.5]-undecanes, a retrosynthetic analysis is outlined in Scheme 1.

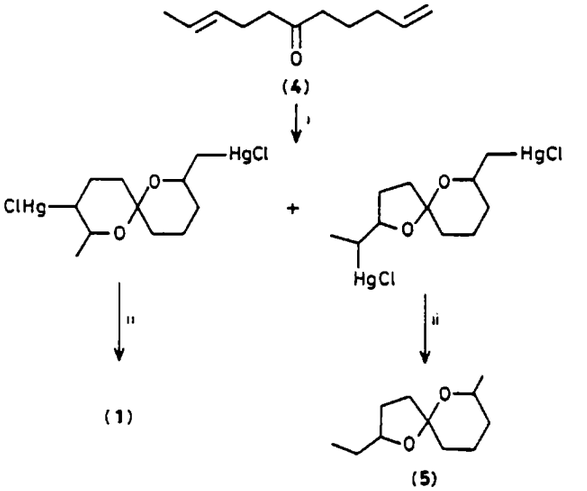
Thus treatment of ethyl formate with pent-4-enylmagnesium bromide (2 equiv.), followed by Jones oxidation, *etc.*, provided the necessary dienone (**3**), which on treatment with $Hg(OAc)_2$ in H_2O–tetrahydrofuran (THF) (*ca.* 50:50 with 1% $HClO_4$) and then NaCl–H_2O, provided a mixture of two crystalline stereoisomers (**a**) and (**b**) of 2,8-bis(chloromercurymethyl)-1,7-dioxaspiro[5.5]undecanes (**2**) (X = Cl). (The isomer ratio varied with reaction time as expected for reversibility in oxymercuration and cyclisation). The mercurials (**2**) were completely characterised by ^1H, ^{13}C, and ^{199}Hg n.m.r. spectroscopy; one diastereoisomer (**2a**) exhibited one ^{199}Hg signal, whereas the other (**2b**) exhibited two equally intense signals ~200 p.p.m. downfield from phenylmercury(II) chloride (0.5 M) in Me_2SO. In the ^{13}C n.m.r. spectrum the spiro carbon in the isomer (**2a**) resonated at δ 96.5 and in the isomer (**2b**) at δ 98.3. Reductive removal of mercury in the general way (alkaline $NaBH_4$)[2] provided (**1**) but significant 'deoxymercuration' occurred.[3] However use of $NaBH_4$ in a biphasic system (H_2O–CH_2Cl_2 with phase transfer catalysis) avoided this problem.[3] [Bu_3SnH (benzene) may be employed but complete removal of tin residues is more difficult.] Although the diastereoisomers (**a**) and (**b**) of (**1**) are separable (prep. v.p.c.) it was possible to obtain the essentially pure mercurial (**2a**) by fractional crystallisation from CH_2Cl_2. Reduction of the total mercurial product formed in the absence of $HClO_4$ provided a mixture of the 2,8-dimethyl-1,7-dioxaspiro[5.5]undecanes (**1a**) (major) and (**1b**) (minor), with reproducible, small amounts (2—4%) of the diastereoisomer (**1c**) (gas chromatography–mass spectrometry, g.c.–m.s.). Isolation of the intermediate mercurials is not essential, and in synthesis of spiroacetals of the [4.5] and [5.5] systems, oxymercuration–cyclisation–reduction (basification; biphasic system; benzyltriethylammonium chloride) proceeded very efficiently (overall yields >90%). High-field ^1H and ^{13}C n.m.r. and mass spectra of the spiroacetals obtained were completely consistent with the assigned structures. A similar approach using the unsymmetrical dienone (**4**) led to a mixture of products, resulting from the non-regioselective nature of the oxymercuration step (Scheme 2). [Spiroacetal (**5**) is a component of *Dacus cucumis*.]

Mercury(II)-induced cyclisation of hydroxyenones (compare selenocyclisation)[4] is particularly efficient as was demonstrated initially in the formation of 2-methyl-1,7-dioxaspiro[5.5]undecane (**7**). Conversion of the ketoaldehyde (**6**)

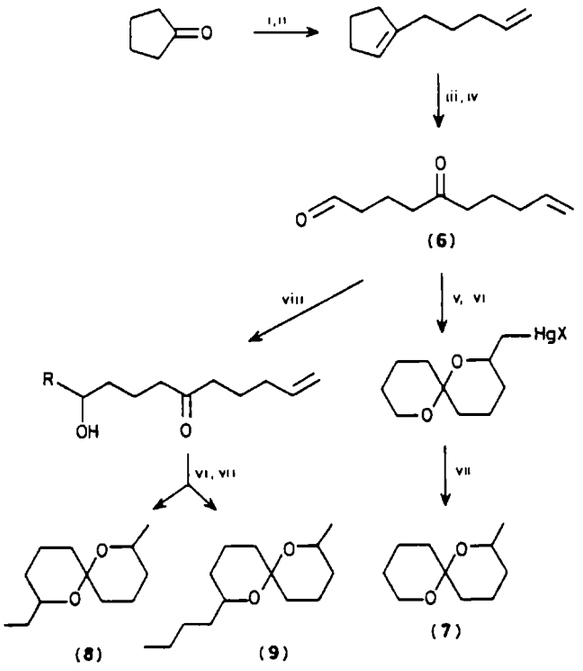


(1) R = Me
(2) R = CH_2HgX

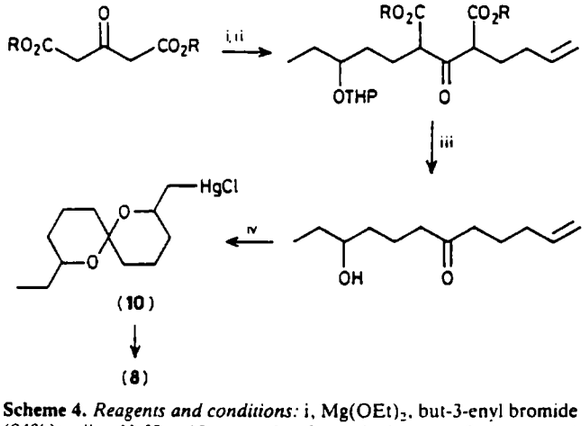
Scheme 1



Scheme 2. *Reagents and conditions:* i, $Hg(OAc)_2$, H_2O–THF, 1% $HClO_4$; ii, $NaBH_4$ (overall >90%).



Scheme 3. *Reagents and conditions:* i, pent-4-enylMgBr; 0 °C (90%); ii, distil from $KHSO_4$ (75%); iii, *m*-chloroperbenzoic acid, CH_2Cl_2, Na_2CO_3; iv, $NaIO_4$ (90%); v, $NaBH_4$; vi, $Hg(OAc)_2$, H_2O–THF, 1% $HClO_4$; vii, Bu_3SnH in benzene, >90%; viii, EtMgBr or Bu^nMgBr, ether, −30 °C (40%).

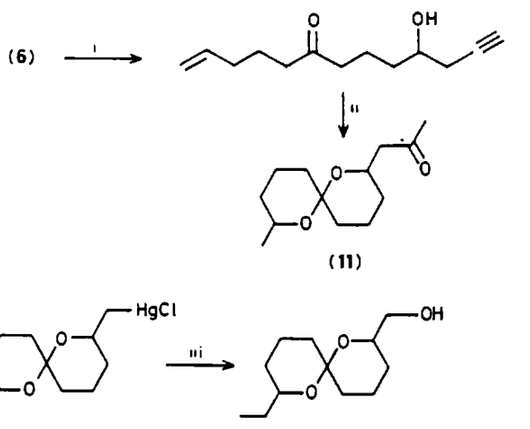


Scheme 4. *Reagents and conditions:* i, $Mg(OEt)_2$, but-3-enyl bromide (84%); ii, NaH, 18-crown-6, 3-tetrahydropyran-2-yloxypentyl chloride, NaI; iii, NaOH, then H^+ (70%); iv, Hg^{II} *etc.*

by chemoselective Grignard addition[5] (−30 °C; RMgBr; R = Et or Bu^n) into the secondary alcohols led to the new even-carbon-numbered spiroacetals (**8**) and (**9**), both minor fly components (Scheme 3).

To avoid the problem of chemoselective Grignard addition to the ketoaldehyde (Scheme 3, step viii), the spiroacetal (**8**) was obtained more efficiently by double alkylation of diethyl 3-oxoglutarate, with intermediate (**10**) being essentially one diastereoisomer (M^+ 434) by ^{13}C n.m.r. spectroscopy (Scheme 4). Genuine hydroxy participation *via* the ketol form of the hydroxyenone may be involved in this stereoregulation.

Simultaneously with mercury(II) cyclisation, it is possible to hydrate an installed propynyl function,[6] as demonstrated in the synthesis of the spiroacetal (**11**) (Scheme 5) initially



Scheme 5. *Reagents and conditions:* i, prop-2-ynyl bromide, Zn THF–H_2O (NH_4Cl) (90%); ii, Hg^{II} *etc.* (90%); iii, O_2, $NaBH_4$ (−10 °C) (50%) together with reduction product (50%).

suspected to be present in *D. latifrons*; this component was in fact (**9**) (both have M^+ 226). [A less satisfactory route to (**11**) involved allylation of (**6**), followed by oxymercuration–cyclisation–reduction and pyridinium chlorochromate oxidation.] Certain hydroxy spiroacetals may be acquired by 'oxidative' demercuration,[7] thus enlarging the scope of this approach. Treatment (with $NaBH_4$) of the mercurial dissolved in dimethylformamide (DMF) saturated with O_2 (−10 °C) led to acceptable yields (~60%) of the hydroxy derivative, together with the (easily separated) reduced (alkyl) counterpart, as shown in Scheme 5.

Finally, we have observed that use of mercury(II) tartrate[8] in the oxymercuration step may result in useful (15% enantiomeric excess, e.e.) asymmetric induction in the resultant spiroacetals. For example, use of 5-oxo-nona-1,8-diene leads to a mixture of three diastereoisomers of 2,7-dimethyl-1,6-dioxaspiro[4.4]nonanes with significant e.e., as judged by complexation gas chromatography. This low level of induction is useful in identifying the natural stereoisomers.

These general approaches to spiroacetals, using Hg^{II}, Tl^{III}, and Br_2–H_2O cyclisations are being extended to syntheses of various trioxadispiro and related systems.

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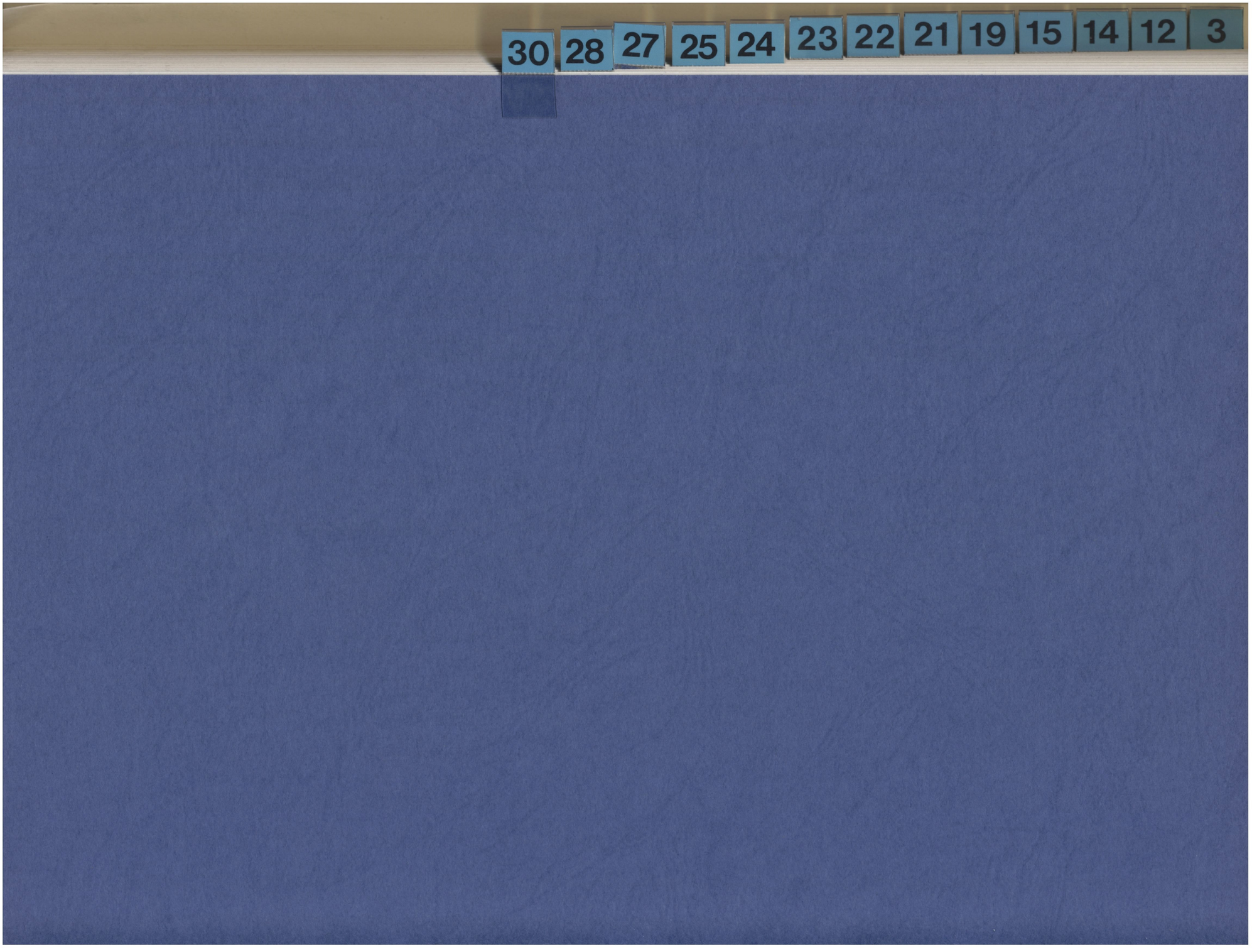
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Bacteria Associated with some *Dacus* Species (Diptera: Tephritidae) and their Host Fruit in Queensland

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Abstract

Over a period of 18 months the bacteria associated with approximately 70 adult flies of four *Dacus* species were isolated and identified. The flies were *D. tryoni* (Froggatt) and *D. neohumeralis* Hardy from guava (*Psidium guajava* L.), mulberry (*Morus nigra* L.) and peach [*Prunus persica* (L.) Batsch], *D. cacuminatus* (Héring) from wild tobacco (*Solanum mauritianum* Scop.), and *D. musae* (Tryon) from banana (*Musa paradisiaca* L.), and were collected in the field when these host plants were fruiting. All flies examined were surface-sterilized prior to aseptic dissection in which crop and mid-gut (stomach) or oesophageal bulbs were removed for culturing. Bacteria were also isolated from faeces of field-collected flies, as well as from host fruit surfaces, oviposition sites and larvae-infested tissue in host fruit. The predominant bacteria found in the alimentary tract of flies and in associated fruit specimens were members of the family Enterobacteriaceae. *Klebsiella oxytoca*, *Erwinia herbicola* and *Enterobacter cloacae* were the most frequently isolated species, with *Serratia* spp., *Citrobacter freundii*, *Proteus* spp., *Providencia rettgeri* and *Escherichia coli*, being found less frequently. No one bacterial species was found to be consistently associated with any one fly species. The bacterial species found most frequently in the alimentary tract were also found in large numbers on the surfaces of host fruit and in stung fruit.

Introduction

In the family Tephritidae, a close association between the insect and its alimentary tract microflora has long been assumed (Petri 1910). The bacteria of the alimentary tract have been reported to be obligate symbionts (Petri 1910; Hagen 1966; Baerwald and Boush 1968; Lambrou and Tzanakakis 1978; Miyazaki *et al.* 1983); non-symbionts (Yamvrias *et al.* 1968; Tsiropoulos 1983; Rossiter *et al.* 1983; Fitt and O'Brien 1985; Howard *et al.* 1985); or ingested food (Dean and Chapman 1973; Drew *et al.* 1983). The importance of the alimentary tract bacteria in the biology of fruit flies has thus been generally accepted, but the precise nutritional role these bacteria play in the life of the larva or the adult fly remains poorly defined.

Many different microbiological methods have been employed to determine the bacteria associated with fruit flies (Allen *et al.* 1934; Rubio and McFadden 1966; Boush *et al.* 1972; Tsiropoulos 1976). Only limited attempts have been made to study the microflora in different parts of the alimentary tract (Dean and Chapman 1973). If plant-surface microorganisms provide a natural food source as suggested by Courtice and Drew (1984) the leaf and fruit microflora of host, and possibly non-host, trees may be a vital component in the fruit fly ecological system.

In attempting to understand further the role which bacteria may play in the biology and ecology of fruit flies in Queensland, the present investigations were aimed at

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a comprehensive survey of bacteria associated with different species of adult *Dacus* spp. collected in the field from various host trees at different times of the year. The predominant microflora of various parts of the alimentary tract (as described by Drew *et al.* 1983), together with the types of organisms present on the surfaces of host fruit and in oviposition sites and larval-infested tissue of stung fruit, were also investigated.

Material and Methods

Field Collection of Flies and Fruit

Adults of four fruit fly species were collected singly in sterile glass tubes from their respective hosts, *Dacus cacuminatus* (Héring) from wild tobacco (*Solanum mauritianum* Scop.), *Dacus tryoni* (Froggatt) and *Dacus neohumeralis* Hardy from guava (*Psidium guajava* L.), mulberry (*Morus nigra* L.), and peach [*Prunus persica* (L.) Batsch] and *Dacus musae* (Tryon) from banana (*Musa paradisiaca* L.), when these host plants were fruiting.

Flies collected in suburban areas of Brisbane were held at room temperature prior to examination. All flies, with the exception of *D. musae* specimens, were examined within 2 h of collection. *D. musae* specimens were collected from north Queensland, frozen in liquid nitrogen and transported to the Brisbane laboratory for examination. Laboratory-reared *D. tryoni* flies were obtained from a colony which had been maintained under laboratory conditions for many years.

Fruit from host trees from which flies were obtained were placed singly in sterile containers at the same time as the flies were collected.

Dissection of Flies and Isolation of Microorganisms from the Alimentary Tract

Prior to examination, all live flies were anaesthetized by cold (3 min at −4°C), the anal and mouth openings sealed with sterile wax and the whole fly surface-sterilized by washing in 70% (v/v) alcohol (30 s), 0·25% (w/v) sodium hypochlorite (1 min), and sterile distilled water (30 s). The flies were then mounted on sterile wax blocks (dorsum downwards) and dissected aseptically under sterile water. Crop and midgut content colour, size of crop and state of ovarian development in females were recorded. Various parts of the alimentary tract as described by Drew *et al.* (1983), viz. crop, mid-gut (stomach) and oesophageal bulb (diverticulum), were carefully removed and spread directly onto peptone–yeast extract–agar (PYEA; peptone 10 g, yeast extract 5 g, NaCl 5 g, agar 15 g, distilled water 1 litre, pH adjusted to 7·2). To reduce the risk of cross-contamination during dissection, oesophageal bulbs were only removed from flies in which the remainder of the alimentary tract was left intact. Faecal deposits, if present in the collection tubes by the time of dissection, were suspended in a drop of sterile water and spread onto PYEA plates.

All plates were incubated aerobically at 30°C and examined daily. A qualitative assessment of the number and types of colonies present on each plate was made after 48 h and representative colonies of the predominant types on each plate were subcultured, purified and maintained on PYEA slopes at 4°C. Plates with less than five colonies were recorded as 'insignificant bacterial growth' and no subcultures were made from these specimens.

Isolation of Bacteria from Fruit Surfaces

Since a comprehensive survey of host fruit surface organisms was beyond the scope of these studies, examination of the microflora of host fruit near which flies had been collected was aimed primarily at determining the presence or absence of bacteria commonly found in flies (hence referred to as 'fruit-fly type bacteria'). Each fruit was washed in sterile distilled water for 1 min with gentle hand agitation. Aliquots (0·1 ml) of wash solution were plated on PYEA and after 2 days representative colonies of 'fruit-fly type' bacteria were subcultured for identification.

Isolation of Bacteria from Fruit Stung by Fruit Fly

Field-collected stung fruit examined were guava, wild tobacco, mulberry, peach, and banana. Fruit which contained visible oviposition sites was washed and surface-sterilized by dipping for 1 min in running tap water, 2 min in 70% (v/v) alcohol, 5 min in 0·25% (w/v) sodium hypochlorite and 1 min in sterile distilled water. Microorganisms present in oviposition sites were isolated by aseptically dissecting a small wedge of tissue through the centre of the site and smearing the cut edge over the surface

of a PYEA plate. If larvae were present in the fruit, a loopful of the associated rotting tissue was similarly plated.

Identification of Bacteria

All bacterial isolates were initially Gram-stained and tested for oxidase activity (Oxidase Reagent Droppers, Marion Scientific, Kansas City, Missouri). Almost all isolates from flies, oviposition sites and larval rot were Gram-negative, oxidase-negative, rod-shaped organisms which were identified by the API-20E system for Enterobacteriaceae. The few organisms isolated which did not belong to this family were not further characterized. Motility was determined by growing organisms in semi-solid motility medium (peptone 10 g, beef extract 3 g, NaCl 5 g, agar 4 g, distilled water 1 litre) followed by microscopic examination of hanging-drop preparations.

Results

Microflora of Field-collected Flies

Bacteria were isolated from four *Dacus* species collected from host plants during months of peak fruiting (Table 1). The numbers of specimens examined, bacterial isolates obtained and percentage of these isolates identified as Enterobacteriaceae are shown in Table 2.

Table 1. Field collection of *Dacus* species for microbiological examination

Fly species	Host tree	Time of collection	No. of flies examined
D. cacuminatus	Wild tobacco	February–April	26
D. tryoni	Guava	April	11
D. neohumeralis	Guava	April	1
D. neohumeralis	Mulberry	October	7
D. neohumeralis	Peach	November	4
D. tryoni	Peach	November	10
D. musae	Banana	March	14

Table 2. Bacteriological examination of the alimentary canal, faeces and host fruit tissue of field-collected *Dacus* species

Material examined	No. of specimens examined	No. of specimens containing bacteria[A]	No. of bacterial isolates[B]	Isolates identified as Enterobacteriaceae No.	%
Insect					
Crop	52	34	38	30	79
Mid-gut	53	52	65	59	91
Oesophageal bulb	16	12	12	11	92
Faeces	30	20	20	20	100
Fruit					
Oviposition site	19	19	23	21	91
Larval rot	17	17	19	14	74

[A] More than five colonies isolated on PYEA.
[B] One or more bacteria were isolated from each plate on the basis of different colony characteristics.

Although no accurate quantitative assessments of bacterial populations were made in this investigation, some general conclusions could be drawn concerning the numbers of bacteria present in various sections of the alimentary tract. With the exception

of one newly emerged fly, all specimens examined contained very large numbers of bacteria in the mid-gut. However, bacterial populations of crops, bulbs and faeces were more variable, and 35% of crops, 25% of bulbs and 33% of faeces examined contained very low numbers of bacteria (i.e. less than five colonies per plate). Crops which appeared empty (deflated) on dissection consistently contained very low numbers of bacteria, but large fluid-filled crops did not always contain large numbers of bacteria.

When primary isolation plates were examined after 48 h, usually no more than two colony types were detected from any one specimen, and frequently only one colony type appeared to be present.

Of 135 isolates obtained from the alimentary tract and faeces of field-collected flies, 120 were oxidase-negative, Gram-negative rods which were successfully identified as species in the family Enterobacteriaceae by the API−20E system. Of the 15 remaining unidentified isolates, a small number were oxidase-positive *Pseudomonas* species. Only four of the 73 field flies examined were found to contain microorganisms other than Gram-negative rods. They were two flies which contained Gram-positive cocci and two flies which contained small Gram-positive rods as well as the commonly found species in the Enterobacteriaceae. Yeasts were not detected in any part of the alimentary canal. The lower percentage of Enterobacteriaceae in crops (79% compared with 91 and 92% in mid-guts and bulbs, respectively) indicated the more varied microflora of this part of the alimentary tract (Table 2).

Table 3. Isolation of Enterobacteriaceae species from field-collected *Dacus* species and from stung host fruit

Bacterial species	No. of isolations from					
	Crop	Mid-gut	Bulb	Faeces	Oviposition site (fruit)	Larval rot (fruit)
Erwinia herbicola	6	6	1	7	4	3
Klebsiella oxytoca	7	17	1	1	5	3
Enterobacter cloacae	8	13	2	9	11	7
Citrobacter freundii	4	10	4	1	0	0
Proteus and *Providencia* spp.	4	7	2	1	1	1
Escherichia coli	1	4	0	1	0	0
Serratia spp.	0	2	1	0	1	0

The species of Enterobacteriaceae found associated with field flies and with oviposition sites and larval rot in infested host fruit are shown in Table 3. *Erwinia herbicola* (syn. *Enterobacter agglomerans*), *Klebsiella oxytoca*, and *Enterobacter cloacae* were the most frequently isolated species, with *Citrobacter freundii*, *Proteus mirabilis* and *P. vulgaris*, *Providencia rettgeri*, *Escherichia coli*, *Serratia liquefaciens* and non-pigmented *S. marcescens* being less frequently isolated.

Fly species, sex, host tree and time of collection did not appear to affect the bacterial species present in the alimentary tract.

No one species of bacterium was consistently associated with any one species of fly. *E. herbicola*, *K. oxytoca* and *E. cloacae* were isolated in approximately equal numbers from crops. *K. oxytoca* was the species most commonly found in the mid-gut and *E. cloacae* the most common isolate from faeces samples. The number of oesophageal bulbs examined was much smaller than the number of crops and mid-guts, but in the bulbs which did contain moderate numbers of bacteria, *C. freundii*

was the most commmon bacterium isolated. Five of the 13 *E. herbicola* strains isolated from the alimentary tract of flies were yellow-pigmented.

Microorganisms Associated with Oviposition Sites and Larval Rot

Bacteriological examination of oviposition sites and larval-infested tissue in host fruit showed large numbers of bacteria present in all specimens from a variety of fruit (Table 2). Provided stung fruit were adequately surface-sterilized, each oviposition site or area of larval rot yielded bacteria of only one or two colony types. In all, 91% of the isolates from oviposition sites and 74% of isolates from larval rot were identified as Enterobacteriaceae. The three most common species found in the alimentary tract of adult field flies, viz. *E. herbicola*, *K. oxytoca* and *E. cloacae*, were also the three most commonly isolated from inside host fruit, with *E. cloacae* occurring twice as frequently as the other two species.

C. freundii and *E. coli* were found in the alimentary tract of flies but have not been isolated from field-stung fruit, while non-pigmented *Serratia* species have been isolated from only one oviposition site and not from larval-infested tissue.

When isolations were made from firm tissues of guava fruit up to 10 mm from unhatched eggs, the same bacteria as in the oviposition site were found in the apparently intact adjacent fruit tissue. This indicated that the bacteria can spread in host tissue ahead of the larvae. Fruit tissue well removed from an oviposition site was sterile. When larvae were present and tissue breakdown was more advanced a lower proportion (74%) of the bacteria isolated from host tissue belonged to the Enterobacteriaceae (Table 2). This may indicate secondary invasion of infested host fruit tissue by resident or casual fruit-surface organisms.

Table 4. Bacteria isolated from field-collected *Dacus* species and from the surface and interior of host fruit from trees in which flies were collected

Bacterium	Host tree source[A]		
	Flies	Fruit surface	Oviposition site and/or larval rot
Erwinia herbicola	TGMP	TGPB	M
Klebsiella oxytoca	TGMPB	PB	MPB
Enterobacter cloacae	TGMPB	TGP	GMPB
Citrobacter sp.	TGMPB	G	
Proteus spp. and *Providencia rettgeri*	TMPB	P	GP
Serratia spp.	GB	GB	G

[A] T, wild tobacco; G, guava; M, mulberry; P, peach; B, banana.

Bacteria Present on Host Fruit Surfaces

Bacteria found in the alimentary tract of field-collected flies were usually found on the surfaces of host fruit from trees in which flies had been collected (Table 4). A comparison of bacteria on caged (protected from fruit flies) and uncaged (accessible to fruit flies) guava fruit in the field has shown that immature fruit in both cases supported relatively few Enterobacteriaceae on their surfaces. As fruit matured, and flies began frequenting the uncaged tree, the proportion of 'fruit-fly type' bacteria on exposed fruit increased greatly (Drew and Lloyd 1986).

Bacteria Present in Laboratory-reared D. tryoni

During the course of this investigation the bacteria present in the alimentary canal of laboratory-reared *D. tryoni* were also identified. Results showed that Enterobacteriaceae were the predominant organisms present in crops and mid-guts but, unlike field-collected flies, laboratory flies contained predominantly pigmented and non-pigmented *Serratia marcescens* and *S. liquefaciens*. It has also been shown that *Drosophila melanogaster* (Meigen) frequently found around laboratory-reared colonies, carry large numbers of *S. marcescens* and are consequently a likely source of reinfection of newly emerged laboratory-reared flies.

Discussion

Results presented here show that the natural alimentary tract microflora of four field-collected *Dacus* species consisted predominantly of seven species of bacteria in the family Enterobacteriaceae (Table 3). *K. oxytoca*, the predominant species in the midgut, and *E. cloacae*, the predominant species in faeces, were also the most common organisms found in the alimentary tract of *Rhagoletis pomonella* (Dean and Chapman 1973; Rossiter *et al.* 1983), and *K. oxytoca* was the most common isolate from oesophageal bulbs of the same species (Howard *et al.* 1985). The fact that one-third of the faeces samples cultured contained no bacteria is consistent with the earlier findings of Drew *et al.* (1983). One-quarter of the oesophageal bulbs dissected from field flies contained no bacteria recoverable on PYEA. Hence the importance of this organ in maintaining a constant supply of bacteria to the gut, as suggested by Ratner and Stoffolano (1982, 1984) for *R. pomonella*, is not clear from the data for the *Dacus* species studied here.

The bacteriological methods adopted here, as in most published work on bacteria associated with fruit flies, were limited to some extent in that they were designed to detect rapidly growing aerobic organisms with no special growth requirements. As no one species of the bacteria detected was consistently associated with any one species of fly, the term 'symbiosis' implying a specific, mutualistic relationship does not seem appropriate (Brooks 1963). The bacteria belonging to the Enterobacteriaceae which have been characterized here are probably best considered as the predominant commensal inhabitants of the alimentary tract, at least until their nutritional role is better-defined. Other recent studies on the bacteria associated with fruit flies have also questioned the existence of an obligate symbiotic relationship (Yamvrias *et al.* 1970; Tsiropoulos 1983; Fitt and O'Brien 1985; Howard *et al.* 1985). The possibility exists, however, that the fruit fly alimentary tract may contain small numbers of other organisms, possibly slow growing or with more fastidious growth requirements, which are as yet undetected. Such organisms, if present, could be involved in an obligate symbiotic relationship with the fly.

The importance of studying field-collected flies has been demonstrated by results presented here and elsewhere (Tsiropoulos 1983) in that marked differences are shown between the bacteria found in wild and laboratory-reared flies. Fitt and O'Brien (1985) found *Serratia* species to be the most common in their 'wild' flies which were reared in the laboratory from field-collected, larval-infested fruit. Our studies have shown that *Serratia* species were common in the alimentary canal of adult laboratory flies but were not common in field-collected adult flies. It appears that the predominance of *Serratia* species, in particular red-pigmented *S. marcescens*, in adult flies may be a laboratory-acquired characteristic related to the presence of

this organism in *D. melanogaster* which commonly infests laboratory-reared colonies in Queensland.

The alimentary tract bacteria were also consistently associated with host fruit surfaces, oviposition sites and larval rot in stung fruit (Table 3). *E. cloacae* was the most common isolate in infested host fruit and Fitt and O'Brien (1985) have shown that this organism has a beneficial effect on development of *D. jarvisi* larvae in artificial media. Fitt and O'Brien (1985) also examined the bacteria in larval-infested tissue of various host fruits of *Dacus* species and found several species (*E. cloacae*, *K. pneumoniae*, *E. herbicola* and *S. liquefaciens*) to be present.

The means by which bacteria are introduced into stung fruit at oviposition is as yet unclear. Although Petri (1910) claimed that there was an elaborate anatomical arrangement in the ovipositor of *D. oleae* for smearing bacteria on to the surfaces of eggs as they were laid, no such organs are known in tropical *Dacus* species. It has been suggested by Courtice and Drew (1984) that female flies may inoculate the surface of fruit with regurgitated spittle prior to ovipositing. Preliminary investigations have shown that the typical alimentary canal bacteria are present in fly spittle. It is thus likely that these bacteria are spread on the surfaces of host fruit and then introduced into the fruit by the ovipositor.

Drew *et al.* (1983) have shown that fruit flies can be reared on cultures of their own alimentary tract bacteria as a nitrogenous source. Drew and Lloyd (1986) have shown that there is a marked increase in the population of these 'fruit-fly type' bacteria on fruit surfaces, once flies begin frequenting a host tree. Hence, it is possible that, once these alimentary tract bacteria have been introduced onto a fruit surface, they may proliferate there, and in so doing, provide a natural source of protein food for foraging adult flies.

The predominant microflora of Queensland fruit flies having been identified, further studies are now in progress to define the possible multiple functions of these bacteria in the life of this insect.

Acknowledgments

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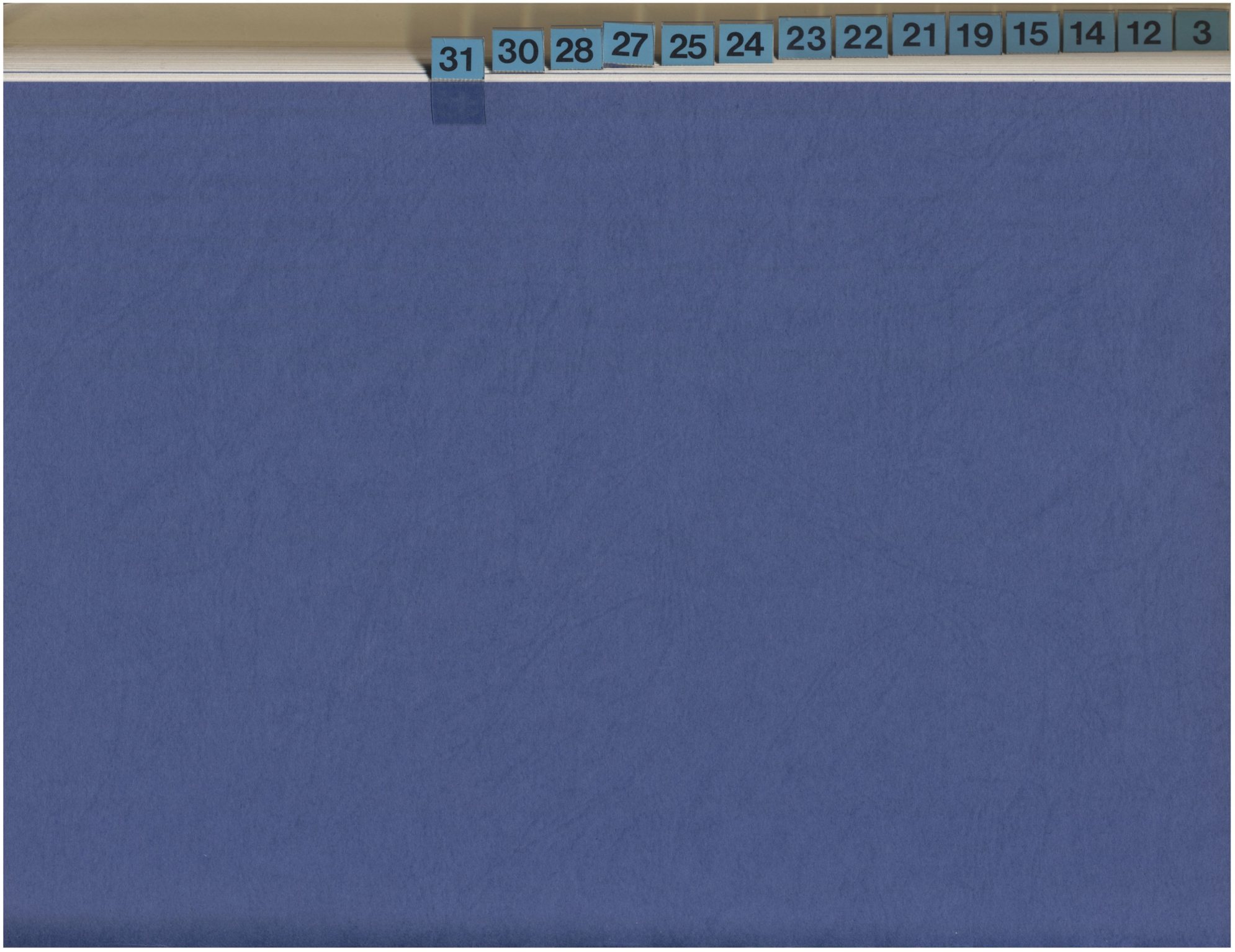
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Dispersal of Irradiated Queensland Fruit Flies, *Dacus tryoni* (Froggatt) (Diptera: Tephritidae), in South-Eastern Australia

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Abstract

Mark–release–recapture studies with laboratory-reared irradiated *Dacus tryoni* (Froggatt) were undertaken in summer in south-eastern Australia. These showed that flies can disperse up to 94 km, almost four times the furthest distance recorded previously for this species. Most recaptures beyond 6 km were east of the point of release. Several distant traps each caught more than one fly, indicating that the flies moved together over long distances. This suggests that mating could occur and that new infestations could result from the long-distance migration of adults.

Introduction

Previous studies with the Queensland fruit fly, *Dacus tryoni* (Froggatt), in Australia have shown that post-teneral adults have a dispersive phase (Bateman and Sonleitner 1967; Fletcher 1973), and mark–release–recapture work has shown that flies disperse up to 24 km (Fletcher 1974; Drew and Hooper 1983). This distance, however, was the limit of the placement of traps in these studies, and the flies' true limit of migration may have been greater.

Greater distances of migration have been recorded for other *Dacus* species. Oriental fruit flies, *Dacus dorsalis* Hendel, have been recovered up to 50 km from their site of release (Steiner 1969*b*; Iwahashi 1972), and individuals of the melon fly, *Dacus cucurbitae* (Coquillett), were recaptured 108 km (Steiner 1969*b*) and 200 km (Miyahara and Kawai 1979) from their points of release.

It has been stated that, today, significant movements of *D. tryoni* over long distances are almost invariably the result of transporting larvae in fruit, rather than of migration by adults (Bateman 1979). This was, presumably, based on the relatively short distances recorded for the migration of *D. tryoni* in the past. The current study was undertaken to determine whether or not *D. tryoni*, when released in a southern Australian town, would disperse for greater distances than previously reported, and to consider whether or not this type of movement could result in new infestations.

Materials and Methods

The release site was Wangaratta, a town in north-eastern Victoria, in a region of open grassland interspersed with rivers and dry eucalypt forests. Four releases of young *D. tryoni* adults were made. For the first three releases the flies were obtained from a culture housed at the Queensland Department of Primary Industries' laboratories, at Indooroopilly. Those for the fourth release were bred from a culture at the Plant Research Institute, Burnley, Vic.

Larvae were reared on a modification of the carrot medium devised by Christenson *et al.* (1956). Pupae were collected after they had completed approximately 80% of their development, and were irradiated in a Gammacell 220 ^{60}Co source. Preliminary tests showed that a dose of 8000 rads [80 Gy]

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gave 100% sterility of males and females, and this dose was used for the pupae of the first release. Pupae for subsequent releases were irradiated at 7000 rads [70 Gy], after tests showed that this dose gave 100% sterility in females and 97% sterility in males, but reduced mortality.

Irradiated pupae were measured volumetrically, dusted with Day-Glo (Day-Glo Color Corp., Ohio, U.S.A.) fluorescent dye (Holbrook *et al.* 1970) at the rate of 1 g per 13 000 pupae, and put into paper trays. To ensure that they became adequately marked, pupae were covered with approximately 2 cm of sawdust containing dye at the rate of 1 g per 14 g of sawdust. A dye of a different colour was used for each release.

For the first three releases, the dusted pupae were kept in cages for several days at 25°C and 60% RH until most adults had emerged. Sugar cubes and water were provided as food. The cages were transported to the release point, a park in the centre of Wangaratta. For the fourth release, the dusted pupae were kept in 45-l covered plastic bins at the release site. Emerged adults escaped through holes near the top of the bins. The percentage emergence was measured for each release. Releases of young *D. tryoni* adults were made on 12 December 1983, 7 February and 6 March 1984 and 14 February 1985; the numbers released were estimated to be 540 000, 400 000, 420 000 and 500 000, respectively.

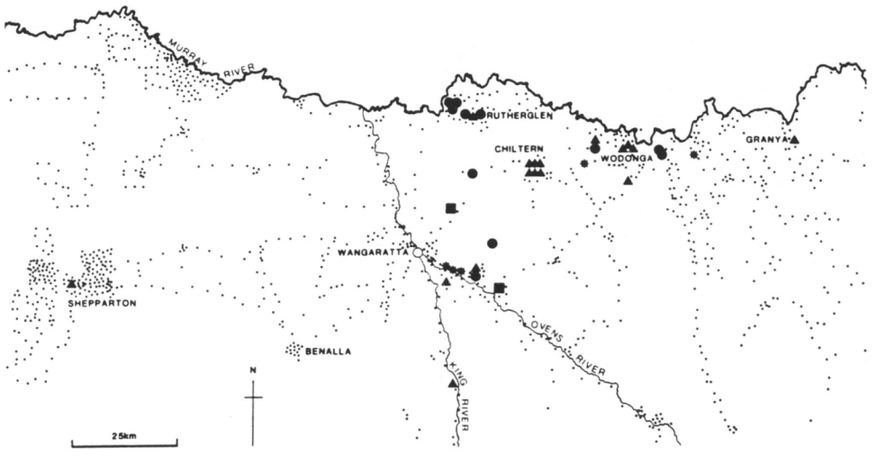

Fig. 1. Location of cue-lure baited Jackson traps (·) and fly recaptures beyond 6 km from the release point (○) for the first (▲), second (●), third (■) and fourth (✶) releases of *Dacus tryoni*.

Flies were captured with the male attractant cue-lure 4-(*p*-acetoxyphenyl)-2-butanone in modified Jackson sticky traps (O'Loughlin *et al.* 1983). Traps were generally placed in fruit trees near houses, although in some locations beyond Wangaratta, *Eucalyptus* spp. or other native shrubs were used. The network of traps in the area surrounding the release point is shown in Fig. 1. These traps were usually spaced at 5-km intervals and their locations were largely determined by the roads in the area. They were checked fortnightly as part of the normal fruit fly surveillance system in Victoria. Most townships in the area contained four or more traps, with the larger towns such as Benalla and Wodonga having up to 50.

For the first three releases, traps were also located closer to the release point to measure directional movement. Within Wangaratta, traps were placed 1, 1·5 and 2 km from the release point, in eight directions which approximated the eight major points of the compass, and also along a watercourse which runs from south-east to north-west through the centre of the town. Beyond 2 km, the limit of the built-up area of Wangaratta, the traps were continued in the same eight directions at 1-km intervals up to 6 km. These traps were checked weekly for 9 weeks after each release.

All fruit flies captured in Jackson traps in Victoria after the releases were checked, under ultra-violet light, for fluorescent dye. Most marked flies carried the dye on their bodies and within their head capsules. Initially, flies without dye on their bodies had their heads crushed in acetone onto filter paper (Steiner 1965). Later, a more convenient technique was used: the head capsule was dissected under a dissecting microscope and examined for dry specks of dye (K. T. Fisher, personal communication).

The catch data from the traps within 6 km of the release point were subjected to analysis of variance to assess whether or not there were significant differences associated with direction or the watercourse. A square root plus one transformation was used to stabilise the variance (Snedecor and Cochran 1973), and Duncan's Multiple Range Test was used to compare the transformed means.

Table 1. Estimated time to reach maturity and percentage recovery of released *Dacus tryoni*

Estimates of time to reach maturity are from Meats (1981)

	From release No.			
	1	2	3	4
Date of release	12.xii.1983	7.ii.1984	6.iii.1984	14.ii.1985
Mean temp. (°C) for 2 weeks after release	22·0	22·0	17·9	20·4
Estimated time to reach maturity (days)	15	15	27	21
Percentage recovered in traps	0·3	0·2	0·03	–

Table 2. Numbers of *Dacus tryoni* recaptured 1–6 km from the release point during the 9 weeks after releases 1–3

Wr., watercourse; –, absence of traps

Distance (km)	Numbers recaptured from trap lines to the: N.	NE.	E.	SE.	S.	SW.	W.	NW.	SE.(*Wr.*)	NW.(*Wr.*)
					Release No. 1					
1·0	27	45	34	21	5	10	19	7	66	233
1·5	23	16	40	17	8	16	4	1	20	36
2·0	2	17	10	3	2	1	0	2	4	0
3·0	2	4	0	26	0	0	0	1	–	–
4·0	5	2	2	4	0	0	0	2	–	–
5·0	1	0	8	1	0	0	0	0	–	–
6·0	0	0	0	0	0	0	0	0	–	–
					Release No. 2					
1·0	28	10	12	18	28	5	4	3	66	33
1·5	19	5	3	0	0	1	0	1	10	27
2·0	2	3	4	0	3	0	0	0	3	0
3·0	2	0	0	1	0	0	0	0	–	–
4·0	1	1	3	3	0	0	0	1	–	–
5·0	0	0	1	0	0	0	0	0	–	–
6·0	0	0	1	0	0	2	0	0	–	–
					Release No. 3					
1·0	6	3	1	9	6	0	0	0	9	4
1·5	1	4	0	0	0	0	0	0	4	2
2·0	2	0	3	0	0	0	0	0	0	0
3·0	0	1	0	2	0	0	0	0	–	–
4·0	0	0	0	0	0	0	0	1	–	–
5·0	0	0	1	0	0	0	0	2	–	–
6·0	0	0	1	0	0	0	0	0	–	–

Results

The average time taken by the released flies to reach maturity (i.e. the stage when they are attracted to cue-lure) was estimated, by the formula of Meats (1981), to be 15 days for the first two releases, 27 days for the third and 21 days for the fourth (Table 1). The rates

of recovery for the first three releases were 0·3, 0·2 and 0·03%, respectively (Table 1). No estimate of recovery was made for the fourth release because only traps beyond 6 km from the release point were used.

The numbers of flies recaptured 1–6 km from the release point during the 9 weeks after the first three releases are shown in Table 2. Most were recaptured in the built-up area of the town, within 1·5 km of the release point. An analysis of variance of the relationship between mean catch over 1–6 km and direction showed that there was a significant ($P<0·05$) easterly movement in the first release but not in the second or third (Table 3).

Table 3. Relationship between mean catch of released *Dacus tryoni* and direction from release point

All data are for traps 1–6 km from release point. Within each release, values with the same letter in the superscript are not significantly different at the $P<0·05$ level

Release No.	Mean catch in traps to the:							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1	$8·6^{AB}$	$12·0^{A}$	$13·4^{A}$	$10·3^{A}$	$2·1^{B}$	$3·9^{B}$	$3·3^{B}$	$1·9^{B}$
2	$7·4^{A}$	$2·7^{AB}$	$3·4^{AB}$	$3·1^{AB}$	$4·4^{AB}$	$1·1^{B}$	$0·6^{B}$	$0·7^{AB}$
3	$1·3^{A}$	$1·1^{A}$	$0·9^{A}$	$1·6^{A}$	$0·9^{A}$	0^{A}	0^{A}	$0·4^{A}$

Table 4. Wind speed and direction for 21 days after releases of *Dacus tryoni*

Days after release	Wind speed (km h^{-1}) and direction after release No.:			
	1	2	3	4
1	26 SW.	10 SE.	10 NE.	9 S.
2	10 SW.	18 SE.	36 SW.	11 NW.
3	26 SW.	18 S.	10 SW.	25 SW.
4	26 S.	10 SE.	16 SE.	9 S.
5	18 S.	4 N.	18 SW.	9 SE.
6	18 SE.	18 S.	4 SE.	9 NW.
7	10 N.	10 SW.	16 NE.	7 N.
8	26 NE.	18 SE.	10 SW.	9 N.
9	18 NW.	10 NW.	26 N.	10 NW.
10	18 SW.	18 N.	26 W.	11 SW.
11	10 W.	10 E.	18 SW.	7 NW.
12	4 NW.	4 SE.	10 NE.	7 N.
13	4 SW.	18 N.	4 SE.	14 W.
14	10 SW.	10 N.	18 SW.	22 SW.
15	4 SE.	10 N.	26 SW.	7 NW.
16	10 SE.	18 NE.	18 SE.	9 NW.
17	18 NW.	10 NW.	4 SE.	10 NW.
18	18 N.	18 SW.	10 NE.	18 W.
19	4 W.	4 SE.	10 SE.	7 N.
20	26 N.	18 NE.	18 NW.	25 SW.
21	26 NE.	36 SW.	18 N.	14 S.

Traps along the watercourse also had significantly higher catches ($P<0·05$) than non-watercourse traps in a similar direction.

The catches beyond 6 km for the four releases are shown in Fig. 1. All catches were east of the release site, with the exception of one fly recovered at Shepparton 80 km west. Most recoveries were made in townships where there were several traps. In total, 35 flies were recaptured more than 6 km from the release point. At three locations, two flies were recovered from the same trap at the same time; these were Chiltern after the first release, and Wodonga and Rutherglen after the second.

The fly recovered furthest from the release point had reached Granya, 94 km north-east. It was trapped 50 days after the first release. The other long-distance fliers from this release were recovered sooner, the earliest at Wodonga and Rutherglen after 22 days. The earliest recovery from the second release was made after 17 days, at Rutherglen. In the third and fourth releases, the earliest recaptures were made after 30 and 20 days, respectively.

In order to determine whether or not wind influenced the direction in which flies were recaptured, the 1500 h wind data for Wangaratta for 3 weeks after each release was obtained from the Bureau of Meteorology (Table 4). A 3-week interval was chosen because it was considered that this would constitute the main dispersive period for each release, based on the assumption that most flies would disperse before they had matured (Table 1). Strong winds (>20 km h^{-1}) blew from several directions but the most prevalent were from the south-west. After the first release, the strongest winds were from the south-west (twice), north-east (twice), south and north, and mostly during the first 8 days. There was only one strong wind after the second release, a south-westerly on the 21st day. Strong winds from the south-west (twice), west and north blew during the 15 days after the third release. South-westerlies were the only strong winds in the 3 weeks after the fourth release.

Discussion

The major dispersive phase of *D. tryoni* occurs in the period between emergence and maturation, but its outcome cannot be judged until the released males are attracted to cue-lure in Jackson traps. This, usually, is not until they reach maturity (Monro and Richardson 1969; Fletcher 1973). The time taken for this depends on temperature and was estimated to be shorter in the first two releases than in the other two (Table 1). This is supported by the long-distance recoveries, the earliest of which occurred 17 days after the second release.

The proportion of *D. tryoni* recovered in the third release was much lower than that for the first and second (Table 1). A possible reason is the cooler weather after the release in March. This may have reduced the attractiveness of the traps as well as the opportunities for flight. Fletcher (1974) found that few males respond to cue-lure during cold weather and his recaptures dropped off markedly from March onwards.

The catches beyond 6 km for all releases, and at 1–6 km for the first release, suggest that movement of *D. tryoni* was easterly. There was no obvious physiographical reason for this. However, there were more traps north of Wangaratta than south, and the Murray River may have produced an edge effect which influenced the picture to some extent.

Within Wangaratta, the built-up area extended as far west of the release point as east, and the vegetation was similar throughout. Although more flies were trapped at watercourse locations than at others the same distance from the release point, catches were similar in the south-east and the north-west. Fletcher (1974) also found higher catches along watercourses and suggested that this was due to extra shelter and greater availability of water.

Beyond Wangaratta, watercourses appear to have had little influence on movement. The Ovens and King Rivers run south-east to north-west through Wangaratta but only two flies were trapped at river locations more than 6 km from the release point.

One environmental factor that may have influenced movement is wind. The most prevalent strong winds (>20 km h^{-1}) were south-westerly, and these preceded long-distance recoveries in the north-east in three of the releases. However, in the second release, the first strong wind occurred on the 21st day and this was several days after three flies had already been recovered at Rutherglen. It is apparent, therefore, that there is no consistent correlation between strong winds and trap catches. Fletcher (1974) found no clear correlation between prevailing wind and direction of travel of *D. tryoni*, but Steiner (1969*a*) reported that wind had a dominant dispersing influence with *D. dorsalis*. Both Steiner (1969*a*) and Kawai *et al.* (1978) concluded that inter-island dispersal of *D. cucurbitae* was wind-assisted.

Johnson (1969) cited numerous examples of wind-assisted dispersal by other Diptera and insects of other orders.

The results have demonstrated that young *D. tryoni* adults can disperse up to 94 km, approximately four times the distance recorded previously for this species (Fletcher 1974; Drew and Hooper 1983). Whether or not movements of adults over this distance could lead to new infestations may depend on the numbers that move together.

Bateman (1979) suggested that the dispersal characteristics of *D. tryoni* would make it a very poor coloniser of new areas. He was, however, assuming that individuals would arrive in a new area as larvae in fruit rather than as immigrating adults, and that relatively small numbers would be involved. In this context, he proposed that 'dispersing individuals move outwards into a 'vacuum' where their chances of finding a mate are near zero'. This proposition appears to be based both on previous dispersal work on *D. tryoni*, which suggested 'random' movement (Fletcher 1974), and on the fact that adults take approximately 2 weeks to reach sexual maturity, by which time they are presumed to be well separated. However, recent observations in Brisbane (Drew, unpublished data) have shown that *D. tryoni* assemble in host trees to feed and mate prior to oviposition. It is therefore likely that congregation in host trees occurs after dispersal and that this enhances the chances of mating.

In the current study, in spite of the widespread distribution of the traps, there were three cases of more than one fly being collected in the same trap at relatively distant locations. This would suggest that, where large populations are involved, there is a chance of both sexes meeting after long-distance dispersal and new infestations could result.

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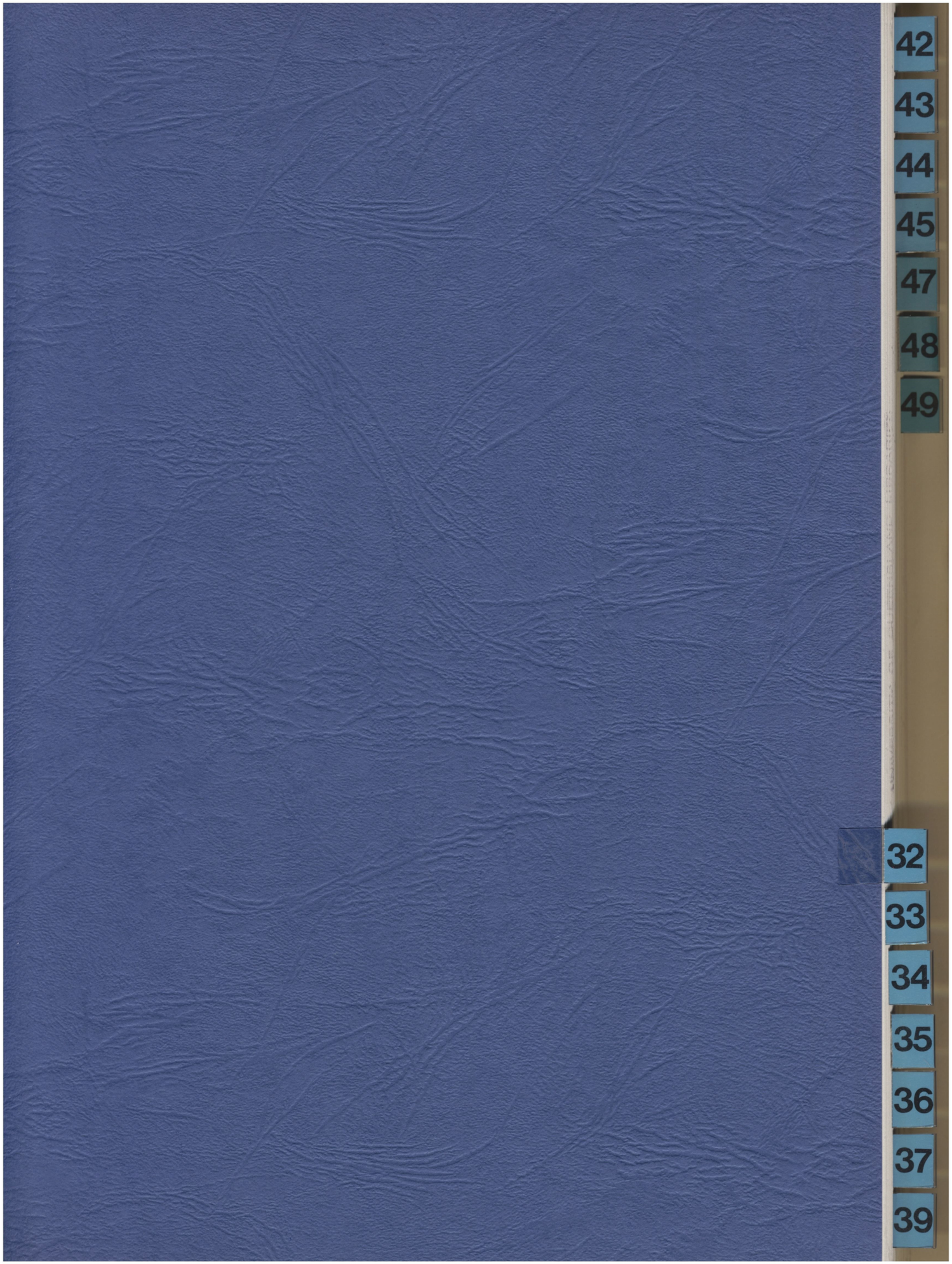
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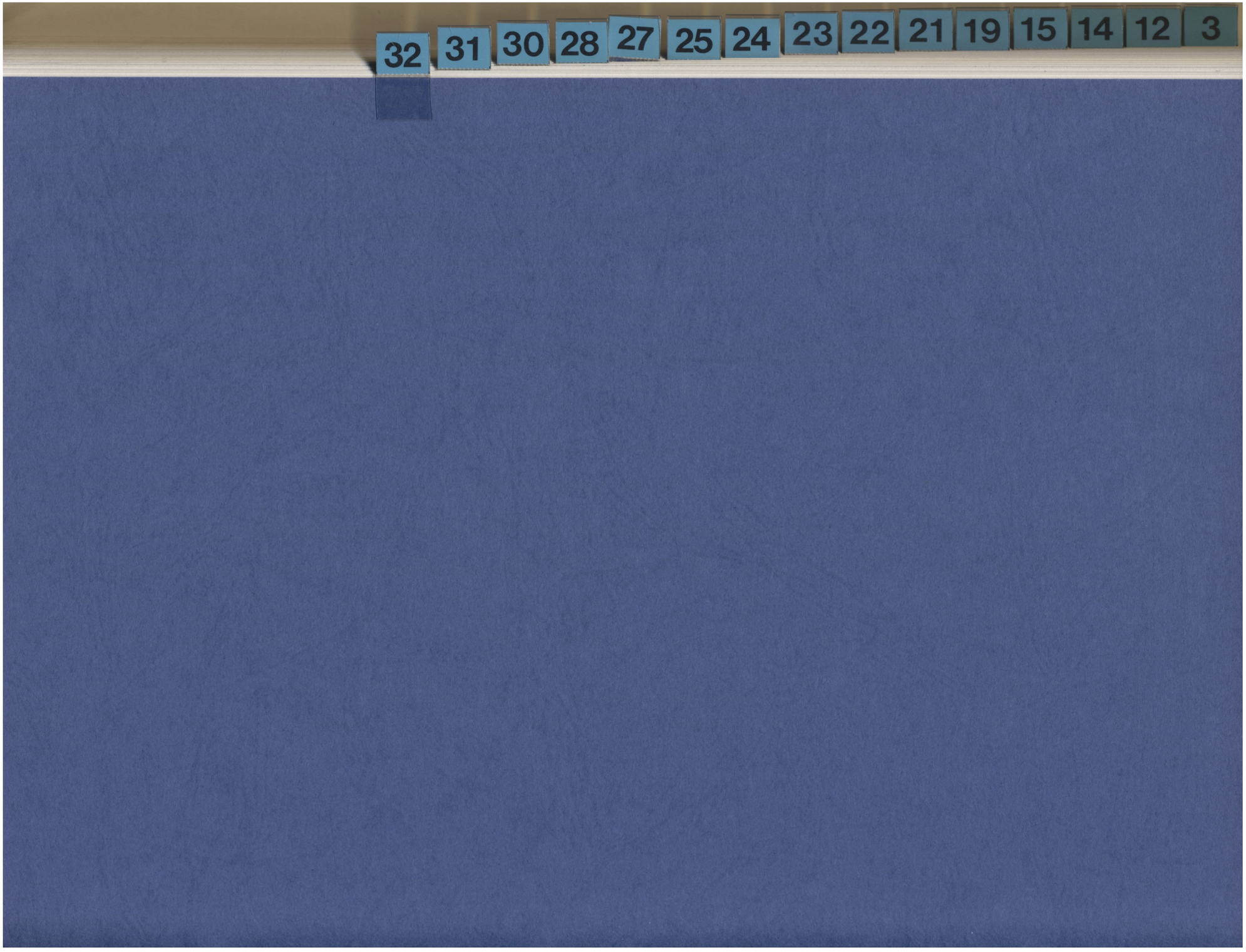
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Reduction in Fruit Fly (Tephritidae : Dacinae) Populations in their Endemic Rainforest Habitat by Frugivorous Vertebrates

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Abstract

The reduction in larval populations of *Dacus cacuminatus* (Hering) and *D. halfordiae* (Tryon) by frugivorous vertebrates feeding on their major host fruits was studied in an endemic rainforest habitat in south-east Queensland. Throughout the spring and summer season, 66% of *Solanum mauritianum* Scop. fruit (*D. cacuminatus* host) was eaten by *Macropygia phasianella* (Temminck), the brown pigeon; this increased to 77% during the fruit fly's breeding season (November–January). The peak feeding time of the birds, the breeding season of the flies, and the peak fruiting season of the plants all coincided. Parasitism of *D. cacuminatus* by Hymenoptera, *Biosteres kraussi* (Fullaway) and *B. oophilus* (Fullaway), never exceeded 16–17%. Rodents consumed larvae in 78% of fallen fruit of *Planchonella australis* (R. Br.) Pierre (*D. halfordiae* host). It is proposed that frugivorous predators are the major natural enemies of larvae of tropical Tephritidae in their endemic habitat.

Introduction

The economic importance of tephritid fruit flies has resulted in considerable research on their natural enemies and biological control. Mature larvae leaving the fruit, pupae and emerging adults (all associated with soil) are the stages most exposed to the action of natural enemies, particularly predators (Bateman 1972). The egg and larval stages in fruit are relatively well protected from this pressure, but are still attacked by hymenopterous parasites.

The common predators have been defined as Formicidae, Dermaptera (Chelisochidae), Staphylinidae, Carabidae, Chrysopidae, Pentatomidae, mites, field crickets and myriapods (Monteith 1971, 1972; Bateman 1972; Boller and Prokopy 1976). However, the Formicidae, Carabidae, Staphylinidae and myriapods do not appear to be able to detect and/or crack pupae (Boller and Prokopy 1976). The reduction in fly populations due to these predators appears to be small.

A large number of parasitic Hymenoptera have been studied, but most exist in low densities in native hosts and rarely influence infestation rates in cultivated hosts (Bess and Haramoto 1961; Boller 1966; Bateman 1972).

All major fruit fly biocontrol programs have been based on the release of parasitic Hymenoptera (Newman 1908; Noble 1942; Bess *et al.* 1961; Snowball *et al.* 1962; Snowball and Lukins 1964; Snowball 1966). However, these play only a minor role in reducing fly numbers and a high degree of effective control has never been achieved by the use of parasites (Bateman 1972; Boller and Prokopy 1976; Prokopy 1977).

This paper reports data on the destruction, by vertebrates feeding on them, of host fruit of *Dacus cacuminatus* (Hering) and *Dacus halfordiae* (Tryon) in the endemic rainforest habitat. The associated reduction in numbers of fruit flies is discussed.

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Materials and Methods

The major part of the work was undertaken at Mt Glorious (27°20'S.,152°46'E., altitude 730 m) in south-east Queensland from mid-August 1981 (late winter) to the end of March 1982 (early autumn). The area is covered with subtropical rainforest interspersed with small farms. *Solanum mauritianum* Scop. (wild tobacco) is a small shrub which grows on the margins of the rainforest, and fruits during spring and summer. Its inflorescence and fruiting heads have been described by Symon (1981) and Drew and Hooper (1983). *Planchonella australis* (R. Br.) Pierre is a large tree within the forest, where it attains 30 m in height and fruits prolifically in late spring and early summer. Its fruits are oval, approximately 5 cm in diameter, and black when mature,

Some supplementary studies were carried out on *S. mauritianum* at Brisbane, on the coastal lowlands, where it fruits throughout the year but most prolifically during spring and summer.

Caged branches. Four large branches of *S. mauritianum* (each on a separate plant) were each enclosed in a cage that excluded frugivorous vertebrates but permitted access by fruit flies. Each cage was 1·5 by 1 m diameter, covered with 13-mm wire-mesh, and floored with 1-mm nylon mesh. Weekly counts were made of the number of flower heads, immature fruit clusters, mature fruit clusters, total berries, fallen berries, fruit flies and parasites reared from fallen berries.

Uncaged branches. Fruit-collecting trays were suspended beneath four large branches of *S. mauritianum* on separate plants. The trays were 1 m^2, of 13-mm wire-mesh, beneath which was attached a bag made of 1-mm nylon cloth. These trays were painted green for camouflage and designed so that fruit could fall through the wire mesh into the cloth bag. A similar, larger tray (2 by 1 m) was placed beneath a large branch in Brisbane, an area that does not have frugivores of *S. mauritianum*. The same weekly counts were made as for the caged branches.

Ground cage. A cage 4 by 2 m and 0·3 m high was built on the ground beneath a large area of *S. mauritianum* plants. The cage was covered with 13-mm wire-mesh and floored with 1-mm nylon mesh. Weekly counts were made as for the caged and uncaged branches, except that the total number of berries on the plants was not counted.

Uncaged ground area. An area of 4 by 2 m was marked out beside the ground cage and beneath the same plants. Each week the same counts were made as for the ground cage.

Trapping. A Steiner trap baited with methyl eugenol (4 ml with 1 ml 50% w : v dichlorvos concentrate) and a McPhail trap baited with brewer's yeast (5 g in 200 ml water) were set in the grove of *S. mauritianum* at Mt Glorious.

Observations. The feeding behaviour of frugivorous vertebrates was observed in the *S. mauritianum* plants throughout each weekly sampling day. The number of fallen mature fruits per flower head was estimated for the caged and uncaged branches for the entire spring–summer season (September–February) and the fruit fly breeding period (November–January), and the difference between these values was used to assess the percentage of fruit lost to the birds.

During mid-November 1982, the feeding of nocturnal rodents on *P. australis* fruit was studied. Fruit samples were randomly collected and counts made of fruit damaged, undamaged fruit, and fruit fly larvae present in both categories of fruit.

Results

Studies on S. mauritianum

Data relating to the successful maturation of *S. mauritianum* berries on the caged and uncaged branches are given in Table 1. For the duration of the study (mid-August to late March) the number of fallen berries per fruit cluster on the uncaged branches fell by 66% (Table 1). During the oviposition period of *D. cacuminatus* (10 November 1981–27 January 1982) the fruit was heavily infested, and the number of fallen berries per fruit cluster was further reduced, by 77%.

D. cacuminatus oviposited in the berries as soon as they reached a mature green stage and often before they became soft.

Large quantities of mature fruit were taken by the brown pigeon *Macropygia phasianella*, which uses *S. mauritianum* berries as one of its primary food sources. Generally the birds

'eyed' a fruit and occasionally 'mouthed' it before selecting and swallowing the berry whole. Occasionally, they dropped unsatisfactory berries. Other birds that fed occasionally on the berries were the king parrot *Alisterus scapularis*, regent bower bird *Sericulus chrysocephalus*, catbird *Ailuroedus crassirostris*, and crimson rosella *Platycercus elegans*, although these were responsible for only a minor reduction in berry numbers.

The number of brown pigeons that visited the study area and fed increased from the end of winter (late August) to late spring but declined in early summer, when courtship, mating behaviour and nesting was observed. In early autumn, large flocks of young brown pigeons were observed feeding on fruit of the sandpaper fig *Ficus opposita* Miq.; these were probably the progeny of birds that fed on *S. mauritianum* in spring.

At Mt Glorious, the birds' feeding caused a major reduction in the number of fruit clusters that reached maturity, the number of yellow berries present on mature fruit clusters, and the number of fallen berries per flower head. This loss of fruit was not reflected in the total numbers of flies reared from fallen fruit. Fewer flies were reared from fruit from the caged branches (112 flies from 516 fruit) than from the uncaged ones (185 flies from 399 fruit), probably because fewer flies entered the cages to oviposit. Also, fallen caged fruit was sampled once per week and exposed to sun on the cage floors, so that overheating may have caused greater mortality than in the fruit from uncaged branches. During the oviposition period the fruit clusters on the caged branches were larger, averaging 30·4 berries compared with 10·5 for the entire fruiting season (Table 1).

Table 1. Effect of exclusion of birds on the development of fruit of *S. mauritianum* at Mt Glorious

	Spring–summer		Fruit fly breeding season	
	Uncaged branches	Caged branches	Uncaged branches	Caged branches
No. of fruit clusters	159	102	58	17
No. of mature clusters	18	102	–	–
No. of yellow fruits	17	673	–	–
No. of fallen fruits	565	1072	399	516
No. of fallen fruits per cluster	3·55	10·5	6·9	30·4
No. of fruit flies reared	–	–	185	112
Percentage loss of fruit	66	–	77	–

In Brisbane, fruit flies bred throughout the year in *S. mauritianum* and the fly populations were much larger than at Mt Glorious. All *S. mauritianum* fruit clusters developed to maturity and produced consistently larger numbers of berries (33·4 per fruit cluster). Frugivorous vertebrates were absent. Consequently, many more flies were reared from the greater number of fallen berries beneath the uncaged branch in Brisbane (763 flies) than from the uncaged (185 flies) and caged (112 flies) branches at Mt Glorious. The infestation rate in berries was also greater in Brisbane.

In the ground study, the number of fallen fruit per fruit cluster was 20% less in the uncaged than in the caged ground area (Table 2). The total numbers of fruit flies reared from the fallen fruit were similar, but the number of flies reared per cluster was 15% lower in the uncaged than the caged area. This indicates that frugivores had selected infested fruit.

The activity of hymenopterous parasites was erratic. The oviposition activity of parasites at Mt Glorious reached a peak in the middle of the fruit flies' 12-week breeding period, when in 1 week 27 parasites emerged from nine out of a total of 53 fruit fly pupae. This represented a parasitism rate of pupae of 17% during the peak period of fly oviposition. Similarly, in Brisbane, parasitism reached a peak of 16%. Two parasite species were

recorded, *Biosteres kraussi* (Fullaway) and *B. oophilus* (Fullaway), the latter being more prevalent.

Female *D. cacuminatus* were collected in the yeast traps during the flies' oviposition period. Male *D. cacuminatus* were collected at methyl eugenol over a longer period, with the peak catch (1228 flies per trap per week) in mid-December, the middle of the fly oviposition period.

Table 2. Effect of exposure to ground-dwelling vertebrates on the loss of fruit of *S. mauritianum* at Mt Glorious during spring and summer

	Caged ground area	Uncaged ground area
No. of fruit clusters	204	255
No. of fallen fruits	836	784
No. of fallen fruits per cluster	4·1	3·3[A]
No. of fruit flies reared	176	187
No. of parasites	31	27
No. of fruit flies reared per cluster	0·86	0·73

[A] 20% of fruit was lost.

Studies on P. australis

Regular visits to the Mt Glorious rainforest revealed that rodents were active at night and inactive during the day. *P. australis* fruit with fresh damage, bearing numerous teeth marks matching those caused by rodents, were always present in the mornings. Consequently it was concluded that the nocturnally feeding rodents had damaged the fruit.

A total of 102 pieces of *P. australis* fruit were collected from the forest floor. This fruit was heavily infested by *Dacus halfordiae* and occasionally by *Dirioxa pornia* (Walker), and all undamaged fruits contained an average of 25 larvae. Overall, 78% of fruit had been predated upon and of these 32% contained no fruit fly larvae at the time of collection. The flesh was removed from the upper half of the fruit as far as the large seed in the centre, and placed in a circle around the fruit. The animals most probably ate the fruit fly larvae they found within the fruit.

Discussion

The current data have established that frugivorous vertebrates are responsible for major reduction in larval populations of two species of fruit fly in endemic rainforest areas. Consequently, it is proposed that such vertebrates may be the major cause of reduction in fruit fly populations in their natural habitat. This influence may be due to: (1) the ingestion of infested fruits, leading to direct destruction of fruit fly eggs and larvae; (2) the ingestion of uninfested fruits, which destroys the breeding resource available to fruit flies.

The population changes and relationships of *D. cacuminatus* to the host plant, in the study area, were reported by Drew and Hooper (1983). Fruit studies revealed 100% infestation of mature fruit; numbers of larvae per fruit decreased from seven in the first instar to four or five in the second and three in the third instar. However, when fruit were taken into the laboratory, the number of flies produced fell: 1·2 pupae were recovered per gram of fruit, and the average weight of fruit was 0·7 g. This indicated a laboratory recovery rate (less than one pupa per fruit) markedly lower than the known larval infestation rate in the field; consequently, laboratory recovery rates cannot be used as indicators of field infestation rates.

Numbers of fruit flies increased rapidly in spring, coinciding with the increase in production of *S. mauritianum* fruit, and with increasing temperature. The fruit fly efficiently

utilised the fruit as it became available. Because all mature fruits were infested, and because this was the stage eaten by birds, the 66% loss of fruits due to frugivore feeding probably caused a similar reduction in the fruit fly population. The latter, however, may have been even greater, because the loss of fruit was highest during the fruit fly's breeding period. It is possible that the birds preferred infested fruits. Not only did they select mature fruit (the stage infested by flies), but, as Crome (1975) has emphasised, the role in the birds' diet of insect larvae taken in this way cannot be overlooked. The birds' peak feeding time on the wild tobacco fruits coincided with the oviposition period of the flies and the peak fruiting period of the plants. In contrast, in the urban area of Brisbane where frugivorous vertebrates are absent, the production of fruit is much higher than at Mt Glorious, and the fruit fly population is much larger, although there is no marked difference in climate during the spring and summer. At both Mt Glorious and Brisbane, the rate of parasitism by Hymenoptera was low. At Mt Glorious, the egg and larval stages of the parasites must have suffered considerable losses due to the frugivores.

The apparent loss of *D. halfordiae* larvae due to the feeding of nocturnal rodents on the forest floor is another example of the effect of vertebrates on endemic fruit fly populations. The cassowary, *Casuarius casuarius* (L.), a large ground-dwelling bird, inhabits the rainforests of north-east Australia and feeds on fruits of 78 plant species from the middle and upper forest canopy (Stocker and Irvine 1983). Many of these fruit species (Stocker and Irvine 1983) are known hosts of the fruit fly, and the cassowary's breeding season corresponds with the time of maximum abundance of fruit (Crome 1976), which in turn is the period of maximum fruit fly infestation. It seems likely, therefore, that the fruit-eating habits of the cassowary may result in significant mortality of fruit fly larvae. Vertebrates have been overlooked as natural enemies of fruit flies by many reviewers (Bateman 1972; Boller and Prokopy 1976; Prokopy 1977).

The tropical Dacinae have an extremely high fecundity, with some species (notably the economic ones) ovipositing in many fruit hosts and fitting the concept of an *r*-selected species (Drew and Hooper 1983). It appears that there has been considerable natural selection pressure, induced by vertebrate predators, leading to this high reproductive capacity. The skipping (popping) behaviour of the tephritid larvae leaving fruit for pupation in the soil is possibly an adaptation to escape both vertebrate and invertebrate predation. It would be an effective escape mechanism, particularly when ground-dwelling predators are feeding on fallen fruit. In contrast, the flower-feeding tephritid larvae do not skip, and generally pupate in the flower head. There are no records of animal feeding on the host flowers of these flies.

Hymenopterous parasites are not major natural enemies of fruit flies in their endemic habitat, and probably have limited use as agents for fruit fly control in cultivated host fruits.

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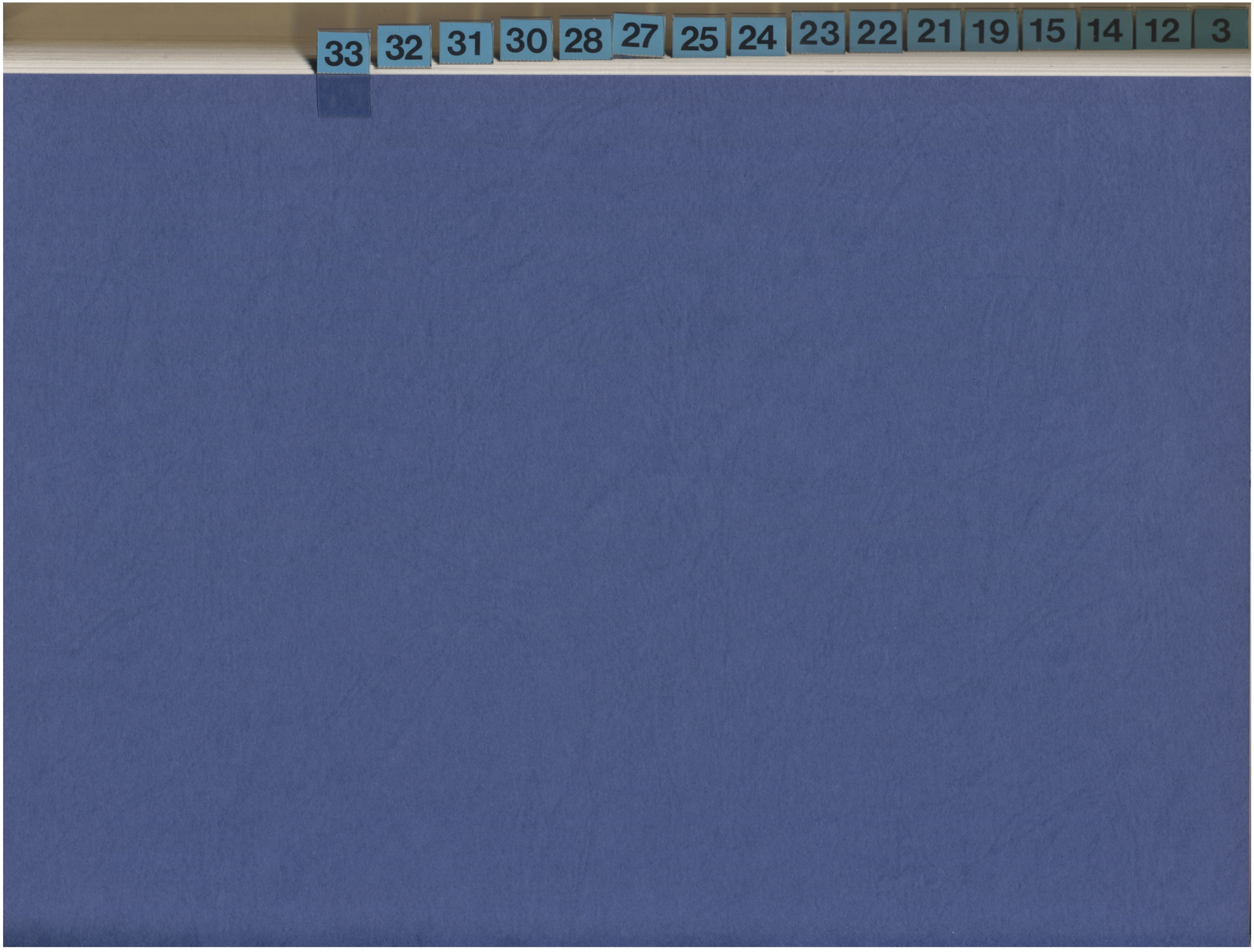
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Behavioural strategies of fruit flies of the genus *Dacus* (Diptera: Tephritidae) significant in mating and host-plant relationships

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Abstract

Adults of *Dacus* spp. feed on plant surface bacteria. The responses of *D. tryoni* (Froggatt) and *D. cacuminatus* (Hering) to some components of bacterial odours and to cue-lure were tested in a field-cage olfactometer, in studies in south-eastern Queensland. One component of bacterial emission, 2-butanone, attracted *D. tryoni* (a species responding to cue-lure) but not *D. cacuminatus* (a species responding to methyl eugenol) and is suggested as the attractive portion of the cue-lure molecule. Sexually mature males and immature females of *D. tryoni* responded to 2-butanone, cue-lure and bacterial odours in field-cage tests. Females fed on sugar and water required protein hydrolysate to produce eggs, but males were fertile with or without protein. These different nutrient requirements, and the fact that males and females possess different crop colour and bacterial contents when feeding in the same host-plant, indicate that the sexes feed on different substrates. Consequently, the strong bacterial attractant cues in the host-tree may be a feeding attractant to females and a sex attractant to males. It is proposed that 2-butanone is an important rendezvous stimulant in nature, bringing the mature male flies into the feeding and oviposition sites (host-trees) of the developing females for mating encounters.

Introduction

Little is known about the attraction of species of Dacinae to their hosts and the behaviour of the flies within the host-plant. The males of many species respond to specific male attractants (Drew, 1974; Drew & Hooper, 1981), and this suggests some odour orientation in the life system of the fly. Consequently there has been considerable attention paid to understanding the biological significance of these chemicals in the fruit fly life system.

Because the flies feed vigorously on the lures when attracted, some workers have defined them as food lures (e.g. Beroza & Green, 1963), yet the almost specific attraction for males has led others to believe that they are specific sex attractants. Fletcher (1968) and Fletcher *et al.* (1975) have called them parapheromones and believe that they attract males because of a fortuitous resemblance to male aggregation or female sex pheromones.

A number of workers have observed that virgin females respond to these chemicals over short distances and that this response declines after mating (Nakagawa *et al.*, 1970; Fitt, 1981). This led Fitt (1981) to state that they are intimately related to the pheromone communication system of the flies. Metcalf (1979) reported that virgin and starved females have been recorded as responding to cue-lure and methyl eugenol. Methyl eugenol has

been isolated from a range of plants representing ten families (Metcalf, 1979), but cue-lure has not been recorded in any plant. However, Metcalf (1979) defined both chemicals as plant kairomones that have arisen from a common precursor, *p*-hydroxycinnamic acid that occurs within plants. Further, Metcalf *et al.* (1979) suggested that the primitive Dacinae coevolved with plants containing *p*-hydroxycinnamic acid and as speciation progressed two subgroups segregated, one responding to methyl eugenol and the other to *p*-hydroxyphenyl-2-butanone. It was also suggested that these chemicals are important in bringing the sexes together for mating on the host-plant, promoting host selection through a complex chemical ecology (Metcalf, 1979; Metcalf *et al.*, 1983).

The restriction of mating to host-plants has been defined as a crucial element in the theory of sympatric speciation (Bush, 1966, 1969, 1974; Huettel & Bush, 1972), and Bush (1966) suggests that host-plant odours may act as secondary sex attractants or rendezvous stimulants to bring the sexes together within the host-plant.

Recently, it has been shown that specific plant surface bacteria are a natural source of food for adult fruit flies (Drew *et al.*, 1983), and in the present paper, studies on adult behaviour, nutrition and attraction to bacterial odours are reported in order to explain the significance of these bacteria in the life system of the flies.

Materials and methods

The response of *Dacus tryoni* (Froggatt) to phenyl acetate, cue-lure and some components of the odours of bacteria, viz. 2-butanone (methyl ethyl ketone), butan-1-ol and isopentanol, was tested in a large field cage (3·1 × 3·1 × 2·1 m) in south-eastern Queensland. Approximately 2000 flies (*ca.* 50:50 sex ratio) representing all stages of sexual development were released into the cage. Six Steiner traps, five baited with one of the test chemicals and one unbaited, were hung from the ceiling of the cage equidistant around the perimeter; 10 ml of chemical was placed in each trap in a small glass vial with a pore 2 mm in diameter in the lid. The traps were rotated every hour, at which time the captured flies were counted, sexed and dissected for assessment of sexual maturity after the method of Drew (1969). The experiment lasted for 6 h and was replicated three times on three different days. The data were analysed using a factorial analysis of variance. Similarly, the response of *D. cacuminatus* (Hering) to phenyl acetate and some components of bacterial odours, viz. 2-butanone, butan-1-ol and isopentanol, was tested.

The attractancies of 2-butanone and cue-lure were compared under field conditions by baiting two pairs of traps as above and suspending one pair in a peach tree and the other in a mulberry (both without fruit). Two drops of dichlorvos at 500 g/litre were placed in each trap on small sheets of filter paper, and the number of flies collected was recorded.

The development of response of *D. tryoni* to cue-lure from emergence to sexual maturity was investigated by assessing the responses of flies from emergence to 13 days old. Fourteen cages, each containing 200 flies (*ca.* 50:50 sex ratio) which had emerged on the same day, were held at a constant temperature of 25°C and fed on sugar, water and protein hydrolysate. Each day, one set of 200 flies was released into the field cage for testing and removed the following day before the next release. One trap baited with 5 ml cue-lure on a cotton wick and one unbaited control trap were suspended from the ceiling on opposite sides of the field cage and rotated every hour for 6 h, after which the flies in each trap were counted and released.

The influence of hydrolysed protein diet on the survival and fertility of males of *D. tryoni* was studied. Separate cages of 50 males and 50 females which emerged on the same day were held at 25°C. One cage of each sex was fed on sugar and water, and two cages of each were fed on sugar, water and hydrolysed protein (autolysed brewers' yeast fraction, Amber—BYF, Amber Laboratories, Wisconsin, USA). Twenty-one days after emergence, cages of males plus females were set up in the following combinations: males fed on sugar and water plus females fed on sugar, water and protein; males fed on sugar, water and protein plus females fed on sugar and water; males plus females fed on sugar, water and protein. After combining, they were fed on sugar and water only, and seven days later the

numbers of males and females in each cage were counted and a hollowed apple dome (made by removing the flesh from half an apple, piercing the dome of skin with fine holes and fixing it to a plate with wax) used to collect eggs for 2 h. The eggs were counted and held for 48 h, after which the percentage egg hatch was calculated.

To investigate the possibility that *D. tryoni* males and females may feed on different substrates, the protein requirement of each sex was compared. Two experiments were conducted. Separate cages of either 100 males or 100 females were held at 25°C and fed specified diets for 21 days after emergence, then 50 males and 50 females were combined for three days before an egg production and fertility test was undertaken. All flies were fed sugar and water during the entire experiment, with the protein hydrolysate diet being varied and the sexes combined as follows: males from cage of 100 fed no protein were combined with females from cage of 100 fed excess protein; males fed 0·05 g protein/100 flies per week with females fed excess protein and the reciprocal combination; males fed 0·025 g protein/100 flies per week with females fed excess protein and the reciprocal; both males and females fed excess protein. In the second experiment, the protein diet was changed to give the following combinations: males fed nil protein with females fed excess protein; males fed excess protein with females fed nil protein; males and females fed excess protein; males fed 0·01 g protein/100 flies per week with females fed excess protein and the reciprocals. In all cases, eggs were collected over a 5-h period in a hollowed apple dome and held for three days to estimate the number of eggs produced per female per hour and the percentage egg hatch.

The capacity of *D. tryoni* females to produce eggs on a single protein feed and the time taken after this feed for egg maturation was assessed. Eight cages of *ca.* 100 flies (50:50 sex ratio) were all held at 25°C and fed on sugar and water for the duration of the experiment. Beginning on day 2 after emergence and thereafter every two days until day 14, one cage of flies was fed excess protein hydrolysate for 6 h. One cage of flies was fed on sugar and water only. On day 15 after emergence, an egg production test was conducted on each cage of flies by allowing flies to oviposit in a hollowed apple dome for 4·75 h and the number of eggs produced per female per hour and percentage egg hatch estimated. The egg production of flies fed on day 14 was nil on day 15, and so these flies were again tested on day 16 (two days after the protein feed).

Results

The total number of *D. tryoni* collected at each chemical and the percentages of mature and immature female and male flies are given in Table I. The significant differences (at the 5% level) when analyses were carried out in four categories, i.e. total flies attracted per hour, number of male flies attracted per hour, number of female flies attracted per hour and percentage of male flies attracted are shown in Table II. 2-Butanone attracted the highest number of flies per hour and this catch was significantly higher than that for the other chemicals. Cue-lure attracted mostly males (93·6%). The number of females collected at cue-lure was equal to that for isopentanol, butan-1-ol and the control trap. In

TABLE I. *Total numbers and maturity state of* Dacus tryoni *collected at various lures during tests in a large field cage containing approximately 2000 flies**

	Males			Females		
Chemical lure	No.	% Mature	% Immature	No.	% Mature	% Immature
Cue-lure	413	80	11	39	1	8
2-Butanone	658	55	16	263	9	20
Phenyl acetate	219	57	12	95	11	20
Butan-1-ol	171	45	26	70	11	18
Isopentanol	135	73	4	40	3	20
Control (unbaited trap)	50	24	26	31	22	28

* Three replications; fly counts lasted 6 h.

TABLE II. *Significant differences between numbers of males and females of* Dacus tryoni *attracted to various lures during tests in a large field cage containing approximately 2000 flies**

Chemical lure	Mean no. of flies/h**	Mean no. of male flies/h**	Mean no. of female flies/h**	% male flies/h**
Control (unbaited trap)	5·00 *a*	3·36 *a*	1·48 *a*	67·9 *a*
Isopentanol	9·97 *ae*	7·36 *a*	2·24 *a*	75·8 *a*
Butan-1-ol	10·97 *be*	7·85 *b*	2·90 *a*	78·9 *b*
Phenyl acetate	14·24 *b*	9·61 *b*	4·33 *b*	63·4 *a*
Cue-lure	23·48 *c*	21·26 *c*	1·78 *a*	93·6 *c*
2-Butanone	47·21 *d*	33·18 *d*	13·39 *c*	70·5 *a*

* Three replications; fly counts lasted 6 h.
** Data are equivalent means; an arc sine transformation was applied to data before analysis.
Values followed by the same letter in each column are not significantly different at the $P = 0{\cdot}05$ level.

these traps, the collection of females can be assumed to be incidental. 2-Butanone collected 78·9% males but also attracted significantly more females than the other chemicals.

No specimens of *D. cacuminatus* responded to 2-butanone, butan-1-ol and isopentanol, while one male was collected at phenyl acetate.

During the first two days of the field test with 2-butanone and cue-lure, three males of *D. tryoni* were collected at 2-butanone and 21 males at cue-lure. On the third day, all the 2-butanone had evaporated while the cue-lure remained and continued to attract flies.

The numbers of males of *D. tryoni* of increasing age from emergence to 13 days old responding to cue-lure are given in Table III. All flies caught were males except for one female on day 4. Sexually immature flies did not respond to cue-lure. Under the temperature conditions of the experiment, some flies reach sexual maturity in five days (Drew, 1969), with increasing numbers reaching this state daily thereafter. This development was reflected in the numbers of flies attracted, with a total of eight males (8%) responding on day 5, increasing to 97 (97%) on day 13.

TABLE III. *Numbers of* Dacus tryoni *that responded to Steiner traps baited with cue-lure, with increasing age**

	Age of flies (days)												
	0	1	2	3	4	5	6	8	9	10	11	12	13
No. of males	0	0	0	1	1	8	29	32	51	68	77	93	97
No. of females	0	0	0	0	1	0	0	0	0	0	0	0	0

* The sum of 6 × 1-h counts in a field cage containing approximately 200 flies.
0 = newly emerged.

The number of males and females of *D. tryoni* remaining alive 28 days after emergence on different diets, the number of eggs collected in 2 h on day 28 and the percentage egg hatch are given in Table IV. The absence of protein in the diet had a marked effect on survival, with 21 males and 14 females surviving after 28 days. Egg fertility was affected, with 21 males fed on sugar only producing a 30% fertility rate in 1544 eggs and 44 males fed on sugar and protein producing 78% fertility.

Reduced levels of protein hydrolysate in the diet of adult flies markedly affected egg production but did not reduce egg fertility (Tables V & VI). Although there is some discrepancy between the two experiments in egg production when males received no protein and the females excess protein, when the level of protein hydrolysate fed to females was reduced from excess to 0·05, 0·025 and 0·01 g/50 females per week the egg production decreased to 0·5, 0·9 and 0/female per hour, whereas the same reductions in male diet did not cause any reduction in egg fertility. Even when males were fed only on sugar and water, egg fertility was not reduced markedly.

TABLE IV. *Numbers of* Dacus tryoni *that survived from 50 of each sex after 28 days of being fed on different diets, number of eggs laid per hour on day 28 and percentage egg hatch*

Diet	No. flies surviving after 28 days	No. eggs laid/♀/h on day 28	Egg hatch (%)
Males fed sugar + Females fed sugar and protein	21 / 45	34	30
Males fed sugar and protein + Females fed sugar	46 / 14	0	—
Males and females fed sugar and protein	44♂ / 41♀	25	78

TABLE V. *Influence of different protein hydrolysate levels fed to males and females of* Dacus tryoni *on egg production and fertility*

♂ Diet*	♀ Diet*	No. eggs/♀/h	Egg hatch (%)
Nil	Excess PH	16·5	66
0·05 g PH/week	Excess PH	2·4	94
Excess PH	0·05 g PH/week	0·5	86
0·025 g PH/week	Excess PH	2·2	91
Excess PH	0·025 g PH/week	0·9	86
Excess PH	Excess PH	2·2	98

* All flies received sugar and water: nil diet = sugar and water only; PH = protein hydrolysate.

TABLE VI. *Influence of different protein hydrolysate levels fed to males and females of* Dacus tryoni *on egg production and fertility*

♂ Diet*	♀ Diet*	No. eggs/♀/h	Egg hatch (%)
Nil	Excess PH	3·1	72
Excess PH	Nil	0	—
Excess PH	Excess PH	3·6	87
0·01 g PH/week	Excess PH	6·8	81
Excess PH	0·01 g PH/week	0	—

* All flies received sugar and water: nil diet = sugar and water only; PH = protein hydrolysate.

When an excess supply of protein hydrolysate was available for one 6-h feed, there was no decline in egg production (Table VII) from the levels achieved on a continual supply of protein (Tables V & VI). Also, 0 eggs were produced one day after this single feed, 0·37 egg/female per hour after two days and up to 7·95 eggs/female per hour after three days. It is apparent that there is a rapid development of eggs after protein ingestion and that a constant supply of protein is unnecessary.

TABLE VII. *Influence of a single feed of excess protein hydrolysate for 6 h on egg production and fertility in* Dacus tryoni

Age of flies when fed protein (days)	No. eggs/♀/h	Egg hatch %
2	0·07	100
4	0·94	78
6	2·86	86
8	5·05	88
10	7·54	92
12	7·95	87
14	0	—
Nil diet	0	—

All flies received sugar and water; nil diet = sugar and water only; fly egg production was tested on day 15.

Egg production of 14-day-old flies was tested again two days after feeding and they produced 0·37 eggs/♀/h, of which 87% hatched.

Discussion

Phenyl acetate and 2-butanone together form the cue-lure molecule. The markedly increased catch of *D. tryoni* at 2-butanone (*ca.* two times that at cue-lure) and the reduced catch at phenyl acetate (*ca.* 0·7 times that at cue-lure), indicated that 2-butanone is the primary attractive component of the cue-lure molecule. This conclusion is reinforced by the studies of Beroza & Green (1963) and Alexander *et al.* (1962) in which large numbers of chemicals were tested as potential attractants for *D. cucurbitae* Coquillett (a species responding to cue-lure), and all the successful lures had the same root, 2-butanone. The nil response of *D. cacuminatus* (a species responding to methyl eugenol) to 2-butanone in the field-cage tests also emphasises the relationship of 2-butanone and cue-lure. It has been found that field and laboratory olfactometer tests do not always agree (Beroza & Green, 1963; Alexander *et al.*, 1962) and so the poor response to 2-butanone in the field is not unusual. It may be that the molecular weight of 2-butanone (boiling point 80°C) is too light to produce a strong vapour trail.

Gas-liquid chromatography and mass spectrometry analyses of the head space components produced by *Proteus* species (Hayward *et al.*, 1977) have shown that 2-butanone is present. Current chemistry studies on *Providencia rettgeri* (the genera *Proteus* and *Providencia* are closely related) isolated from the crops of field-collected feeding flies and grown on yeast autolysate have also shown that 2-butanone is produced (C. Moore & M. Fletcher, pers. comm.). Also, it has been demonstrated that 2-butanone is evolved from a range of fresh fruits, many of which are susceptible to fruit flies (Nursten, 1970).

Gow (1954) found that odours emitted by bacteria growing on soya meal attracted *D. dorsalis* Hendel, *D. cucurbitae* and *Ceratitis capitata* (Wiedemann) and that ammonia, at best, was only a mild attractive component. Recent studies have shown that several bacteria isolated from field-collected flies are strong attractants for several fruit fly species when growing on a protein-rich substrate (Drew, unpublished data). An attractancy study undertaken on *P. rettgeri* incorporated in protein hydrolysate in a field cage situation showed that the bacterial odours had a strong attraction for sexually mature males of *D. tryoni* (Drew & Fay, in press), agreeing with the results above for cue-lure and 2-butanone. While there is probably a range of chemicals in the bacterial odours attracting fruit flies, 2-butanone is likely to be a significant component.

In a study of the establishment of fruit flies and their bacteria in a large peach tree in Brisbane (Drew & Lloyd, in press), the first flies that arrived in the tree, after the fruit became susceptible to oviposition, were primarily immature females (85% immature and 15% mature) and mature males (86% mature and 14% intermediate). None of the immature females and only *ca.* 50% of the mature females had mated prior to arrival in the tree and there was a steady increase in the maturation of females with time. Flies were observed mating during a 14-day period from five days after the arrival of the first flies in the tree. Ovarian development and mating occurred after the flies had ingested protein and, from the above data, it is apparent that the host-tree attracts immature females and mature males and that the host-tree is a significant site for protein feeding, egg development and mating.

Microbiological studies (Drew & Lloyd, in press) have shown that (a) adult flies regurgitate large quantities of bacteria onto the surfaces upon which they feed and (b) there is a major build-up of these bacteria (Enterobacteriaceae), most of which occurs on the surfaces of ripening fruit, in the host-tree as the fly population increases. In studies on bacteria as a natural source of food for adult fruit flies (Drew *et al.*, 1983), it was found that in a mulberry tree (a) mature gravid females had not fed for at least one day, (b) developing females were feeding actively and possessed large quantities of bacteria in their crops and deep purple (mulberry-coloured) crop contents, (c) males generally did not have bacteria in their crops and had brown crop contents, and (d) based on the colour and bacterial composition of the crops, males and females feed on different substrates. It is apparent that after flies arrive in a host-tree they inoculate the surfaces of ripening fruit with specific bacteria and then feed on these bacteria (Drew & Lloyd, in press). This is particularly significant for developing females as they were able to produce eggs within

three days after protein intake, a very short time in relation to the fruiting period. The characteristic of flies seeking protein was illustrated when protein bait sprays were applied to mulberry (host) trees without fruit and guava trees bearing fruit-fly-susceptible fruit; no flies responded to baits on the mulberry trees (although male lure traps indicated the presence of very large populations), while large numbers were attracted to the same baits on the guava trees (Drew, unpublished data). It appears that flies only respond to protein baits in the presence of maturing fruit, showing that they seek and ingest protein for egg production only when suitable fruit for oviposition is available. The development of eggs after the flies arrive in the host-tree would be most economical in the energy budget of the insect as eggs are costly, in terms of energy, to produce.

In the laboratory feeding studies, it was demonstrated that males required little or no protein to fulfil their role in fertilizing eggs whereas the females required at least one protein feed to ensure egg production. This same difference between the sexes in nutrient requirements was shown to occur in *Rhagoletis pomonella* (Walsh) (Webster *et al.*, 1979). Considering that the fruit surface bacteria are a satisfactory source of nutrients for egg production and that the males appear to feed on different substrates, it is possible that the bacterial odour cues from the host-tree (e.g. 2-butanone) serve as two different stimuli, a feeding attractant to females and a sex attractant to mature males. This may be the reason why immature females and mature males comprised the majority of flies that first entered the peach tree and that responded to cue-lure and 2-butanone, and why flies have been recorded as feeding on cue-lure after attraction. There are records of male fruit flies swarming and feeding on substrates away from host-plants; for example, a large population of males of *D. jarvisi* (Tryon) was observed feeding on sunflower flower heads on 9 March 1984 at Katherine, Northern Territory, Australia (G. Strickland, pers. comm.). Such males would probably require a sex attractant to lure them into the host-tree if they do not normally feed there.

When a low concentration of cue-lure vapour was released by using a slow release vial, more females were collected (Table I) than when a high concentration was released on a cotton dental roll (Table III). This may be due to high concentrations of cue-lure repelling inseminated females that no longer require mates.

The host-tree appears to be the centre of activity for a fruit fly population. It is the site of adult feeding, mating, oviposition and larval feeding. The stimuli that control this are probably not only visual, especially in the Dacinae which have a weak response to colour and shapes (Hill & Hooper, 1984) and considering the fact that primarily immature females and mature males are attracted to the host-plants. It is most likely that olfactory stimuli such as 2-butanone in bacteria odours are essential elements and that these are longer distance attractants. They may even be perceived at greater distances than visual stimuli. Microbially-derived odours are thought to assume chemical communicatory significance in mammals (Albone *et al.*, 1977) and while bacterial odours seem to be similarly important in fruit flies, this special relationship may exist in other Diptera.

In studying the mating behaviour of the dung fly, *Scathophaga stercoraria* (L.), Parker (1979) reported that males often fly long distances and arrive at a fresh cowpat before the females. The males sit around the pat and wait for the females to arrive, after which mating occurs around or on the pat and the male remains on the female during oviposition. Bacterial odours or biproducts of bacterial decay may be the stimuli that attract these flies to the dung pat, males responding to lower boiling point chemicals that are emitted first. A similar mating behaviour has also been reported in the fruit fly subfamily Tephritinae in which the females oviposit in flower heads (Grewal & Kapoor, 1984). Zwolfer (1974) noted that 45 species (representing 18 genera) of Tephritinae exhibit characteristic rendezvous behaviour where the males utilize the larval host-plants as species-specific waiting places and territories for courtship and mating. It was also noted that if the sexes do not meet on their specific host-plants (rendezvous places) they are not able to recognize conspecific partners. Consequently, the dacine host fruit tree, the scatophagid dung pat and the tephritine flower head have much in common in being the major centre of activity for the flies.

Parker (1978) stated that the insect's search for mates has much in common with their search for food, that mate encounter sites have evolved in areas of resource value to females in which the females might be aggregated anyhow and that selection is always likely to be more intense on the males tracking females than vice versa. Our present understanding of the attraction of fruit flies to fruit surface bacterial odours conforms with this thesis. This strategy in fruit flies would have two important influences, one on maximizing reproductive success in the population and the other on speciation, which may depend on the restriction of mating to the host-plant (Bush, 1966, 1969, 1974).

The reproductive behaviour of Tephritidae can be used to exemplify the principles of the Recognition Concept of species (Paterson, 1978, 1985). According to this concept, it is the mechanisms which function to bring about fertilization under natural conditions that delimit the gene-pool of a species. This fertilization system includes the Specific-mate Recognition System (SMRS), which constitutes a signal-response reaction chain between the sexes. In motile biparental organisms like fruit flies, it is differences in the SMRS that determines the different gene-pools. The SMRS characters have evolved to bring about successful meeting and mating between the sexes. They are not isolating mechanisms as they have not evolved to prevent hybridization. According to this concept, species can be defined as that most inclusive group of biparental organisms that share a common fertilization system (Paterson, 1982, 1985). This study has been concerned with the fertilization systems of a number of *Dacus* species and how they relate to the mode of action of lures.

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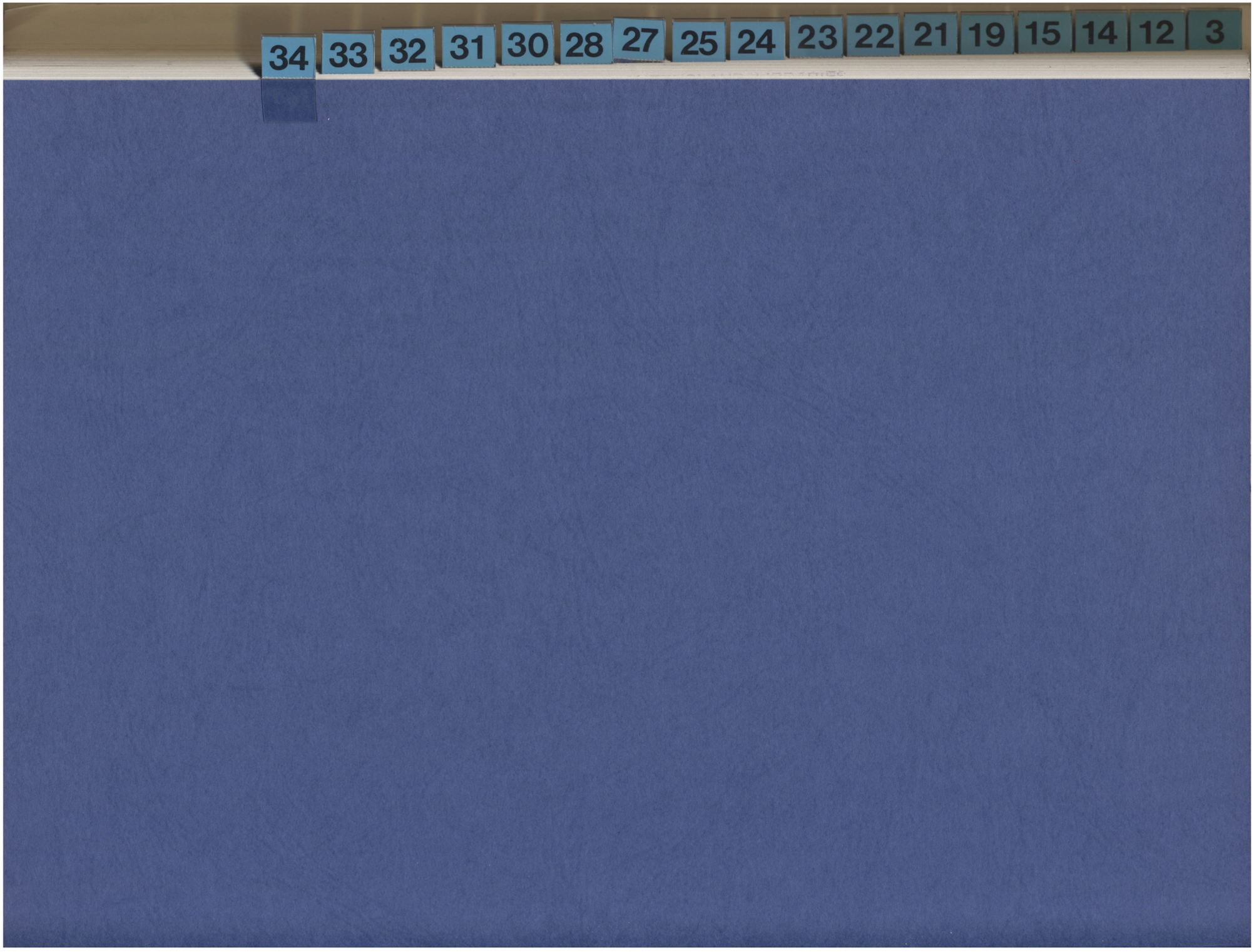
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Relationship of Fruit Flies (Diptera: Tephritidae) and Their Bacteria to Host Plants

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ABSTRACT Fruit fly species, *Dacus tryoni* (Froggatt) and *Dacus cacuminatus* (Hering), regurgitated and reingested alimentary canal contents, which included bacteria. A comparison of bacteria on caged and uncaged nectarine trees and a study of bacterial and fly populations on an uncaged peach tree, in Brisbane, indicated that fruit flies introduced certain bacteria from the alimentary tract onto the host fruit surface. Adult feeding, female maturation, mating, oviposition, and larval feeding of *D. tryoni* and *Dacus neohumeralis* Hardy were all observed in the same peach tree. Certain species of introduced bacteria belonging to the family Enterobacteriaceae appeared to be an important adult food source and thus played a significant role in the biology of the fly.

KEY WORDS *Dacus*, bacteria, host plant, adult food

ALTHOUGH THE bacteria associated with several different species of Tephritidae have been studied (Petri 1910, Rubio & McFadden 1966, Yamvrias et al. 1970, Girolami 1973, 1983, Luthy et al. 1983, Rossiter et al. 1983) the true biological significance of this insect/microbe relationship has not been elucidated. The possibility of an "obligate symbiotic" relationship between fruit flies and their bacteria is now questioned (Drew et al. 1983, Fitt & O'Brien 1985, Howard et al. 1985, Lloyd et al. 1986). A brief review of the bacteria associated with different species of Tephritidae and theories on their biological significance have been presented elsewhere (Drew & Lloyd, in press).

It is only in the last few years that the possibility of plant-surface bacteria providing a natural food source for adult flies has been seriously considered (Drew et al. 1983), although the analysis of crop contents by Dean & Chapman (1973) indicated that field-collected flies were ingesting bacteria. Certain species of bacteria isolated from crops and stomachs of actively feeding wild flies provided a complete breeding diet for *Dacus tryoni* (Froggatt) under laboratory conditions (Drew et al. 1983). Courtice & Drew (1984) suggested that availability of bacterial food on leaf surfaces played an essential role in distribution and abundance of these insects. Such "environmental criteria" in the insect/microbe relationship, as originally described by Steinhaus (1960), have largely been ignored in most studies on tephritids. The significance of leaf- and fruit-surface microflora of host, and possibly nonhost trees, in the fruit fly ecological system has not in the past been fully appreciated.

As the first step in exploring these possibilities, Lloyd et al. (1986) isolated and identified the bacteria associated with four *Dacus* species and their host plants in Queensland. Generally the bacteria present in the alimentary tract of flies were also present on the surfaces of host fruit from plants in which flies had been collected. Most of the bacteria belonged to the family Enterobacteriaceae, with *Klebsiella oxytoca, Enterobacter cloacae,* and *Erwinia herbicola* the predominant species. These are referred to as "fruit-fly-type" bacteria in this text.

This paper reports further experiments undertaken to elucidate the role of these fruit-fly-type bacteria in the behavior of fruit flies in their host trees.

Materials and Methods

These studies were undertaken in Brisbane during late spring and summer. Maximum daily temperatures ranged from 25 to 32°C and relative humidity was >70%. The fruit fly species studied are endemic to the area.

Observations on Regurgitation by Flies Feeding on Mulberry. Observations were made on the regurgitation of fluid from the mouthparts of adult fruit flies. In the first experiment, adult *D. tryoni* and *Dacus cacuminatus* (Hering) were collected in a mulberry tree bearing ripe fruit. Single specimens were placed in clear glass tubes with cotton wool stoppers. The pattern and color of regurgitated fluid and feces were recorded.

In the second experiment, starved laboratory-reared adult *D. tryoni* were placed singly in clear glass tubes containing a macerated ripe mulberry fruit. The feeding and regurgitation behavior of the flies was recorded.

Isolation of Bacteria Distributed During Feeding and Regurgitation by Adult Flies. Individual adult *D. tryoni* (both laboratory-reared and field-collected) were allowed to feed on sterile peptone yeast-extract agar plates (PYEA) (Lloyd et al. 1986) for varying times up to 15 min. The points where

the mouthparts touched the agar were marked on the underside of the plastic petri dish. When a fly appeared to have ceased feeding it was then transferred to a sterile tube and observed for regurgitation behavior for 1 h. If regurgitant droplets were produced, these were removed with a sterile swab and streaked on PYEA. The plates were incubated for 2 d at 28°C before examining for bacterial growth. Individual flies were also examined microscopically during regurgitation and reingestion.

Origin of Bacteria Distributed by Flies. To determine the origin of orally distributed bacteria, alimentary-tract dissections were performed on some flies on which observations on regurgitation behavior were made. Individual wild *D. tryoni* (bred ex guava collected at Nambour) were allowed to forage on individual sterile PYEA plates. They were then surface-sterilized and dissected as previously described (Lloyd et al. 1986). The mouthparts of each fly were removed for bacteria culturing prior to surface sterilization. The esophageal bulb, crop, and midgut of each fly were removed and streaked directly onto PYEA plates and incubated as described.

Salivary glands from laboratory-reared *D. tryoni* were also cultured, but attempts to find and remove these glands from wild flies were unsuccessful.

Identification of Bacteria. Representative colonies of bacterial strains, indicated by preliminary screening tests as belonging to the family Enterobacteriaceae, were identified by the API-2OE system as previously described (Lloyd et al. 1986).

Fate of Ingested Bacteria. To determine the fate of ingested bacteria, a labeled strain of *Klebsiella oxytoca* (doubly resistant to 500 ppm rifampicin and 500 ppm streptomycin) was prepared from one originally isolated from a field-collected fly. Approximately 500 7-d-old laboratory-reared *D. tryoni*, previously maintained on sugar and water only, were allowed to feed for 6 h on labeled *K. oxytoca* growing on PYEA. The antibiotic-resistant strain was routinely maintained on PYEA containing 500 ppm rifampicin and 500 ppm streptomycin (PYEA [500R + 500S]), but before feeding to flies it was grown for one subculture only on PYEA without antibiotics. This was done to prevent flies from ingesting the antibiotics.

The persistence of the labeled organism in the alimentary canal of the flies was monitored for 13 d after this feeding by sterile dissection and culturing of the contents of the esophageal bulb, crop, midgut, and rectum on PYEA (500R + 500S). Two males and two females, randomly selected, were examined immediately after feeding and then 1, 2, 4, 6, and 13 d later.

Thirteen days after the initial feeding of labeled *K. oxytoca*, individual flies were allowed to forage on sterile PYEA (500R + 500S) plates for 30 s and the areas of agar touched by the mouthparts were recorded.

Plates were incubated as above and examined for the presence of antibiotic-resistant bacteria.

Transfer of Labeled Bacteria onto Host Tree. Approximately 400 adult *D. tryoni* (ca. 50:50 sex ratio) were fed sugar, water, and labeled *K. oxytoca* until 14 d old. Five males and five females were then surface-sterilized, homogenized, and plated on PYEA (500R + 500S) to ensure that labeled bacteria were established in the flies. Ca. 200 flies were then released into a field cage (made with gauze sides and iron roof) containing four nectarine trees with ca. 20 mature green fruits. These flies died within 24 h due to absence of water. Consequently the remaining flies were released into the cage and these also died within 24 h. Seven days after the first introduction of flies, bacterial isolations were made onto PYEA (500R + 500S) from leaf and fruit surfaces, oviposition spots in fruit, and larva-induced fruit rots. Details of methods used in these isolations have been reported by Lloyd et al. (1986).

Comparison of Bacteria on Caged and Uncaged Nectarine Trees. Two small nectarine trees were enclosed, after fruit set, in a 2-m^3 cage made from fine nylon mesh to exclude fruit flies. These trees held ca. 30 pieces of fruit. Approximately twice weekly, for a period of 50 d from the time at which the fruits were mature green and becoming susceptible to fruit fly oviposition, two fruits were sampled into sterile glass beakers covered with aluminum foil. The maturity of each fruit in terms of skin color and firmness was noted and the surface area of each was estimated using the measured average diameter. The bacterial populations on each fruit surface were determined as follows: each fruit was shaken in 30 ml sterile distilled water for 1 min on a mechanical shaker; the wash solution was diluted in a 10-fold series; 0.1-ml aliquots were spread on PYEA plates and incubated for 2 d at 28°C. The total number of bacterial colonies and the number of probable Enterobacteriaceae colonies (based on colony characteristics, cream or pale yellow color, and rapid growth in 24 h) were determined for each fruit. Representative strains of the latter were retained for identification.

A nectarine tree with ca. 100 pieces of fruit, and ca. 20 m from the caged trees, was left uncaged. The number of fruit flies in the tree and infested fruits was noted at the beginning of the experiment. Fruits were sampled and bacteria isolated as for the caged trees. This sampling period lasted for 17 d at which time all fruits were heavily infested and falling.

At the same sampling times the bacterial populations on the surfaces of caged and uncaged nectarine leaves were determined. Six leaf disks, each 2.27 cm^2, were removed aseptically from the center of separate leaves, washed, and plated as for fruit samples.

Study of Fruit Fly Activity and Bacteria in a Peach Tree. In a peach tree (ca. 3 m high with canopy ca. 4 m diameter) holding ca. 1,200 fruits, leaf- and fruit-surface bacteria were counted, isolated, and identified as for the nectarine tree study.

This was done from the hard green fruit stage, 20 d before fruit fly activity in the tree, to the time when all fruits were heavily infested, 16 d after flies had arrived in the tree. Before the arrival of flies, counts of surface bacterial populations were done once weekly on two fruits and then, following the arrival of flies, twice weekly on six to eight fruits.

From the arrival of the first fruit flies (ca. 20 d after the study began) the number of flies in the tree and of mating pairs after dusk were counted almost daily. The counts were made using a dull fluorescent light (6 W) and under such conditions the flies remained motionless on the lower leaf surfaces. Twice weekly, beginning on the day of arrival of first flies and ending 5 d after all fruit had fallen (a 6-wk period), 12–32 flies were sampled at night, identified, sexed, and males dissected for estimation of sexual maturity state (after Drew [1969]) and females for ovarian development and presence of sperm in spermathecae. For the latter, spermathecae were squashed in Eide & Reinecke's (1970) saline. The percentage of mature and immature males and females, and percentage of mated females were estimated.

Results

Observations on Regurgitation by Flies Feeding on Mulberry. Field-collected immature female *D. tryoni* and *D. cacuminatus* contained distended crops and deep purple crop and midgut contents. Both these, and the laboratory flies that were fed on macerated mulberry fruit, deposited dark purple feces and large drops of pale purple regurgitant on the walls of the glass tubes. Up to 12 drops were produced equidistantly in a line over distances up to 2 cm as the fly walked, and each drop was exuded with one dab of the proboscis on the glass. After some time, 3–30 min, the flies reingested the regurgitant, each drop taken up with one dab of the proboscis as the fly retraced the line of drops.

Isolation of Bacteria Distributed During Feeding and Regurgitation by Adult Flies. Two methods of bacterial distribution were observed: bacteria were spread onto the food substrate during the process of feeding; and large quantities of fluid containing bacteria were regurgitated, after feeding, by flies with fully distended crops.

Laboratory-reared flies frequently engaged in prolonged feeding on sterile PYEA for periods of up to 3 min. Wild flies, either field-collected as adults or reared from field-collected fruit, were less inclined to feed on agar medium. Generally the wild flies probed the agar surface once or twice with the proboscis and then departed.

Examination of PYEA plates, on which individual laboratory *D. tryoni* had fed, showed a line of bacterial growth corresponding to the contact points with the proboscis. Occasionally colonies grew on either side of these contact points, indicating the presence of bacteria on other parts of the fly's body, but by far the heaviest and most consistent bacterial growth corresponded to the line of proboscis contact. At no time during these experiments did the flies excrete feces while in contact with the agar surface.

Single laboratory flies usually produced one or several long lines of regurgitant drops on the sterile glass tube walls, 1–20 min after feeding on sterile PYEA, and then reingested these drops. Observations on 10 female and 9 male *D. tryoni* showed that both males and females regurgitated in this manner and that a long line of regurgitated drops was more likely to occur if the fly had a well-distended crop, i.e., after a short period of constant feeding (1–2 min) or a longer period of erratic feeding (10–20 min). When laboratory flies were engaged in constant feeding, some paused, raised the proboscis, and released a single drop of fluid onto the agar and then resumed feeding.

Microscope observations of single flies in glass tubes revealed deflation of the crop during regurgitation and distension of the crop upon reingestion of fluid drops.

Although wild *D. tryoni* did not feed on PYEA as actively as the laboratory flies, single flies that touched the agar briefly with the proboscis also distributed bacteria. Because wild flies did not feed actively on sterile PYEA, their crops did not become distended and regurgitation of long droplet lines was only occasionally observed.

Regurgitant fluid from both laboratory and wild flies, when cultured on PYEA, contained large numbers of fruit-fly-type bacteria.

Origin of Bacteria Distributed by Flies. Isolations from the proboscis and parts of the alimentary tract of field-collected *D. tryoni* revealed that fruit-fly-type bacteria spread during feeding were similar to those present in the alimentary tract and were usually present in small numbers on the proboscis. Bacteria were not isolated from salivary glands.

Identification of Bacteria. Bacteria isolated from feeding surfaces, mouthparts, regurgitant droplets, and parts of the alimentary tract of *D. tryoni* were almost always species belonging to the family Enterobacteriaceae. *K. oxytoca*, *K. ozaenae*, and *E. cloacae* were the most common species isolated, with *E. herbicola* and *Providencia rettgeri* less common. In some specimens the same bacterial species distributed by the proboscis was also isolated from the crop, whereas in other specimens the distributed bacterium was isolated from the stomach.

Identification of the bacteria orally distributed, during feeding and in regurgitant droplets, by laboratory flies showed that most flies were spreading the same bacteria (either *K. oxytoca* or *E. cloacae*) during both the feeding and the regurgitation processes.

Fate of Ingested Bacteria. The labeled *K. oxytoca* strain, when fed to adult *D. tryoni*, persisted in large numbers in the crop and midgut of all flies

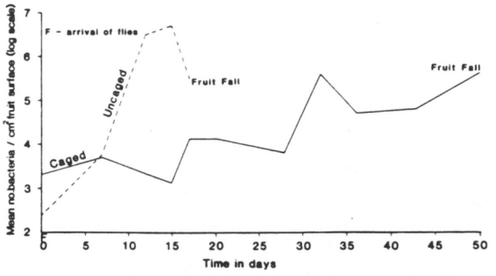

Fig. 1. Comparison of bacterial numbers on surfaces of caged (fruit flies excluded) and uncaged nectarine fruits growing in Brisbane. (F, day of arrival of first fruit flies in tree.)

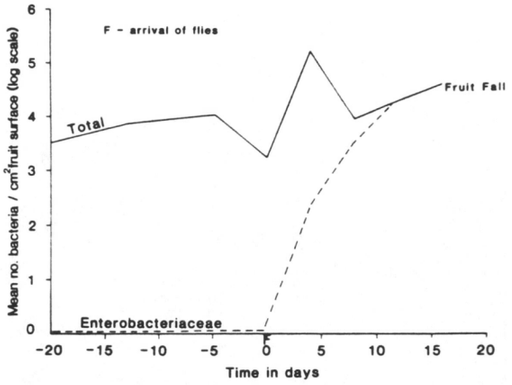

Fig. 2. Total numbers of bacteria and increase in numbers of fruit-fly-type bacteria on surfaces of peach fruits growing in Brisbane. (F, day of arrival of first fruit flies in tree.)

examined up to 13 d after feeding. Small numbers of the labeled organism were occasionally recovered from the esophageal bulb and rectum.

When individual flies (both male and female) fed on sterile PYEA (500R + 500S), a line of antibiotic-resistant bacterial colonies was produced along the line of proboscis contact. This again demonstrated that alimentary tract bacteria of the fly were orally distributed during foraging.

Transfer of Labeled Bacteria onto Host Tree. *D. tryoni* fed labeled *K. oxytoca* and released onto caged fruiting nectarine trees had only a short survival time due to lack of water. The iron roof excluded water condensate normally present on plants during evenings and early mornings. In spite of the short fly survival time, all fruits on the trees were stung within 48 h. Seven days after the first release of flies the labeled strain of *K. oxytoca* was isolated in large numbers from fruit surfaces, oviposition spots, and larval-induced fruit rots, but was not isolated from leaf samples.

Comparison of Bacteria on Caged and Uncaged Nectarine Trees. Uncaged nectarine fruit showed an increase in total surface bacterial counts from 0.27×10^3 per cm² (when ovipositions were first observed) to a maximum of $6{,}000 \times 10^3$ per cm² 15 d later, 2 d before all fruits fell (Fig. 1). The large populations on the surface of stung fruit were almost entirely fruit-fly-type bacteria. Representative isolates were identified as *E. cloacae*, *K. oxytoca*, *E. herbicola*, and *C. freundii*. Leaf-surface populations on the uncaged tree varied from 0.15×10^3 per cm² to 1.9×10^3 per cm² during the 17-d sampling period, but fruit-fly-type bacteria were not isolated.

At the beginning of the study only ca. 2 flies were present in the uncaged tree on any day but, after 7 d, the number of flies increased to ca. 50 per d. After 17 d all fruit had fallen due to 100% infestation.

The caged nectarine fruit remained undamaged on the tree until soft ripe (50 d after commencement of observations). No Diptera other than occasional specimens of Dolichopodidae were present in the cage during this time. Bacterial populations on the surfaces of caged fruit increased slowly from 2×10^3 per cm² to peaks of 490×10^3 per cm² at 31 d and 400×10^3 per cm² at 50 d. When the caged fruits were almost ripe, the bacterial flora consisted primarily of yellow- and orange-pigmented isolates, some of which were identified as *Pseudomonas maltophilia*, *Flavobacterium multivorum*, and *E. herbicola*. Leaf populations on the caged tree varied from 0.73×10^3 per cm² to 44×10^3 per cm². Fruit-fly-type bacteria, predominant on uncaged fruit, were not isolated from the caged fruit or leaf surfaces. Toward the end of the sampling time, the caged trees became infested with two-spotted mites, *Tetranychus urticae* (Koch). Culturing of homogenized mite samples revealed small numbers of unidentified bacteria but none of the yellow- and orange-pigmented types that were prevalent on the fruit surfaces.

Study of Fruit Fly Activity and Bacteria in the Peach Tree. For 20 d prior to the arrival of fruit flies in the peach tree, the total bacterial numbers on the fruit surfaces ranged from 1.7×10^3 per cm² to 10×10^3 per cm², but no fruit-fly-type bacteria were isolated (Fig. 2). Four days after the arrival of flies, the total bacterial count on the fruit surfaces had increased to 140×10^3 per cm² and fruit-fly-type bacteria were present on the surfaces of stung fruits. Thereafter, the number of these bacteria increased rapidly until 11 d after fly arrival when the entire bacterial population on the fruit surfaces was of the fruit fly type (39×10^3 per cm²). Identification of 20 of these isolates showed the numbers of individual species to be *E. cloacae* (12), *E. herbicola* (6), and *K. oxytoca* (2).

Sixteen days after arrival of flies, all fruits had fallen from the tree. Larva-induced rot in this fallen fruit contained large numbers of the same species of bacteria present on the fruit surfaces before fall. Samples of peach leaves examined during this experiment had total bacterial populations of 0.17×10^3 to 10×10^3 per cm² but significant

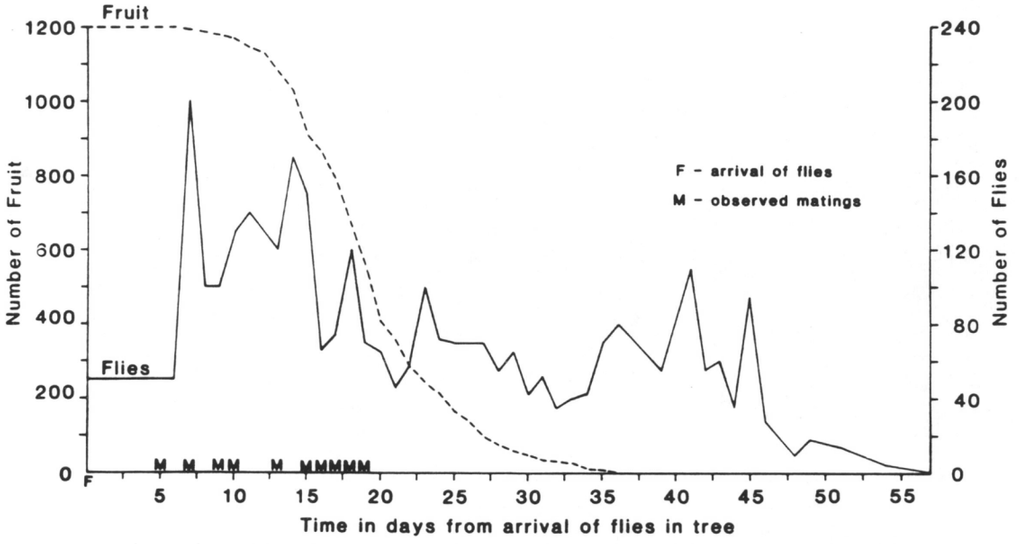

Fig. 3. Daily numbers of fruit flies (*D. tryoni* plus *D. neohumeralis*) and decrease in number of fruits present in a peach tree in Brisbane. (F, day of arrival of first fruit flies in tree; M, days on which matings of *D. tryoni* were observed.)

numbers of fruit-fly-type bacteria were not found even after all the fruit had fallen and flies were still present in the tree.

The first fruit flies (*D. tryoni* and *Dacus neohumeralis* Hardy) arrived in the peach tree when the fruit was mature green. Infested fruit began to fall 7 d later and during the next 21 d 94% of the fruit fell (Fig. 3). The percentage of infested fruit rose sharply to 100, 11 d after the first flies arrived (Fig. 4), although flies continued to oviposit for at least another 3 wk until all fruit had fallen. The number of flies in the tree varied on most days, beginning with 50 arrivals on the first day and remaining at this level until day 7 (the day fruit began to fall), when another 150 arrived (Fig. 3). Flies generally arrived at dusk. The flies that arrived in the tree, particularly during the first 7 d, were mostly sexually mature males (86%) and immature females (85%) with only ca. 50% of the mature females having previously mated (Fig. 4). There was a steady increase in the number of mature females and mated females, which reached a peak 10 d after the first flies arrived and remained at this level for another 13 d until the beginning of a decline (Fig. 4). During this period, in which the number of mature females was at a maximum, mating pairs of *D. tryoni* were observed (Fig. 3) with a maximum of four pairs per night. The 13-d period of maximal percentages of mature and mated females coincided with the period of major fruit fall (Fig. 3). The percentage of mature females, of mated females, and of infested fruit all increased at a similar rate until ca. 10 d after the arrival of flies in the tree (Fig. 4). The later decline in the percentage of mature females, mated females, and mature males coincided with the emergence of large numbers of flies from pupae in the soil beneath the tree. Mating pairs (maximum of four on one night) of *D. tryoni* were observed after dusk between day 5 and 19 after arrival of the first flies. No attempt was made to count mating pairs of *D. neohumeralis*, which mate throughout the day. The sex ratio of flies in the tree varied erratically—for *D. tryoni*, female/male, 0.22:1 to 5:1; for *D. neohumeralis*, female/male, 0.17:1 to 2.3:1. The ratio of *D. tryoni* to *D. neohumeralis* also varied from 0.8:1 to 12.5:1, although the ratios often remained reasonably constant for a period of 4–6 d.

After all fruit had fallen there were usually few flies in the tree during the day, whereas numbers increased markedly at dusk and decreased again next morning; e.g., on day 36, there were 10 flies during midafternoon, 80 after dusk, and 4 next morning (2 of these were newly emerged). Flies continued to arrive in the tree for at least 3 wk after all fruit had fallen (Fig. 3).

Discussion

Field-collected adult *D. tryoni* and *D. cacuminatus* regurgitated and reingested large quantities of fluid immediately following feeding in a mulberry tree, and laboratory-reared *D. tryoni* exhibited similar regurgitation and reingestion behavior after feeding on macerated mulberries. In addition, results with laboratory-reared and wild *D. tryoni* showed that during the process of regurgitation, large numbers of bacteria belonging to the family

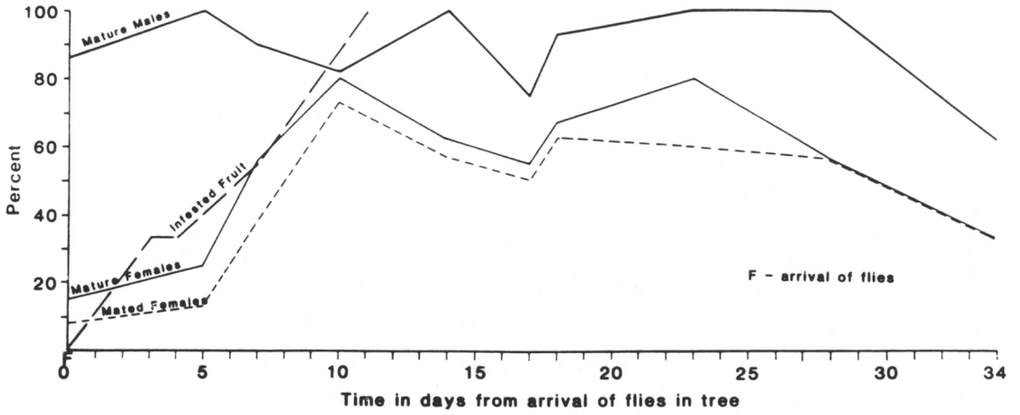

Fig. 4. Percentage of mature males, mature females, and mated females (*D. tryoni* plus *D. neohumeralis*) and infested fruit in a peach tree in Brisbane. (F, day of arrival of first fruit flies in tree.)

Enterobacteriaceae, which colonize the alimentary tract, are distributed. The regurgitation of large quantities of fluid seems to be associated with active feeding in which the crop becomes distended; but even while foraging erratically, flies distributed the same alimentary-tract organisms through the proboscis. The precise source (within the insect) of regurgitated bacteria is as yet uncertain, although the ingestion and expulsion of large quantities of fluid into and out of the crop were observed.

There is little published information on the physiology and mechanisms of feeding in *Dacus* species, but extensive studies have been reported on these processes in blowflies. Graham-Smith (1930) proposed the term "sponging" for the proboscis position of *Calliphora erythrocephala* L., in which the labellar lobes are extended and pressed to a flat surface for the uptake of thin films of liquid. When the proboscis of *D. tryoni* assumed a similar position on a feeding surface, alimentary-tract bacteria were constantly distributed.

The process of crop-emptying in the blowfly, *Phormia regina* Meigen, has been studied in detail by Green (1964), Gelperin (1966), and Thomson (1975). Regurgitation, described as "distinct drops of fluid appearing at the labellar lobes" (Green 1964, 746), occurred as anteriorly directed leakage through the crop duct valve when the crop was greatly distended and fluid was being transferred from the crop to the midgut.

The single drop of fluid released from the labellar lobes of *D. tryoni* during pauses in feeding may be due to a similar process, but expulsion and then reingestion of long lines of fluid drops with corresponding deflation and distension of the crop appear to involve a different process, which has not previously been reported. Feeding mechanisms in insects in general have been extensively reviewed by Smith (1985) but regurgitation/reingestion behavior and associated distribution of bacteria, observed in this study, were not mentioned.

Experiments with labeled *K. oxytoca* have shown that this organism, when fed to *D. tryoni*, became established in the alimentary tract and then was distributed by the mouthparts of the fly during feeding. These mutant-fed flies spread labeled *K. oxytoca* onto nectarine-fruit surfaces and into oviposition sites with the resulting predominance of this organism in larva-induced fruit rot.

These results, together with the absence of fruit-fly-type bacteria on caged nectarine trees and the build-up of fruit-fly-type bacteria on uncaged nectarine and peach fruit surfaces after fruit flies arrived in the trees, demonstrated that specific bacteria were introduced onto the surface of maturing host fruit when susceptible to fruit fly oviposition. Laboratory tests indicated that the bacteria were spread by a process of regurgitation and reingestion of alimentary-canal contents during feeding, and by foraging with the proboscis even in the absence of prolonged feeding.

The fruit-fly-type bacteria did not seem to become established on host leaf surfaces. This may be due to the fact that conditions such as the presence of moisture, leached nutrients, or competition from resident microflora make the leaf surface unfavorable for the growth of these bacteria. It is also possible that, while flies shelter on or under leaves, they may not actively feed on leaf surfaces and therefore do not inoculate these areas with large numbers of regurgitated alimentary-tract bacteria. The absence of fruit-fly-type bacteria on leaf surfaces throws doubt on the suggestion of Courtice & Drew (1984) that leaf-surface bacteria are important as an adult fly food source.

Fruit flies that arrived in the peach tree formed a semipermanent population. Although there were arrivals and departures each day, flies remained in the tree at least until the large influx of immature

females became gravid and oviposited. Ovarian development and mating both occur after flies have fed on protein. Indeed, egg production has been shown to occur in the laboratory 3 d after a single feeding (R.A.I.D., unpublished data). Because most of the early female flies that arrived in the tree were immature and showed a rapid development to maturity, and because mating pairs were observed in the tree, it is evident that an abundant supply of protein food was available within the tree. Certain species of bacteria isolated from the alimentary canal of fruit flies have been demonstrated to provide an adequate breeding diet for *D. tryoni* (Drew et al. 1983). Because these fruit-fly-type bacteria were the ones that became abundant on the peach fruit surfaces in this study and because it is known that flies feed on fruit surfaces (as shown by purple color of crops and midguts of flies feeding in mulberry trees), it is most likely that these fruit-surface bacteria were the primary source of protein food.

Nutrients such as nitrogen are frequently in lower concentration in food tissue compared with insect tissue and they must therefore be concentrated by insects (Slansky & Scriber 1985). Further, this necessity for concentration has led to a range of modifications in food substrates and feeding behavior. The abundance of invertebrate herbivores is influenced directly by the availability of nitrogen in the food plant (White 1984) and nitrogen-rich leachates occur on the surfaces of fleshy fruits when they are ripe (Tukey 1971). It is possible that the fruit-fly-type bacteria play an important role in the food chain by concentrating leachate nitrogen into a suitable food source when it becomes available. Because the fruit flies were present in the peach tree for at least 3 wk after all fruits were infested, they may have been using this niche as a food source. However, newly emerged flies from beneath the tree did not remain in the tree. This may indicate that the postteneral dispersal phase (Fletcher 1973) is entered into immediately after emergence and before protein food is sought.

In contrast to temperate fruit flies, e.g., *Anastrepha* species, which feed in host and nonhost trees (Malavasi et al. 1983), species of tropical Dacinae are not normally observed on nonhost plants. Extensive field observations (R.A.I.D., unpublished data) have never revealed the activity of flies in nonhost vegetation. Also, in this present study, the peach tree was surrounded by a wide variety of nonhost trees but the flies were never observed in these plants.

The host tree appears to be the center of activity for a dacine fruit fly population. It is the adult feeding site, adult female maturation site, mating site, oviposition site, and larval food source. Consequently, flies develop eggs after they have located the fruit for oviposition, a strategy that would be important in the energy budget of the insect.

The first flies that entered the peach tree may have been attracted by visual and olfactory stimuli. However, the large influx of flies 7 d after the first arrivals, and the subsequent large population numbers, suggest that the tree became more attractive with time. It is possible that the build-up of fruit-fly-type bacteria on the fruit surfaces served as an attraction stimulus. The fact that flies kept entering the tree for at least 3 wk after all fruit had fallen indicates that there are attractive stimuli other than fruit visibility.

It appears that the bacteria associated with fruit flies are significant in the host-tree habitat, particularly as a food source for adults, and possibly as a stimulus to attract foraging flies into the tree.

Acknowledgment

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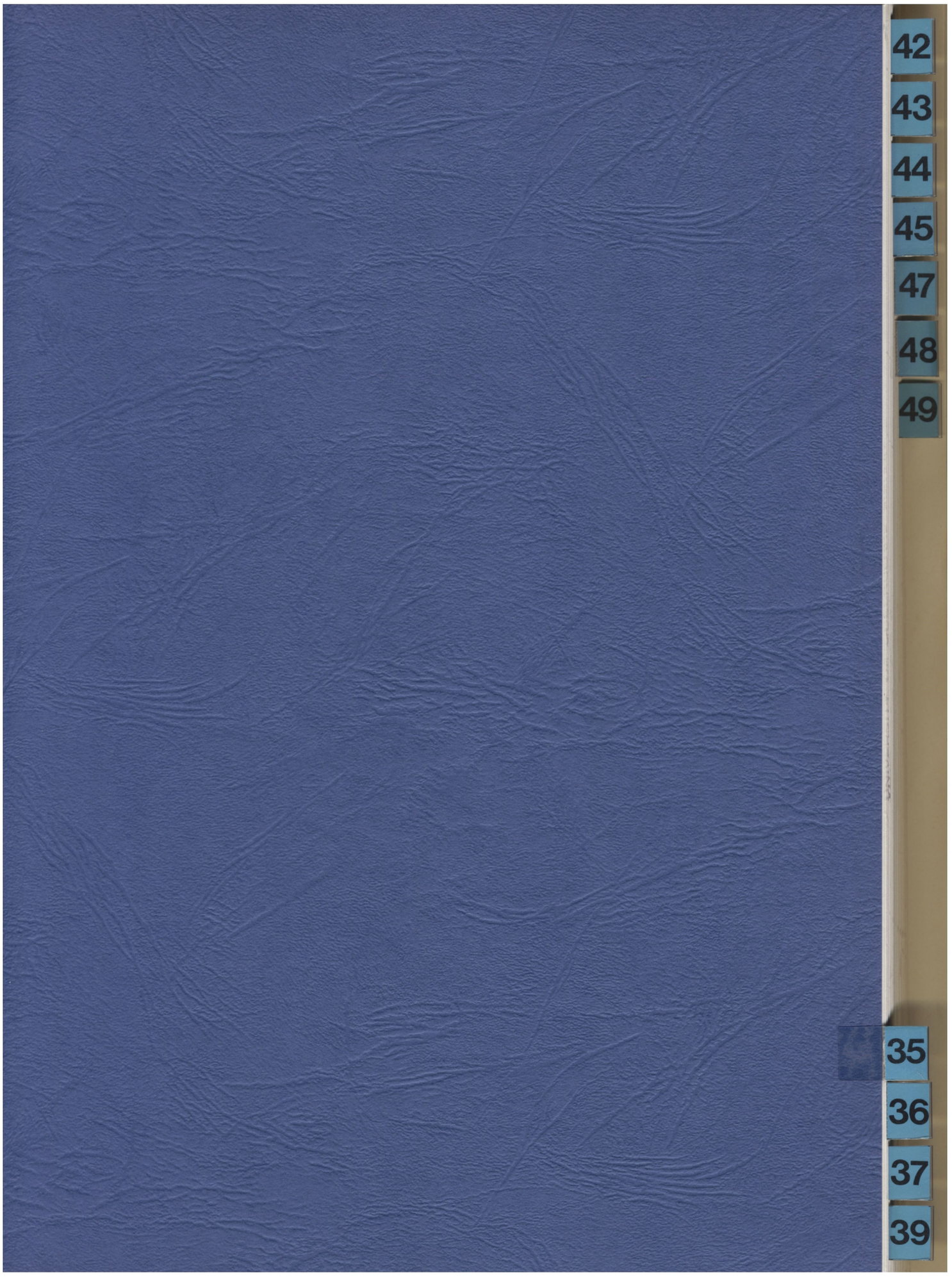
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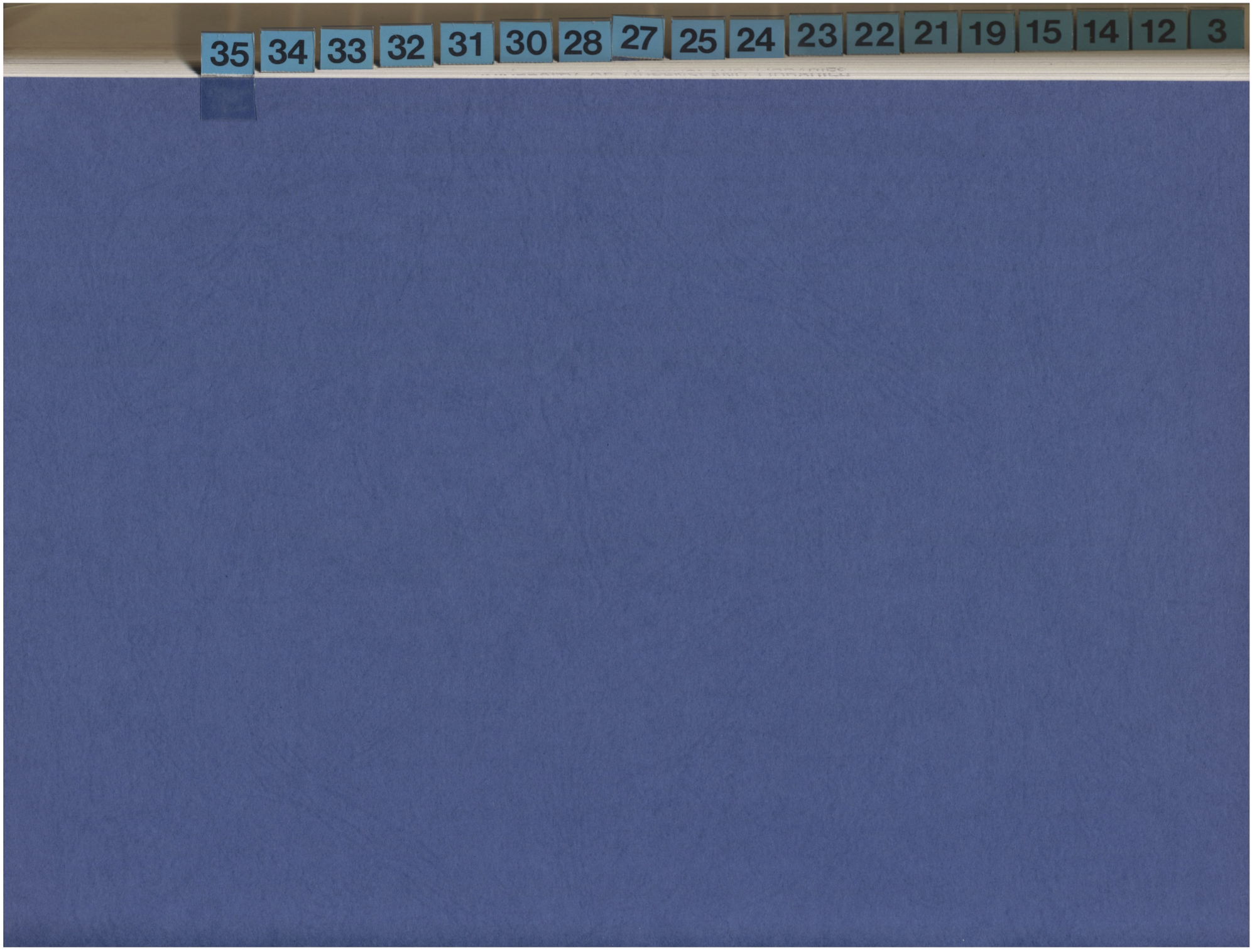

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VOLATILE COMPOUNDS FROM THE FLOWERS OF *SPATHIPHYLLUM CANNAEFOLIUM*

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(*Received* 3 *November* 1987)

Key Word Index—*Spathiphyllum cannaefolium*; Araceae; 'fruit-fly lily'; flower volatiles; aromatic ethers; acetates; GC-MS.

Abstract—Headspace analysis and solvent extraction of the pollenbearing flower spike of *Spathiphyllum cannaefolium* have been conducted by GC-MS, to determine the basis of the flower spike's attractancy to certain fruit-fly species. The major components were benzyl acetate, methyleugenol, methylchavicol, *p*-methoxybenzyl acetate and fatty acids. Benzyl acetate is known to be attractive to *D. cucurbitae*, *D. dorsalis* and *C. capitata* (representing the three different 'male-lure categories') and methyleugenol (one of these male-lures) attracts *D. cacuminatus*, *D. dorsalis* and *D. occipitalis*. Thus the odoriferous flowerspike exhibits wide ranging attractancy and hence *Spathiphyllum cannaefolium* may have some application as a fruit-fly control measure for small orchards where 'methyleugenol-attracted' species (e.g. *D. cacuminatus*, *D. dorsalis*, *D. occipitalis*) are the dominant pests.

INTRODUCTION

Certain plant species have been reported to exhibit significant attractancy towards fruit-flies, and among the volatile compounds contained by the plants are, methyleugenol (**1**), Cue Lure (**2**) or closely related compounds. [(**3**) is Trimedlure, synthetic lure for Medfly—*C. capitata* (Wiedmann)].

The oriental fruit fly (*Dacus dorsalis* Hendel) has been reported [1] to be strongly attracted to the drying leaves and twigs of *Palea anisata* Mann (Rutaceae) and also to the flower of the 'golden flower' plant, *Cassia fistula* L. [2]. Methyleugenol (**1**) was identified as a significant if not dominant, volatile component in both cases. Leaves of the basil plant, *Ocimum basilicum* were also attractive to *D. dorsalis*, and the volatile compounds (**1**), methylchavicol (**4**) and 1,8-cineole (**5**) were identified from the leaves [3]. The Australian plant *Zieria smithii* is attractive to *D. cacuminatus* (but not *D. tryoni*) and the leaf-oil is rich in methyleugenol [4]. The orchid *Dendrobium superbum* is attractive [5, 6] to the male melon fly, *D. cucurbitae* but no evidence for the presence of either (**1**) or (**2**) was found [despite an odour similar to that of (**2**)], and the major volatile components were ethyl acetate and 2-tridecanone.

Our interest in the lily *Spathiphyllum cannaefolium* was aroused by a newspaper report [in the 'Cairns Sun' (North Queensland) 7 October 1984; p. 4] that up to 450 flies could be attracted in one day to one 'fruit-fly plant'. In Northern Thailand, the lily is grown extensively around orchard perimeters, and attracts fruit flies and thus reduce infestation of fruiting trees [Wilson, I., Avondale Nursery, Smithfield (Cairns), North Queensland, personal communication]. The lily has a sweet heavy odour and is strongly attractive to flies, painting the flower spikes with Dipterex or other insecticide results in the killing of large numbers of flies. Drew observed [Drew, R., personal communication] that the predominant species attracted (in North Queensland) to the lily was *D. musae* (Tryon) (banana fly), the males of which are strngly attracted by the synthetic lure, methyleugenol [7]. The origin of the plant is unclear, but it probably was a native of South China, and is found from South-East Asia to Central and South America [Wilson, I., personal communication].

RESULTS AND DISCUSSION

The young lily flower has little odour, but after the formation of pollen in the white flower spike, the characteristic 'sweetish' odour is easily detectable, especially in the early morning. As the flower ages, pollen is lost along with the odour, and the colour changes from white to green. The volatiles of the lily were studied by headspace analysis (with air-flow and 'passive' conditions) and by solvent extraction, the details of which are in the Experimental. Headspace analysis was performed (Table 1) on both the mature flower and on one which no longer provided any obvious odour.

Passive sampling of the mature flower established the presence of five major components—benzyl acetate (**6**) (59%); methyleugenol (**1**) (20%) methylchavicol (**4**); propyl/isopropyl tetradecanoate (6%) and *p*-methoxybenzyl acetate (**7**) (~3%). The structural similarity between the four aromatic compounds is clear, and their identities were confirmed by comparison of retention times and mass spectra with those of authentic samples. Methyleugenol was detected by all sampling methods which is consistent with the observation of Drew that *D. musae*

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Table 1. Compounds identified in *Spathiphyllum cannaefolium* by various samplings

	Solvent extraction		Headspace analysis			
	Ether	Acetone	Mature flower (air flow)	Aged flower (air flow)	Mature flower (passive)	Mature flower (GC insert)
Cyclohexanone	—	—	—	—	*	—
Terpenes	—	—	—	—	**	—
1-H-Imidazole	—	—	—	**	—	—
Phenol	—	—	—	—	*	—
Benzyl alcohol	**	**	—	—	—	—
1,8-Cineole	—	—	**	—	*	—
Benzyl acetate	—	*	***	—	***	***
4-Methoxybenzyl alcohol	**	**	—	—	—	—
1-Allyl-4-methoxybenzene	—	—	**	—	**	**
1-Vinyl-4-methoxybenzene	—	—	*	—	—	—
Methyleugenol	**	**	**	**	**	***
4-Methoxybenzyl acetate	**	**	**	—	**	**
Dodecanoic acid	*	—	*	*	—	—
Unknown (BP = 43)[+]	**	**	—	—	—	—
Tetradecanoic acid	*	—	*	**	—	—
Pentadecanoic acid	*	—	*	**	—	—
Hexadecenoic acid	*	—	—	—	—	—
Hexadecanoic acid	***	***	**	***	—	—
Heptadecanoic acid	*	—	—	*	—	—
Propyl/isopropyl tetradecanoate	—	—	—	—	**	**
Octadecadienoic acid	***	***	—	—	—	—
Octadecenoic acid	—	—	**	**	—	—
Octadecanoic acid	**	—	**	**	—	—
Others	**	**	**	***	**	**

*, < 1% of total amount of volatile compounds as determined by GC/MS; **, 1–20%; ***, > 20%. [+]BP = base peak in MS.

(banana fly) was attracted strongly to this flower. Headspace analysis of the mature flower showed benzyl acetate (**6**) to be the major component, whereas it was essentially absent when the 'old' flower spike was examined. Benzyl acetate is one of the few compounds that is known to be attractive to *D. cucurbitae*, *D. dorsalis* and *C. capitata* [7] and thus the co-occurrence with methyleugenol (one of the three commercially employed male lures) accounts for the broad range attractancy of *Spathiphyllum cannaefolium*.

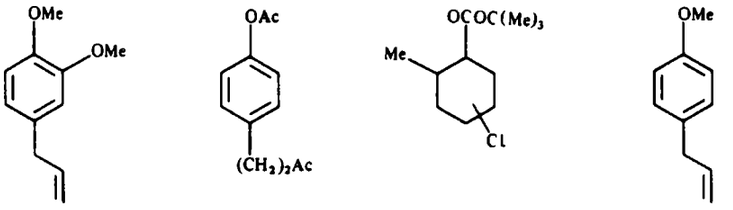
The only aromatic compound present in the headspace after the lily had lost its characteristic odour was methyleugenol. Saturated and unsaturated fatty acids dominated the chromatogram of the old flower. The major acids were hexadecanoic and octadecanoic acids, but for mature flowers, the range of fatty acids varied greatly with the sampling method. It is possible that the fatty acids, while not alone responsible for the attraction of the flies, may have enhanced the effect of other components. There is evidence, however, that the fatty acids in linseed oil exhibited significant attractancy, particularly to the melon fly (*D. cucurbitae*) [6]. Cineole (**5**), while consistently present, is found in many plants not attractive to fruit flies, and is regarded as unimportant in this respect. Methylchavicol (**4**) was a major constituent of the headspace, and Chen [3] observed this compound in the basil plant (the leaf volatiles of which are attractive to *D. dorsalis*), but (**4**) was by itself, not attractive. One component, representing *ca* 10% of the components in solvent extraction, was not identified. This appeared to be aromatic and isomeric with Cue-Lure (**2**) with $[M]^+ = 206$.

The non-availability of live flies prevented extensive testing, but both male and female *D. tryoni* exhibited some attraction toward the aromatic compounds **1**, **4**, **6** and **7**, when open vials containing the test compounds were placed near the cage. β-Methoxybenzyl alcohol (precursor of (**7**)) also exhibited some attractancy under these conditions.

EXPERIMENTAL

Headspace analysis. This procedure involved adsorptive trapping of the volatiles onto a porous polymer followed by thermal desorption into a combined GC-MS system. Thermal desorption is preferable to solvent extraction, as no work-up is required and 'solvent masking' of very volatile components in the gas chromatograph is not a problem. Tenax GC and TA [8] were the chosen adsorbents because of their thermal stability (350–400°), and the very low polarity of these polymers (based on 2,6-diphenylene oxide) renders water retention unimportant. The polymer has a high affinity for organic compounds [9], but no attempt was made to calibrate the efficiency of adsorption for different functionalities, since only a qualitative profile could be obtained. After conditioning the Tenax (3 hr at 270°; He flow (20–40 ml/min) some artifacts remain and a list of these (which include undecane, toluene, xylenes etc) is available [8].

The volatiles were collected on Tenax GC or TA (*ca* 200 mg) held in glass tubes (150 mm; 6 mm diameter) by silanized glass



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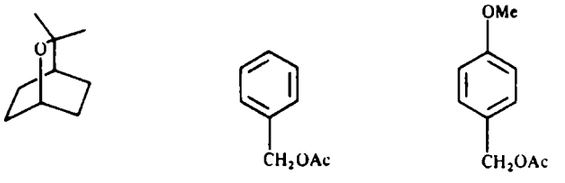

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wool plugs, all connections were by silastic tubing, and thus occasionally some silicon-containing compounds were detected. The volatiles of the strong smelling spike were collected by removing the spike and placing it in an all glass chamber which was sealed with a flange joint. Purified air was streamed through a Tenax-filled pre-tube (to filter any organic material) into the chamber (50–100 ml/min) and two outlets permitted duplicate sampling simultaneously. At each outlet, two tubes were connected in series, the first to collect the volatiles and the second to prevent atmospheric contamination. The volatiles were sampled for one hour and then the tubes were sealed with Teflon caps and stored.

Reproducible results were obtained with this system. However two problems were associated with it—the very volatile components may not have been efficiently trapped with the air flow, and 'cutting off' the flower spike was a destructive sampling technique, as flower production was somewhat irregular. A 'passive' sampling method was employed which involved mounting the Tenax-filled tube (by copper wire suspension) beside the flower and the two were covered by a cylinder (~100 ml) which served to concentrate the volatiles. This was set up at night, and the tube removed and sealed the next morning. The 'passive' method was used routinely, although the results matched those under conditions of air-flow.

The tubes were then transferred to the GC-MS for thermal desorption, utilizing a unit consisting of two metal blocks containing cartridge heaters which were pre-heated to 200°. The adsorption tube was connected to the helium flow at one end, and a specially adapted needle at the other. After *ca* 3 min, the tube was placed between the hinged heating blocks which were clamped, and the needle inserted into the injector port. The plant volatiles were desorbed (for 3 min) from the Tenax and carried by the He flow onto the GC-column at 0°. The needle was removed from the injector port, the heating block unclamped and the GC oven temperature ramped. Reproducible results were achieved with this system, on a Finnigan Mat Automated GC/MS [10].

Solvent extraction. The strongly smelling flower spikes were cut into small pieces and extracted for *ca* 24 hr with either Me_2CO or Et_2O. The extracts were examined directly by GC-MS.

Spathiphyllum cannaefolium were purchased from the Avondale Nursery (Mr I. Wilson), Smithfield 4871 (via Cairns), Queensland, and air-freighted to Brisbane. These plants were extremely hardy and thrived in a sunny room (tenth floor) on the northern side of the Chemistry Building, with a minimum of attention.

Acknowledgements—We are grateful to Mr Ian Wilson (Avondale Nursery) for information on *Spathiphyllum cannaefolium* and to Miss Lily Murphy for observant fieldwork.

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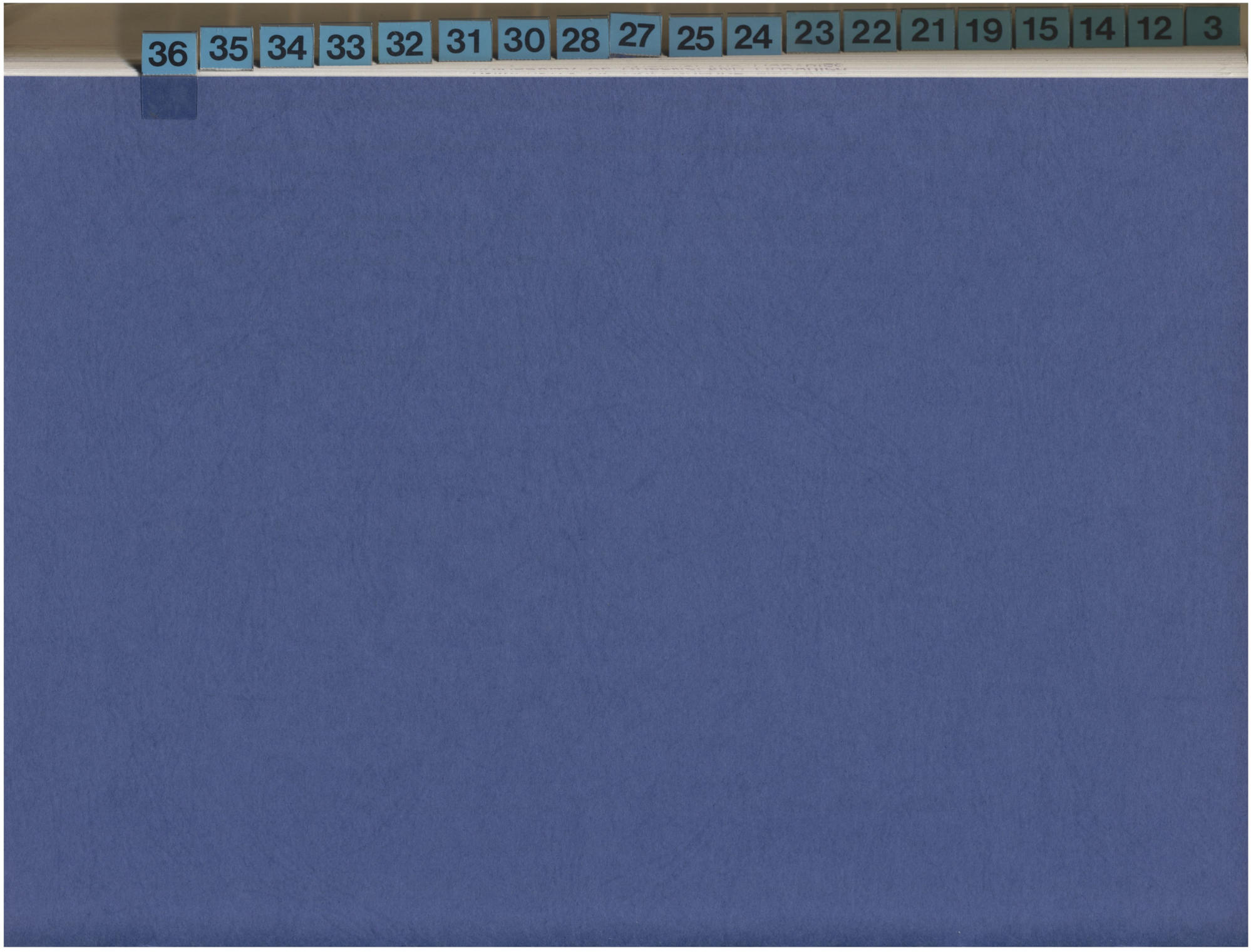
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Amino acid increases in fruit infested by fruit flies of the family Tephritidae

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Solanum mauritianum Scop. (wild tobacco) fruit is the major host of the fruit fly *Dacus cacuminatus* (Hering), and is a major source of food for the brown pigeon *Macropygia phasianella* (Temminck) in eastern Queensland. Amino acid analyses were undertaken on fruit fly infested and uninfested *S. mauritianum* fruits. Infested fruits contained approximately twice the level of protein and essential amino acids compared to uninfested fruit. This increase is probably due to the plant adding additional amino acids to infested tissue and the accompanying growth of bacteria established in the fruit during oviposition. The infested fruit would provide a valuable source of protein during the pigeon breeding season.

KEY WORDS:—Fruit fly – amino acids – infested fruit – brown pigeon.

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INTRODUCTION

In the endemic rainforest habitat of tropical/subtropical fruit flies, many fruit species eaten by vertebrates such as birds (Crome, 1975, 1976; Stocker & Irvine, 1983) are known fruit fly hosts. In a study of the brown pigeon feeding on fruit of *Solanum mauritianum* Scop. at Mount Glorious, south-east Queensland (Drew, 1987), more fruit was eaten during the period when the fruit fly, *Dacus cacuminatus* (Hering), was breeding in the fruit. The phenology of fruiting in *S. mauritianum* and the seasonal variation in fruit fly breeding in this fruit has been studied in detail by Drew & Hooper (1983).

The importance of protein food to growth in pigeon nestlings was stressed by Levi (1963) who showed that pigeon 'milk' used for feeding young birds contained up to 59% protein and was rich in B-complex vitamins. In a study of the fruit feeding pigeons of tropical north Queensland, Crome (1975) noted that

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fruit-eating pigeons ingest higher protein food during the breeding season and feeding of crop milk to nestlings overcomes the disadvantage of a low-protein fruit diet. Crome (1975) also found that the brown pigeon usually feeds on low protein fruit, that truly obligate frugivores are rare, that many frugivorous pigeons augment their diet with insects as a protein source and that insects fed to nestlings induce faster growth in the young birds.

The paper reports amino acid analyses of infested and uninfested *S. mauritianum* fruit and a discussion on the value of this food source to the brown pigeon.

MATERIAL AND METHODS

Samples of completely uninfested fruit of *S. mauritianum* were obtained by enclosing flower heads in fine gauze cages after pollination. Samples of naturally infested fruit were obtained by leaving similar size flower heads, on the same plant, uncaged. One set of samples was taken during a predation study at Mount Glorious (Drew, 1987) and a second set was taken from a large plant growing in Brisbane. The fruit samples were picked at the mature ripe stage and held in an ultra-low deep freeze at −80°C.

Amino acid analyses were carried out by two different methods, one on an amino acid autoanalyser and the second using high performance liquid chromatography (HPLC). Before the analyses were undertaken, the berries were dissected and the seeds discarded as these are not digested by the birds nor decayed by bacteria during fruit fly larval development. In infested fruit samples, the fruit fly larvae and eggs were removed and analysed together, separate from the fruit tissue. In case there was a moisture loss in some samples, the analyses were calculated on a dry weight basis.

In the first set of analyses, 13 infested and 12 uninfested fruits from Mount Glorious were analysed separately as follows. The separate samples of fruit tissue and larvae plus eggs were weighed and homogenized in distilled water (fruit in 2 ml and larvae/eggs in two drops) at room temperature, dried under vacuum and weighed again. The samples were then hydrolysed by adding constant boiling point hydrochloric acid (4 ml for fruit, 2 ml for larvae/eggs), sealed under vacuum at 110°C for 24 h and dried in a vacuum desiccator over P_2O_5 plus NaOH for 24 h. Citrate buffer (0.2 M, pH 2.0) was added (4 ml fruit, 3 ml larvae/eggs) and the solutions were passed through a millipore filter and 200 µl of stock norleucine solution (0.0164 g/25 ml water) added. The samples were analysed on a Technicon Autoanalyser using the standard programme for protein hydrolysates. The amounts of each amino acid, per gram of tissue, were estimated in nanomoles and number of grams. The sum of the individual amino acid weights (in grams) was used as an estimate of total protein in each sample.

In the second set of analyses, 12 infested and 12 uninfested fruits from Brisbane were analysed. After separation of seeds the uninfested fruits were pooled and homogenized together, and similarly for the infested fruits and larvae plus eggs samples. After the filtering stage above, the amino acids were derivated with phenylisothiocyanate in pyridine:acetonitrile:triethylamine:water (5:10:2:3), dried, redissolved in HPLC solvent and analysed in a Waters HPLC system controlled by a Digital Professional 350 computer. Four sub-samples of infested fruit tissue and uninfested fruit tissue, and two sub-samples of the larvae

plus eggs were analysed. The amounts of each amino acid per gram of tissue were estimated in nanomoles. The dry weights of each infested fruit, and its larvae plus eggs, were not taken and consequently the amounts of amino acids (nanomoles) in infested fruit tissue plus larvae and eggs were not calculated in these analyses.

RESULTS

The individual fruits of *S. mauritianum* are *c.* 10–12 mm diameter, growing in bunches of *c.* 10–40. Each fruit contains many very small seeds in the centre, surrounded by a fleshy layer up to 4 mm thick. As many as 20 fruit fly eggs are deposited in each fruit and, during the larval development time of *c.* 7–10 days, up to six larvae survive to later instar stages.

In the first analysis using the autoanalyser 16 amino acids were recorded, including nine that are classified essential to animal growth (Table 1). Tryptophan and cystine are both destroyed by acid hydrolysis and were not identified in the samples. The concentrations, in nanomoles per gram, for each amino acid increased from uninfested fruit tissue to infested fruit tissue and thence to infested fruit tissue plus fruit fly larvae/eggs (Table 1). There was a 40–100% increase in the infested fruit tissue from which eggs and larvae were removed prior to analysis and a 50–130% increase in the infested fruit tissue plus eggs/larvae. The concentrations, in grams per gram, of each amino acid are given in Table 2. Based on these weights, the uninfested fruit tissue contained 4.8% protein, the infested fruit tissue 8.5% protein and the infested fruit tissue plus larvae/eggs 9.5% protein. The amino acids that occurred in greatest quantities in the infested fruit were arginine, asparagine, glutamine, leucine, lysine and valine. There was no major change with infestation in the relative abundance of amino acid in the samples analysed (Table 3). Glutamine plus

TABLE 1. The amino acid content of uninfested fruit of *Solanum mauritianum* Scop. and of fruit infested with *Dacus cacuminatus* (Hering), and percentage increases in amino acids due to the fruit fly infestation. Data based on individual fruit samples from Mount Glorious, Queensland

Amino acid	Uninfested fruit tissue (nmol g^{-1})	Infested fruit tissue (larvae removed)		Infested fruit tissue plus larvae	
		nmol g^{-1}	% increase	nmol g^{-1}	% increase
Lysine	30187	57961	92.0	62732	107.8
Histidine	8862	19038	114.8	20662	133.1
Arginine	27040	37993	40.5	41595	53.8
Threonine	21367	37038	73.3	40876	91.3
Valine	30881	57629	86.6	63691	106.2
Methionine	6823	10490	53.7	11808	73.1
Isoleucine	23641	39469	70.0	43439	83.7
Leucine	36041	61205	69.8	67209	86.5
Phenylalanine	15222	24726	62.4	27040	77.6
Asparagine	46372	91024	96.3	98674	112.8
Serine	30717	47631	55.1	52387	70.5
Glutamine	44634	85913	92.5	99424	122.8
Proline	28719	47786	66.4	54.105	88.4
Glycine	46198	76706	66.0	83817	81.4
Alanine	37247	68600	84.2	78439	110.6
Tyrosine	8003	13917	73.9	18549	131.8

TABLE 2. The amino acid content (g g^{-1}) in uninfested fruit of *Solanum mauritianum* Scop. and in fruit infested with *Dacus cacuminatus* (Hering) and the total protein (%) in each sample. Data converted from Table 1

Amino acid	Uninfested fruit tissue	Infested fruit tissue (larvae removed)	Infested fruit tissue plus larvae
Lysine	0.0039	0.0075	0.0081
Histidine	0.0012	0.0026	0.0028
Arginine	0.0042	0.0059	0.0065
Threonine	0.0022	0.0038	0.0042
Valine	0.0031	0.0058	0.0064
Methionine	0.0009	0.0014	0.0016
Isoleucine	0.0027	0.0045	0.0050
Leucine	0.0041	0.0070	0.0076
Phenylalanine	0.0022	0.0036	0.0039
Asparagine	0.0061	0.0120	0.0130
Serine	0.0027	0.0042	0.0046
Glutamine	0.0057	0.0110	0.0127
Proline	0.0028	0.0047	0.0053
Glycine	0.0026	0.0043	0.0047
Alanine	0.0026	0.0048	0.0055
Tyrosine	0.0013	0.0023	0.0030
Total Protein (%)	4.8	8.5	9.5

glutamic acid, asparagine plus aspartic acid, glycine, alanine, lysine, valine and leucine were detected in higher levels than the other amino acids.

In the analyses based on HPLC, 14 amino acids were recorded (Table 4). Arginine and threonine curves overlapped on the printout and thus could not be estimated and total protein contents were not calculated. There were some unexplained differences in individual amino acid levels between experiments which differed in both environmental conditions and analytical methodology. However eight amino acids showed similar or higher percentage increases, in infested fruit over uninfested fruit, to those in the first analysis, viz. alanine,

TABLE 3. Relative abundance of each amino acid (% of total) present in uninfested fruit of *Solanum mauritianum* Scop. and in fruit infested with *Dacus cacuminatus* (Hering). Data calculated from that in Table 2

Amino acid	Uninfested fruit tissue	Infested fruit tissue (larvae removed)	Infested fruit tissue plus larvae
Lysine	8.1	8.8	8.5
Histidine	2.5	3.0	3.0
Arginine	8.7	6.9	6.8
Threonine	4.6	4.5	4.4
Valine	6.4	6.8	6.7
Methionine	1.9	1.6	1.7
Isoleucine	5.6	5.3	5.3
Leucine	8.5	8.2	8.0
Phenylalanine	4.6	4.2	4.1
Asparagine	12.6	14.1	13.7
Serine	5.6	4.9	4.8
Glutamine	11.8	12.9	13.4
Proline	5.8	5.5	5.6
Glycine	5.4	5.0	5.0
Alanine	5.4	5.6	5.8
Tyrosine	2.7	2.7	3.2

TABLE 4. The amino acid content in uninfested fruit of *Solanum mauritianum* Scop. and in fruit infested with *Dacus cacuminatus* (Hering), and percentage increases in amino acids due to fruit fly infestation. Data based on 12 fruits of each state from Brisbane

Amino acid	Uninfested fruit tissue (nmol g^{-1})	Infested fruit tissue (larvae removed)		Larvae plus eggs (nmol g^{-1})
		nmol g^{-1}	% increase	
Lysine	7446	12063	62.0	63593
Histidine	13990	25322	81.0	34157
Valine	31996	55704	74.1	93.546
Methionine	8624	12843	48.9	16344
Isoleucine	17634	34095	93.4	67283
Leucine	27870	55193	98.0	113.116
Phenylalanine	12339	21844	77.0	51515
Asparagine	32819	53495	63.0	73.514
Serine	29199	38026	30.2	103.946
Glutamine	41805	66052	58.0	140101
Proline	34009	58933	73.3	78101
Glycine	33972	48003	41.3	123633
Alanine	41161	76987	87.0	172305
Tyrosine	10356	20302	96.0	32770

isoleucine, leucine, methionine, phenylalanine, proline, tyrosine and valine (Table 4). The samples of larvae plus eggs possessed high levels of all amino acids (Table 4).

DISCUSSION

During oviposition, fruit flies insert bacteria together with the eggs into the host fruit. The subsequent growth of the bacterial colony appears to be important to the developing larvae which always remain and feed in the bacterial 'soup' (Courtice & Drew, 1984). The similarities in amino acid composition between uninfested and infested fruit tissue lead one to suspect that the plant is adding additional amino acids to the latter. This is, perhaps, a process to repair damaged tissue. The marked increase in amino acid levels in the fruit accompanying fruit fly infestation probably enhances the bacterial growth. In turn, the bacteria most likely provide essential nutrients such as amino acids and vitamins for the developing fruit fly larvae.

Recent studies (Drew, 1987) showed that the breeding season of the brown pigeon coincides with the time of maximum fruit abundance on *S. mauritianum* and the peak level of infestation in the ripe fruit by the fruit fly *D. cacuminatus*. There is 100% infestation of fruit at this peak and also more fruit is eaten by the birds at that time. Crome (1975) noted that the breeding season of fruit pigeons coincided with the period of peak fruiting of food plants and that ripe fruit (the stage infested by fruit fly) is the one always selected for food.

The increased levels of amino acids in the infested fruit would be of value to the pigeons, particularly during the breeding season. The high level of protein in the pigeon crop 'milk' for feeding the newly hatched young, and the subsequent protein food required for the growing birds, could be obtained from protein rich food such as fruit fly infested fruit.

Frugivorous birds have a longer nesting time than non-frugivores and consequently are subjected to greater predation pressure (Morton, 1973). This

nest predation imposes strong selection pressure against birds using fruit as the sole source of food for nestlings and many frugivores seek insects, at that time, as an important protein supplement. The growth rate of young nestlings depends on the rate at which the adult birds can provide essential amino acids (Morton, 1973). Fruit fly infested fruit of *S. mauritianum* would assist in providing this dietary factor to the brown pigeon, and similar infested fruit in the rainforests probably provides a valuable food source to a wide range of fruit eating vertebrate animals.

ACKNOWLEDGEMENTS

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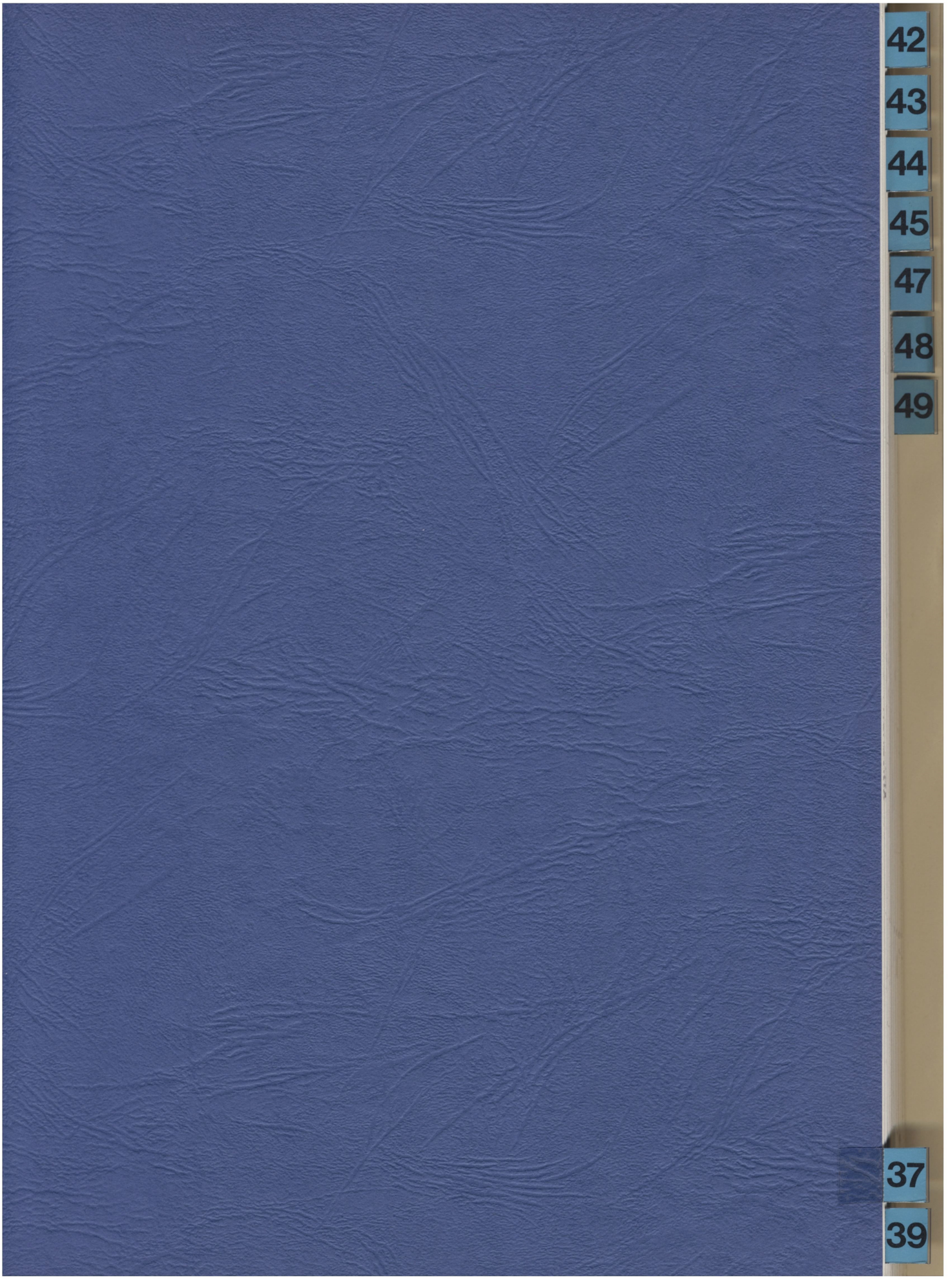
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Comparison of the roles of ammonia and bacteria in the attraction of *Dacus tryoni* (Froggatt) (Queensland fruit fly) to proteinaceous suspensions

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INTRODUCTION

The use of poison baits to control fruit flies has its origins in the 19th century when Tryon (1889) recommended a mixture of quassia, treacle and water, occasionally supplemented with fruit essence. Mally (1908) appears to be the first to have considered poison-bait spraying particularly on host trees. Subsequently, a number of workers recommended a variety of poison-bait sprays based on a sugar-poison mixture. Maxwell- Lefroy (1916) was the first to add protein (casein) to the bait and since Steiner (1952, 1955) incorporated hydrolysed protein in baits there has been no change to the basic formulations.

For fruit flies to be attracted to the baits they must be responding to certain volatile emissions. It is most unlikely that the flies are responding to amino acids, peptides and proteins as these are relatively non-volatile.

Keiser and Wakabayashi (1981) recognised that only fermenting proteinaceous materials were attracting female fruit flies due to slow release of certain unidentified cofactors. Bateman and Morton (1981) studied the volatiles produced by hydrolysed protein suspensions known to attract fruit flies and concluded that ammonia was probably the most significant attractant factor.

The biological significance of the mode of action of hydrolysed protein baits has remained unknown since their inception in 1952. An understanding of this mode of action would enhance the possibility of developing more efficient bait sprays with respect to attractancy and specificity.

It has been shown that some bacteria are a natural source of food for adult fruit flies (Drew *et al.*, 1983). This paper reports on the effect of one of these bacteria, growing in hydrolysed protein baits, on the attractancy of the protein plus bacteria mixtures and the role played by ammonia in this system.

MATERIALS AND METHODS

Attractancy tests were conducted on base solutions of Nu-lure protein hydrolysate fruit fly bait and ammonium bicarbonate. Both solutions were offered at pH 6.5 and 9.0 and the protein hydrolysate adjusted in terms of residual ammonia and bacteria (*Providencia rettgeri* Hadley, Elkins & Caldwell). Nine test solutions and a control were used (Table 1).

All protein hydrolysate suspensions were first diluted from 25 ml to 500 ml with tap water. During the process of acid hydrolysis in the manufacture of protein hydrolysates, ammonium chloride is formed. The solutions requiring removal of this ammonia had the pH adjusted from 3.94 (the pH on arrival from manufacturer) to *ca.* 9.0 by adding 1M NaOH. They were then placed in 1 litre Erlenmeyer flasks and air was passed through at a rate *ca.* 20 l/min at 23° C for 1.5 h. Ammonia-reduced solutions had concentrated HCl (laboratory grade, 0.0003% NH_3) added to readjust the pH to 6.5. Broth cultures of bacteria were prepared by inoculating peptone yeast extract (pH 7.2) with *P. rettgeri* (isolated from the crops of field-collected feeding flies) 24 h prior to use. When inoculated protein hydrolysate was required, 25 ml of bacterial broth was added to 500ml of test solution immediately prior to use in the attractancy tests. 0.01M solutions of ammonium bicarbonate at pH *ca.* 6.5 and *ca.* 9.0 were used (Bateman and Morton, 1981).

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Table 1. Summary of the composition of protein hydrolysate suspensions and ammonia solutions used in attractancy tests for *Dacus tryoni*.

Base solution	pH	NH_3[1]	Bacteria[2]	NH_3 evolved after preparation (µmoles/l)	Treatment designation
Protein hydrolysate 5%	9.0	+	-	47	1
		-	-	44	2
		-	+	67	3
	6.5	-	-	0	4
		-	+	7	5
		+	-	0	6
		+	+	6	7
NH_4HCO_3 0.01 M	9.0	+	-	87	8
	6.5	+	-	0	9
Control (dichlorvos only)					10

[1] + indicates residual NH_3 not removed by aeration, - indicates residual NH_3 removed by aeration.
[2] + indicates *P. rettgeri* added to test solution, - indicates no bacteria added.

Chemical analyses were undertaken, after Bateman and Morton (1981), to estimate the relative quantities of ammonia evolved from each solution at the different pH's. The ammonia was estimated in µmoles per litre evolved for *ca.* 15 min, *ca.* 1 h after preparation (Table 1). The levels of ammonia evolution during the experiments, from solutions with residual ammonia removed, were intended to diminish more rapidly than in other solutions.

The attractancy tests were conducted in an octagonal field cage (*ca.* 2.5 m high and 4 m diameter) which was covered by 1 mm^2 fly mesh. The floor of the cage was carpeted by low grass and no plants were present within the cage. Thirty ml of each test solution in open plastic receptacles (5 cm diameter) were placed in separate Steiner-type (Drew, 1982) fruit fly traps. A strip of filter paper treated with dichlorvos (500 g/l) was placed in each trap to kill flies that entered. The traps were suspended 0.4 m below the cage roof, 0.5 m from the cage sides and 0.75 m apart around the cage perimeter. Approximately 1500 *Dacus tryoni* (Froggatt)(Queensland fruit fly) were released into the field cage from a central position after all traps were in place. The flies were taken from laboratory stocks and were of mixed age and history of food intake and *ca.* 1:1 sex ratio. The trap position was rotated every 40 min when all flies were removed from the traps, counted and sexed. The experiment lasted 6 h 40 min so that each trap occupied each position in the cage for 40 min. Three replicates were carried out, each on a separate day.

The mean numbers attracted were analysed with an analysis of variance based on a square root (x + 1) transformation and means compared by using Duncan's Multiple Range Test. In addition, the percentages of flies attracted by each treatment were ranked within each replicate and Kendall's Coefficient of Concordance (W) (Siegel, 1956) was then computed to determine the agreement in treatment response between replications (i.e. over the 3 test days).

RESULTS

Of the total flies attracted to the solutions the highest proportions responded to the protein hydrolysate suspensions at pH 6.5 to which the bacterium (*P. rettgeri*) had been added and from which little ammonia was evolved (Table 2). When bacteria were added at this pH, more males than females were attracted, indicated by the significant differences in male catches and not in female catches (Table 2). Consequently fly response to bacteria is confounded somewhat when male and female catches are pooled. Generally, fewer flies were attracted to the protein hydrolysate suspensions at pH 9.0 which evolved similarly higher levels of ammonia (Table 1).

Kendall's Coefficient of Concordance (W) = 0.6626 gave a $\chi^2 = 17.89$ (d.f. = 9) ($p < 0.05$), indicating there was greater agreement in treatment response between replications than there would be by chance. This suggested that daily variability in fly condition and weather, which did affect total numbers of flies attracted, did not significantly influence treatment response, although a greater number of daily replications may have made this clearer.

DISCUSSION

Providencia species produce ammonia, indicated by positive reactions for producing both

Table 2. Mean number[1] of *Dacus tryoni* attracted to various protein hydrolysate suspensions and ammonia solutions. Values shown are square root (x+1) transformations.

Treatment designation[2]	Mean no. males	Mean no. females	Mean total no. (ranked means)
5*	68.2 a	30.6 a	100.3 a
7*	61.0 a	7.3 a	78.5 ab
4	30.0 ab	13.5 a	44.5 abc
1	15.7 b	18.5 a	34.3 bc
8	12.1 b	17.5 a	29.7 bc
2	8.1 b	15.7 a	24.0 c
6	10.4 b	10.2 a	20.4 c
9	9.1 b	9.9 a	19.0 c
3*	8.6 b	9.1 a	17.8 c
10	12.8 b	1.8 a	14.9 c

[1] Means within columns followed by the same letter are not significantly different at 5% probability level.
[2] See Table 1.
* Bacteria present.

tryptophane deaminase and urease which release ammonia from tryptophane and urea respectively (Brenner, 1984). Chemical analyses of the test solutions described above, despite not indicating differences in ammonia evolution in solutions with and without residual ammonia removed, showed that quite small quantities of ammonia were produced by the bacteria at pH 6.5 (6 and 7 µmoles/l) which is the optimal pH for their growth. The larger collections of male flies at *P. rettgeri* – inoculated protein hydrolysate suspensions at pH 6.5 indicate that volatiles other than ammonia and produced by bacterial metabolism are involved in the fruit fly attraction. If volatiles additional to ammonia were removed during the aeration procedure then they proved unimportant in the attraction process as those solutions with and without ammonia at similar pH's showed similar levels of attractancy. The small responses to the solutions at pH 9.0 (a level unsuitable for good bacterial growth) where ammonia was evolved in substantial quantities (44-87 µmoles/l), indicate that this gas is not a strong attractant for fruit flies. Also, pH of bait at the concentration recommended for normal fruit fly control programmes is *ca.* 4.0 which deters ammonia production. Therefore, it is unlikely that ammonia is a significant attractive factor produced by proteinaceous baits although this was implicated by Bateman and Morton (1981).

Apart from the critical range in pH, bacterial attractancy is strongly dependent on the species of bacteria involved, although a broad spectrum will attract flies and a number of protein bait sprays have been found to contain a wide range of living bacteria (Drew and Fay, unpublished data). It may be that in the normal shelf life of the product these microorganisms are producing some less volatile attractive factors that cause uninoculated solutions to be effective. The attractancy of these solutions would be further enhanced by inoculation that probably occurs when sprayed onto foliage.

When bacteria were added to the protein suspension at pH 6.5 there was a substantial increase in catches of male flies. The increase in attraction was immediate and probably due to the volatile metabolites produced by bacterial growth. It has been reported that certain plant surface bacteria are a natural food source for adult fruit flies (Drew *et al.*, 1983). It is possible that the flies detect the bacterial feeding sites in the host trees by responding to volatile bacterial metabolites and similarly that the bacteria available in the baits could also be a strong feeding attractant. This influence would be most marked when protein suspensions were sprayed on maturing fruit in host trees. Such fruits are sites upon which the flies have distributed an abundant supply of specific bacteria (Drew and Lloyd, in press). In this light the mode of action of protein bait sprays is probably related to the adult fly behaviour of feeding upon bacteria. The male attractancy to the bacteria – inoculated baits indicates that some bacterial metabolites have a sex-specific role. It is possible that males are attracted to the female feeding and oviposition sites thus ensuring mating success.

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Chemistry of Fruit Flies. Composition of the Rectal Gland Secretion of (Male) *Dacus cucumis* (Cucumber Fly) and *Dacus halfordiae*. Characterization of (*Z*,*Z*)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane

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Combined gas chromatography–mass spectrometry and synthesis have established that the major components of the rectal gland secretion of adult male cucumber flies (*Dacus cucumis*) are the *E*,*E*, *E*,*Z*, and *Z*,*Z* diastereomers of 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane, which have been synthesized utilizing organomercury chemistry from 1,10-undecadien-6-one. The thermodynamically least stable *Z*,*Z* diastereomer has been characterized for the first time, by ^{1}H and ^{13}C NMR measurements and mass spectrometry. Minor amounts of 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane and various derivatives of the 1,6-dioxaspiro[4.5]decane and 1,7-dioxaspiro[5.6]dodecane systems are also present. 1,3-Nonanediol occurs in significant amounts, and both enantiomers have been acquired by Sharpless asymmetric epoxidation of (*E*)-2-nonen-1-ol followed by Red-Al (Aldrich) reduction of the chiral epoxy alcohols. Chiral gas chromatographic analysis of the diols (as their cyclic carbonates) has demonstrated that the natural material is the *R*-(−) enantiomer. Natural (*E*,*Z*)-2,8-dimethyl-1,7-dioxaspiro-[5.5]undecane is shown to be racemic, whereas the more abundant *E*,*E* diastereomer is enantiomerically highly pure, possessing the 2*S*,6*R*,8*S* configuration. The major volatile component of the rectal gland secretion of male *Dacus halfordiae* (Tryon) is also (*E*,*E*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane, with no detectable levels of the *E*,*Z* or *Z*,*Z* isomers. Other spiroacetals present were 2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane and the unusual even carbon-numbered (*E*,*E*)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane. 6-Oxo-1-nonanol, diethyl succinate, and 2-methyl-6-pentyl-3,4-dihydro-2*H*-pyran were also identified.

Introduction

Fruit flies are destructive pests of horticulture in the tropical and temperate world and elaborate detection systems are employed for population monitoring and timing of eradication programs.[1] In recent years, more attention has been directed to the possible use of pheromone-based attractants, following the demonstration[2,3] that male tephritids store the pheromone in a reservoir and secrete it from a sac, both glands being located in the rectal region and appearing in the male (e.g., of Queensland fruit fly, *Dacus tryoni*) 2 days after the pupal–adult apolysis.[2] As the flies mature, droplets of yellowish material form.[2] In only one species, *D. oleae* (olive fly) does the female release the sac pheromone,[4] whereas male-produced pheromones have been identified in several species of tephritid fruit flies including *D. tryoni*,[5] *D. dorsalis*,[6] *D. cucurbitae*,[6] *Anastrepha suspensa*,[7] *A. ludens*,[8] and *Ceratitis capitata*.[9] These secretions are multicomponent in nature. What appear to be sex pheromones have also been found in the males of *Dirioxa pornia* (Walker),[10] *Rhagholitis pomonella* (Walsh),[11] and *R. cerasi L*,[12] but chemical information is lacking. The release of the pheromone is generally accompanied by courting behavior and the females may respond to other visual, auditory, or gustatory stimuli.[1]

Bellas and Fletcher[13] conducted the first chemical examination of the reservoir secretion of a Dacine species, and this work concerned *D. tryoni* (Froggatt) (Queensland fruit fly) and the taxonomically close *D. neohumeralis*, both very serious pests of fruit and vegetable crops in eastern Australia. The same set of six relatively simple amides was found in each species, although in different proportions. Since that report, studies of a number of

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(1) (a) See, for example: Drew, R. A. I.; Hooper, G. H. S.; Baterman, M. A. *Economic Fruit-Flies of the South Pacific Region*; Workshop Text, Department of Primary Industries: Brisbane, 1978. (b) *Fruit-Flies of Economic Importance* Cavalloro, R., Ed.; Proceedings CEC/10BC Int. Symp. Athens, November, 1982; A.A. Balkema/Rotterdam, 1983.
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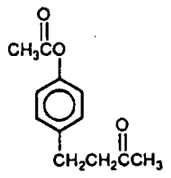
fruit-fly species have been conducted, and a range of chemically diverse structural types have been identified, representing amides, lactones, saturated and unsaturated alcohols and diols, esters, and spiroacetals. Fatty acids also occur.[14] 1,7-Dioxaspiro[5.5]undecane, from female olive flies (*D. oleae*), was the first spiroacetal to be identified as a specific insect sex pheromone.[15]

Australasia is rich in fruit-fly species[1] and regular quarantine monitoring and detection are conducted by using certain chemical lures in traps, e.g. 1 (Cue-Lure), 2 (methyleugenol), or 3 (Trimedlure), which are not pheromones.



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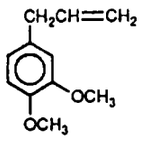

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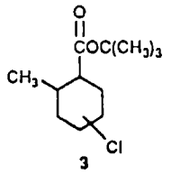

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The males of most tephritids in the South Pacific region are strongly attracted to 1 or 2, whereas isomers of 3 are effective for the Mediterranean fruit fly.[1] In addition to the "Cue-Lure" group and the "methyleugenol" group, there is a third group of flies that does not respond to these lures and hence population variations and penetration of previously uninfested areas are much more difficult to detect.[1] Chief among these are *D. cucumis* (cucumber fly), *D. halfordiae*, *D. decipiens*, and *D. latifrons*. The cucumber fly is a major pest in Queensland (cucurbits, tomatoes, papayas) and is taxonomically close to *D. decipiens*, thought to be confined to New Britain, but potentially a major threat to Australian horticulture.[1] *D. halfordiae* is of restricted habitat in Queensland and of minor economic importance (citrus and loquat crops), but is taxonomically close to *D. cucumis*. *D. latifrons* is now located in Hawaii, as well as in S.E. Asia.

Our attention was directed to this latter group of flies (particularly *D. cucumis*) and our long term goal was the development of an attractant as well as providing data for taxonomic correlation, an area of considerable confusion and flux, particularly with *D. dorsalis* (oriental fruit fly)[16] and *Ceratitis capitata* (med-fly).[16] We have examined as part of a continuing program approximately 15 fruit-fly species from Australasia, and here we report in full our studies of the male cucumber fly, *D. cucumis* (French) and *D. halfordiae* (Tryon).[17]

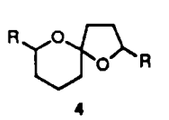
Results and Discussion

Dissection of male cucumber flies was conducted as described in the Experimental Section.[14] Extracts of dissected rectal glands were examined by capillary gas chromatography and it is seen that one major (~60%) and a number of minor components constitute the volatile portion of the glandular secretion. Consideration of the mass spectra confirmed that spiroacetals were predominant and three systems were represented: 1,6-dioxaspiro[4.5]-decanes 4; 1,7-dioxaspiro[5.5]undecanes 5; and 1,7-dioxaspiro[5.6]dodecanes 6. A number of these occurred as diastereomeric mixtures.

Table I. Volatile Components in the Solvent Extracts of the Rectal Gland of Adult Male Fruit Flies

compound[a]	relative amount (%)
Dacus cucumis (French)	
1. trimethylpyrazine	<1
2. tetramethylpyrazine	<1
3. (*EE*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane	~60
4. (*EE*)-2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane	~1
5. (*EZ*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane	5
6. 2-methyl-1,7-dioxaspiro[5.6]dodecane	~1
7. (*ZZ*)-2-ethyl-7-methyl-1,6-dioxaspiro[4,5]decane	~1
8. (*ZZ*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane	8
9. 2-(1′-hydroxyethyl)-7-methyl-1,6-dioxaspiro-[4.5]decane, isomer 1	<1
10. 2-(1′-hydroxyethyl)-7-methyl-1,6-dioxaspiro-[4.5]decane, isomer 2	<1
11. 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5] undecane, isomer 1	~1
12. (*EE*)-2-(hydroxymethyl)-8-methyl-1,7-dioxaspiro[5.5]undecane	<1
13. 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5] undecane, isomer 2	15
14. (*R*)-(−)-1,3-nonanediol	10
Dacus halfordiae (Tryon)	
1. (*E,E*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane	~70
2. 2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane	~1
3. 2-methyl-6-pentyl-3,4-dihydro-2*H*-pyran	~1
4. diethyl succinate	12
5. (*E,E*)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5] undecane	8
6. 6-oxo-1-nonanol	10

[a] Fatty acids were also present. For example, in *D. halfordiae* the following were identified: decanoic, dodecanoic, tetradecanoic, pentadecanoic, hexadecanoic (major).



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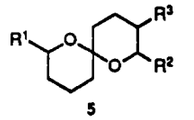

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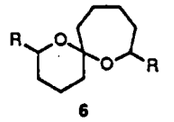

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A full listing of the compounds observed and identified in the extracts of *D. cucumis* (along with approximate percentages) is shown in Table I and discussed below.

The major volatile component (~60%) exhibited a molecular ion at m/z = 184, a weak ion at 169 (M − CH_3), but intense ions at m/z 115 and 112 (100%). Consideration of the known fragmentation patterns of simple alkyl-substituted spiroacetals[18] indicated the compound to be a 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane,[19] and this was confirmed as the *E,E* diastereomer 7 by comparison of its mass spectrum and VPC characteristics with those of a synthesized authentic sample (see below).



7



8



9



10

Two later eluting components had very similar mass spectral patterns (M = 184) except that the m/z = 112 ion was now weaker than the m/z = 115, which was the base peak. VPC comparisons of the known and characterized

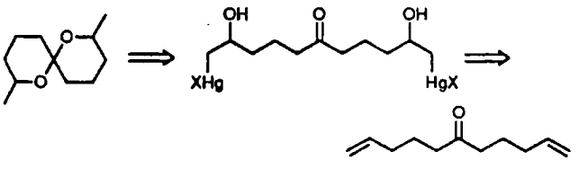
(14) A comprehensive discussion may be found in Lewis, J. A. Ph.D. Dissertation, University of Queensland, 1987.
(15) Baker, R.; Herbert, R.; Howse, P. E.; Jones, O. T.; Francke, W.; Reith, W. *J. Chem. Soc., Chem. Commun.* 1980, 52.
(16) Private correspondence and discussions with Dr. R. A. I. Drew and Dr. B. S. Fletcher (CSIRO Canberra).
(17) Some of this work has been reported in preliminary form: Kitching, W.; Lewis, J. A.; Fletcher, M. T.; Drew, R. A. I.; Moore, C. J.; Francke, W. *J. Chem. Soc., Chem. Commun.* 1986, 853.
(18) (a) Francke, W.; Reith, W. *Liebigs Ann. Chem.* 1979, 1. (b) Francke, W.; Hindorf, G.; Reith, W. *Naturwissenschaften* 1979, *66*, 619.
(19) Francke, W.; Reith, W.; Bergstrom, G.; Tengo, J. *Naturwissenschaften* 1980, *67*, 149.

(^{1}H and ^{13}C NMR) *E,Z* diastereomer (which was acquired by a new procedure discussed below) confirmed the presence of the *E,Z* diastereomer 8, and we concluded, somewhat tentatively at this stage, that the *Z,Z* diastereomer 9 of the same system was also present. 7 and 8 had been characterized previously by Francke,[20] and certain enantiomers of them were described by Mori.[21]

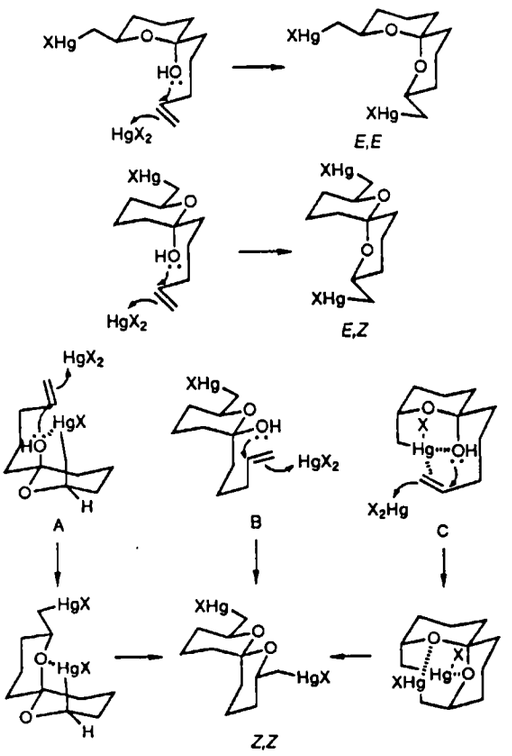
"Headspace volatile"[14] analyses were conducted by adsorption of the volatiles from a collection of 50 male *D. cucumis* (in a glass bell-jar chamber) onto special tubes loaded with Tenax GC to demonstrate that the major glandular components were indeed released into the atmosphere. Flash thermal desorption into the GC/MS system showed the headspace volatiles to consist predominantly of (*EE*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (7) with very minor proportions of the *E,Z* diastereomer 8, the presumed *Z,Z* diastereomer 9, and the hydroxy spiroacetal 15. Similar experiments with a collection of female flies showed a much lower level of these compounds in the atmosphere.

Our conclusion that the previously uncharacterized *Z,Z* diastereomer 9 was present at an appreciable level is of considerable interest, and characterization of a synthetic sample by NMR and GC-MS methods was considered very desirable. However, it was recognized that tactical acquisition of 9 would be difficult for the reasons outlined below. Reversible dehydrative spiroacetalization of the notional racemic keto diol 6-oxo-2,10-undecanediol in principle can provide three diastereomeric 2,8-dimethyl-1,7-dioxaspiro[5.5]undecanes, 7, 8, and 9, with 7 and 9 together representing 50% of the total. The equilibrium between 7 and 9 would be heavily regulated by the anomeric effect[22] so that (*E,E*)-7 would predominate to the virtual exclusion of 9 under mildly aqueous acidic conditions.[23] (Under these conditions, 7 or 9 would not equilibrate with 8.) The estimated relative free energies of 7, 8, and 9 are 0, 2.4, and 4.8 kcal/mol, respectively.[22,23] Hence any approach to 9 should avoid equilibrating conditions and incorporate the possibility of significant stabilization of intermediates leading to 9. This presumably must occur in vivo, where the 9/7 ratio is much greater than its equilibrium value. Metal ion coordination (e.g., calcium) to possible diol or ketol precursors may be providing an energetically feasible route to 9, formed along with the predominating 7.

Synthesis of *E,E*, *E,Z*, and *Z,Z* Diastereomers of 2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane. Simple retrosynthesis shows that (Markovnikov) oxymercuration of 1,10-undecadien-6-one should provide a keto diol, equivalent to the skeleton of the target system.[24] On the assumption that "double" oxymercuration would be stepwise, a number of hemiketal intermediates could be envisaged



Scheme I



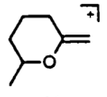
that would lead to *E,E*, *E,Z*, or *Z,Z* spiroacetal systems, when consummated by the second (intramolecular) oxymercuration step (Scheme I). Intermediates providing *E,E* and *E,Z* systems are unexceptional, whereas of the three (A, B, C in Scheme I) possible hemiacetals that could lead to the *Z,Z* spiro system, A and C are more attractive, as B enjoys no anomeric stabilization.[22] The unfavorable 1,3-diaxial interaction between methylene and oxygen (2.4 kcal/mol)[23] in A and C may be offset by the coordination of mercury to oxygen.[25] C has the added feature of mercury–ene coordination. Subsequent to oxymercuration of the second double bond, a single ring reversal for case A or two ring reversals for case C would lead to *Z,Z* spiroacetal with both CH_2HgX groups equatorial. Our hope was that the populations of A and/or C under irreversible conditions would be adequate to permit eventual isolation of some 9 for NMR and GC/MS studies.

1,10-Undecadien-6-one was prepared by addition of 4-pentenylmagnesium bromide to ethyl formate followed by Jones oxidation.[24] Oxymercuration was conducted with $Hg(OAc)_2$ in a 1:1 mixture of THF and H_2O (1% $HClO_4$), and the resulting mercuri-substituted spiroacetals could be isolated as acetates or chlorides, which were viscous oils or solids and relatively air and light stable. Essentially pure *EE* mercurial could be obtained by recrystallization[14,24] and >90% diastereomerically pure directly from the reaction when conducted under acidic conditions for extended periods (~15 h) to permit equilibration, as both spiroacetalization and oxymercuration are reversible under such conditions. However, by controlling the reaction conditions, significant quantities of the *E,Z* mercurial could be produced (~40%), particularly when $HClO_4$ was

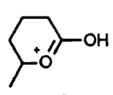
(20) Francke, W.; Reith, N.; Sinnwell, V. *Chem. Ber.* **1980**, *113*, 2686.
(21) (a) Mori, K.; Tanida, K. *Tetrahedron* **1981**, *37*, 3221. (b) Mori, K.; Watanabe, H. *Tetrahedron* **1986**, *42*, 295.
(22) For a full discussion, see: Delongschamps, P. *Stereoelectronic Effects in Organic Chemistry*; Pergamon Press: Oxford, 1983.
(23) Delongschamps, P.; Rowan, D. D.; Pothier, N.; Sauve, T.; Saunders, J. K. *Can. J. Chem.* **1981**, *59*, 1106.
(24) For some preliminary discussion, see: Kitching, W.; Lewis, J. A.; Fletcher, M. T.; De Voss, J. J.; Drew, R. A. I.; Moore, C. J. *J. Chem. Soc., Chem. Commun.* **1986**, 855.
(25) In this connection, see: (a) Henbest, H. B.; Nicholls, B. *J. Chem. Soc.* **1959**, 227. (b) Bentham, S.; Chamberlain, P.; Whitham, G. H. *Chem. Commun.* **1970**, 1528. (c) Giese, B.; Bartmann, D. *Tetrahedron Lett.* **1985**, *26*, 1197.

omitted and reaction times were minimized (<10 min). Under these conditions a low level of a third diastereomer (presumed to be the *Z,Z*) was observed on the basis of ^{13}C signals in the spiro-carbon region for these 2,8-bis(chloromercurimethyl)-1,7-dioxaspiro[5.5]undecanes: *E,E* 97.36 ppm, *E,Z* 98.30 ppm, and *Z,Z* 101.90 ppm (benzene–pyridine-d_5 solvent).

The *E,E* and *E,Z* mercurials were fully characterized by ^1H and ^{13}C NMR and full details are located elsewhere.[14] Reductive demercuration of this latter mixture provided 7 (48%), 8 (40%), and the slowest eluting isomer (capillary GC; OV101) (3%) concluded below to be 9. The EIMS of 7, 8, and (presumed) 9 and of their 5,5,11,11-tetradeuterio isomers are very similar and establish the 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane constitution.[18] The major difference concerns the relative intensities of the ion 11 (*m/z* 112; 116 in tetradeuterio analogue), which is the base peak in 7 whereas *m/z* = 115 (12) is the base peak in 8 and 9. (These differences are apparent also in the mass spectra of the natural components.)



11



12

Very careful preparative gas chromatography of this mixture resulted in the isolation of the known 7 and 8 (each >90% diastereomerically pure), and presumed 9 (~85%). As required by their symmetry, 7 and 8 exhibit six (δ (C_6D_6) ppm: 19.42, 22.34, 33.31, 35.72, 65.23, 96.11) and eleven (19.11, 19.23, 22.12, 22.34, 30.35, 32.60, 33.53, 36.61, 65.93, 68.54, 97.12) ^{13}C NMR lines, respectively,[20] and in the ^1H NMR spectra (C_6D_6) one (δ 3.73) and two absorptions (δ 3.42; 4.26) respectively for >CH–O and also for the methyl groups (7, δ 1.15; 8, δ 1.14, 1.19). That the stereoisomer concluded to be 9 possessed a 2-fold axis was confirmed by its six-line ^{13}C NMR spectrum (δ (C_6D_6) ppm: 19.46, 22.86, 30.88, 32.39, 68.50, 98.78) and the 400-MHz ^1H spectrum (C_6D_6) with one low-field absorption (δ 3.60 with J = 9.3, 6.4, and 3.4 Hz; >CH–O) and a single methyl doublet (δ 1.22; J = 6.4 Hz). The large coupling constant (9.3 Hz) ($J_{2\text{-}3ax}$) for H2 (δ 3.60) in 9 indicated this proton to be predominantly axial (*equatorial* CH_3) so that the conformation depicted for 9 is the dominant one, with no anomeric stabilization. However some distortion of the chair geometry may operate. Full anomeric gain could be achieved by ring-reversals, placing both methyl groups *axial*, but the nonbonded interactions are then severe. The 400-MHz ^1H NMR spectrum of 9 is reproduced in Figure 1, and the resonances of >C*H*–O (when compared with those for the *E,E* and E,*Z* isomers) indicates such protons experience a 1,3-diaxial relationship with carbon, not oxygen, following, for example, the analysis of Mori[21b] on similar systems. In addition, no other ring protons in the *Z,Z* diastereomer 9 appear below δ 1.65, strongly indicative of the absence of any axially disposed C–O bonds. (In 7 and 8, ring proton resonances (other than >C*H*–O) appear as low as δ 2.05 and 1.93, respectively.) More detailed discussion of the ^1H and ^{13}C NMR spectra of 7, 8, and 9 may be found elsewhere.[14]

Equilibration studies provided further evidence for the constitution of 9. Exposure of 9 (contaminated with ca. 6% of each of 7 and 8) to aqueous acid resulted in facile equilibration (<5 min) to a mixture of 7 (94%) and 8 (6%) with 9 now undetectable by capillary VPC. This is required[22,23] if 9 is the *Z,Z* diastereomer, as it can isomerize to the *E,E* diastereomer 7 only if equatorial methyl groups are maintained and configurational changes at the notional

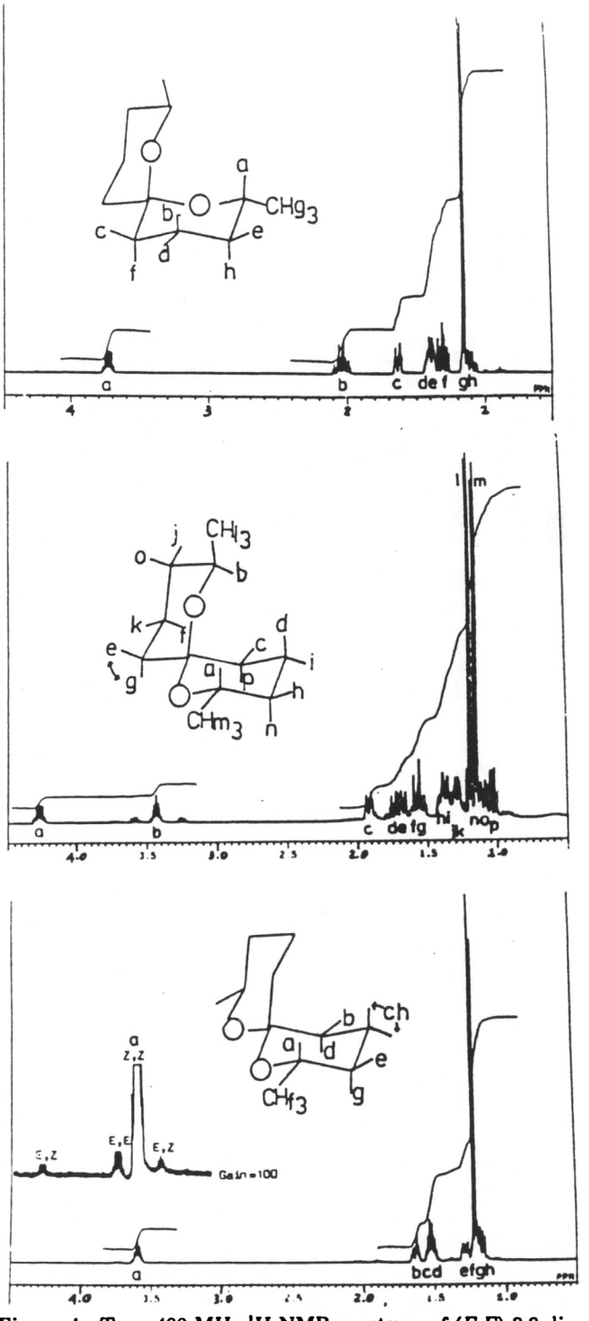


Figure 1. Top: 400-MHz ^1H NMR spectrum of (*E,E*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (C_6D_6 solvent), showing the anticipated one methyl doublet and one >C*H*–O absorption. Middle: spectrum of (*E,Z*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane, showing a duality of methyl doublets and >C*H*–O absorptions. Bottom: spectrum of (*Z,Z*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane, showing one methyl doublet and one >C*H*–O absorption. (In the latter region, residual signals for the *E,E* and *E,Z* diastereomers are indicated.) See text for discussion.

secondary alcohol centers do not occur under such mildly acidic conditions.

With 7, 8, and 9 available, combined GC-MS examinations confirmed that these diastereomers were present in the cucumber fly secretion to the extent of 60%, 5%, and 8%, respectively. Considering the relative energies of 7 and 9, this result is intriguing, and the possible role of

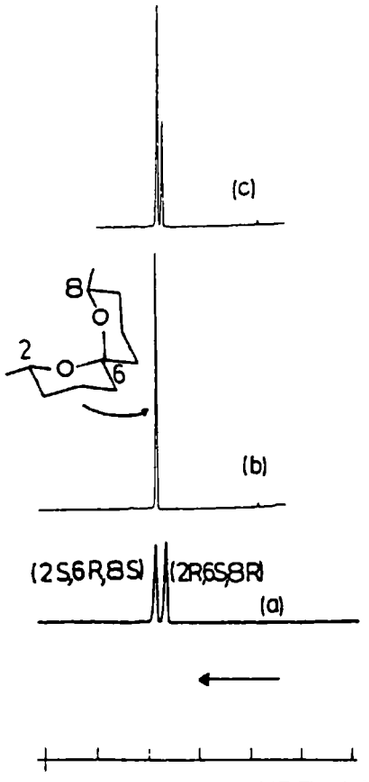


Figure 2. (a) Enantiomer resolution of (*E,E*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane. Conditions: 40 m glass capillary column with per-*n*-hexyl-α-cyclodextrin. Column temperature 80 °C; carrier gas 1 bar H_2. Approximate retention time is 10 min. (b) Corresponding trace for the glandular extract of *D. cucumis*, showing the presence of the 2*S*,6*R*,8*S* enantiomer only. (c) Trace of natural sample (as in b) mixed with (±)-(*E,E*) diastereomer as in a.

metal ions in vivo has been alluded to above. It is conceivable that the presence of thermodynamically less favored isomers would furnish an "inbuilt clock" which would provide information on the age of the bio-signal, given that the 9/7 ratio observed is well removed from the equilibrium value.

Chirality of 7, 8, and 9. The importance of chirality on the level of response by fruit flies to a given compound was demonstrated[26] by the attraction of male and female olive flies (*D. oleae*) to the enantiomers of 1,7-dioxaspiro[5.5]undecane (**10**). Consequently attempts were made to determine the enantiomeric composition of **7**, **8**, and **9**, employing complexation gas chromatography with metal-bearing chiral ligands as developed by Schurig and coworkers.[27] The *E,Z* diastereomer **8**, as secreted by male flies, was nicely resolved into enantiomers on chromatography and was racemic. However, this and similar chiral phases[27] did not resolve the enantiomers of the most abundant *E,E* diastereomer **7** and this is consistent with the view that complexation through oxygen to the metal center appears least favorable for this diastereomer. Conclusions regarding the nature of the least stable **9** were not clear cut, under the above chromatographic conditions. Fortunately, enantiomeric separation of spiroacetal systems, using hydrophobic derivatives of cyclodextrins as chiral phases, has recently been achieved.[28] In particular, the enantiomers of (*E,E*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (**7**) are nicely resolved. As shown in Figure 2, appropriate capillary gas chromatographic determinations, using per-*n*-hexyl-α-cyclodextrin as stationary phase, establish that the natural *E,E* diastereomer is highly enantiomerically pure, possessing the 2*S*,6*R*,8*S* configuration[21] as shown above in **7**. 1,7-Dioxaspiro[5.5]undecane (**10**), as secreted by *D. cacuminatus* and *D. oleae* (olive fly), has been shown to be racemic,[17,26] but here the chirality is associated with the sometimes labile spiro center, whereas (formal) secondary alcohol centers are present in **7**, **8**, and **9**. **8** has opposite chirality at the secondary centers (C_2, C_8) and if **8** results from ring closure of a "preformed" keto diol, the hydroxylation steps must have provided (some) secondary alcohol centers of opposite chirality, but the extent of this regulates the amount of **8** that is possible. (The enantiomers of **7** and **9** have like chirality at C_2 and C_8.) It follows that some keto diol with 2*R*,10*R* stereochemistry would be formed also, but the resulting 2*R*,6*S*,8*R* enantiomer of the *E,E* diastereomer would be present at a very low level.

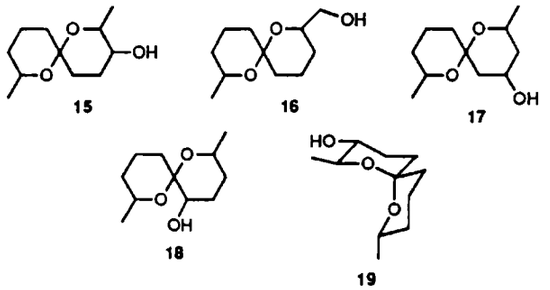
Minor dialkyl spiroacetals in the *D. cucumis* secretion included (*E,E*)- and (*Z,Z*)-2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane (**13** and **14**), which were identified by comparison of GC-MS characteristics with those of authentic samples. Previously the *E,E* and *E,Z* diastereomers had



13 **14**

been identified in other insects,[19] but there have been no reports of the *Z,Z* diastereomer. 2-Methyl-1,7-dioxaspiro[5.6]dodecane was also identified (GC/MS comparison with a published spectrum)[24] as a minor component.

Hydroxy-substituted spiroacetals were also considered to be present and one in significant amount (15%). Compared with **7**, the mass spectrum exhibited ions indicating the presence of an additional oxygen atom, e.g., *m/z* = 156, 128, and an apparent M = 200. A likely candidate was 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (**15**) (on the basis that dehydration and retro-Diels–Alder breakdown would provide the base peak at *m/z* = 112) but isomers **16**, **17**, and even **18** were considered and synthesized for comparison.



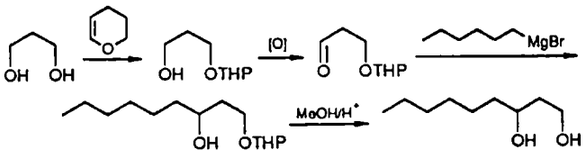
15 **16** **17**

18 **19**

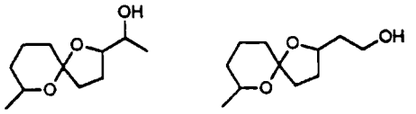
GC-MS comparisons with a synthetic sample of **15** (formed with another isomer (**20**)) confirmed the presence of **15**. This was subsequently shown to be *E,E,E* diastereomer **19** based on VPC comparisons and 2D-NMR analyses of separately synthesized diastereomers of **15**, uncontaminated with **20**. A second isomer of **15** was present in a very minor amount. (The synthesis of com-

(26) Haniotakis, G.; Francke, W.; Mori, K.; Redlich, H.; Schurig, V. *J. Chem. Ecol.* **1986**, *12*, 11.
(27) Weber, R.; Schurig, V. *Naturwissenschaften* **1984**, *71*, 408.
(28) (a) König, W. A.; Lutz, S.; Wenz, G. in press. (b) Private correspondence with Professors König, Francke (Hamburg), and Schurig (Tübingen).

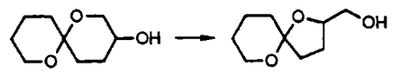
Scheme II



pounds 15–18 and other hydroxy spiroacetals will be reported in detail subsequently.[30] 15 is a minor component of *D. tryoni* (Froggatt) and is the first spiroacetal observed in a male dacine fly attracted to Cue-lure. The three remaining hydroxy spiroacetals were present as very minor components (<1%). The first was (*E*,*E*)-(**16**),[24,31a] which was independently synthesized and showed M = 200 with m/z = 169 (M – CH_2OH), 131, and 128, indicative of hydroxylation, whereas the remaining two were considered to be isomers of either **20** or **21**. Synthesis[30] of isomers



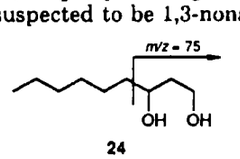
20 **21**



22 **23**

of **20** confirmed their presence in the fly secretion. Baker reported[32] the thermal conversion (GC/MS conditions) of **22** to **23** and similar behavior of **15** could provide **20**, and thus it is uncertain whether **20** is a natural compound. A number of hydroxy-substituted spiroacetals, e.g., **16**, **17**, have been identified in the mandibular gland secretions of species of Andrena bees.[31] Mori has suggested on the basis of private correspondence with Bellas that 1,7-dioxaspiro[5.5]undecane (**10**) is a minor component of the *D. cucumis* secretion.[33] However, examination of many acetone or pentane extracts of this fly from varied sources has failed to reveal this spiroacetal. It is possible that the original specimens of *D. cucumis* were contaminated with a *D. cacuminatus* specimen whose very predominant glandular component (ca. 8 μg/fly) is this simple spiroacetal.[17]

Other Compounds. High molecular weight hydrocarbons and fatty acids were observed together with trimethyl- and tetramethylpyrazine (<1% in some extracts). A further component (~11% of the volatiles) with highest m/z = 113 (30%) and 75 (100%) (EIMS) was also present, and chemical ionization techniques identified ions at 159 (M – 1) and 142 (– H_2O) providing M = 160.[34] This component was suspected to be 1,3-nonanediol (**24**).



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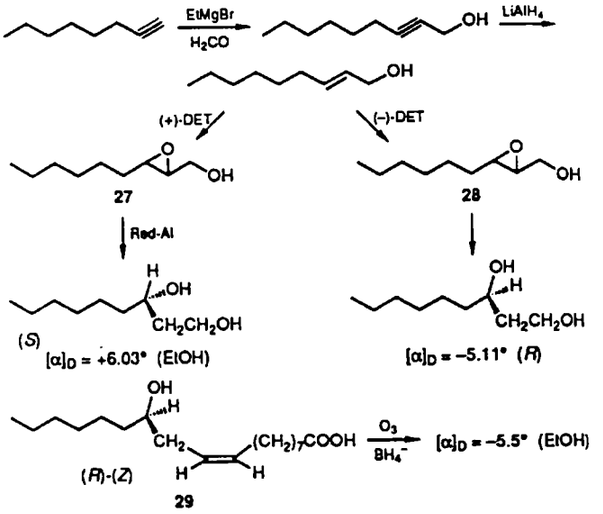
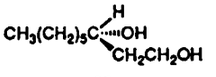
Scheme III



1,3-Nonanediol was initially synthesized by the method in Scheme II. 1,3-Propanediol was selectively protected with dihydropyran as described by Kozluk[35] and separated from other products by silica gel chromatography. (A product not reported by Kozluk was considered to be the 1,3-dioxane derivative of 5-hydroxypentanal, formed by rearrangement of the monoprotected 1,3-propanediol.) Oxidation with pyridinium chlorochromate buffered with sodium acetate provided the protected hydroxy aldehyde, which on reaction with *n*-hexylmagnesium bromide and deprotection afforded 1,3-nonanediol, identical in all respects (GC, EIMS and CIMS) with the natural material. The base peak (m/z = 75) was provided by the fragmentation shown on **24**.

In view of the demonstrated importance of chirality in some semiochemicals[36] and the possible biosynthetic connection between diols and spiroacetals, determination of the chirality of this natural diol was considered worthwhile. This involved enantioselective syntheses of both (*S*)-(+) and (*R*)-(–)-1,3-nonanediols using Sharpless asymmetric epoxidation[37] as a key step and chiral gas chromatographic analyses of these and of the natural diol.[38]

Reaction of octynylmagnesium bromide with gaseous formaldehyde provided 2-nonyn-1-ol (86%), which on reduction ($LiAlH_4$) yielded exclusively (*E*)-2-nonen-1-ol (76%) together with a minor amount of 1,2-nonadiene, which was easily separated. Epoxidation (MCPBA) to 2,3-epoxy-1-nonanol and reduction with Red-Al (THF; –30 °C → –10 °C) provided exclusively 1,3-nonandiol (80%). Hence Sharpless asymmetric epoxidation[37] of (*E*)-2-nonen-1-ol followed by Red-Al reduction[39] would represent enantioselective routes to (+)- and (–)-1,3-nonanediol (**25** and **26**). (See Scheme III.)



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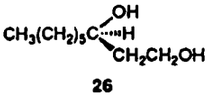

26

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(37) Sharpless, K. B.; Woodard, S. S.; Finn, M. G. *Pure Appl. Chem.* **1983**, *55*, 1823.
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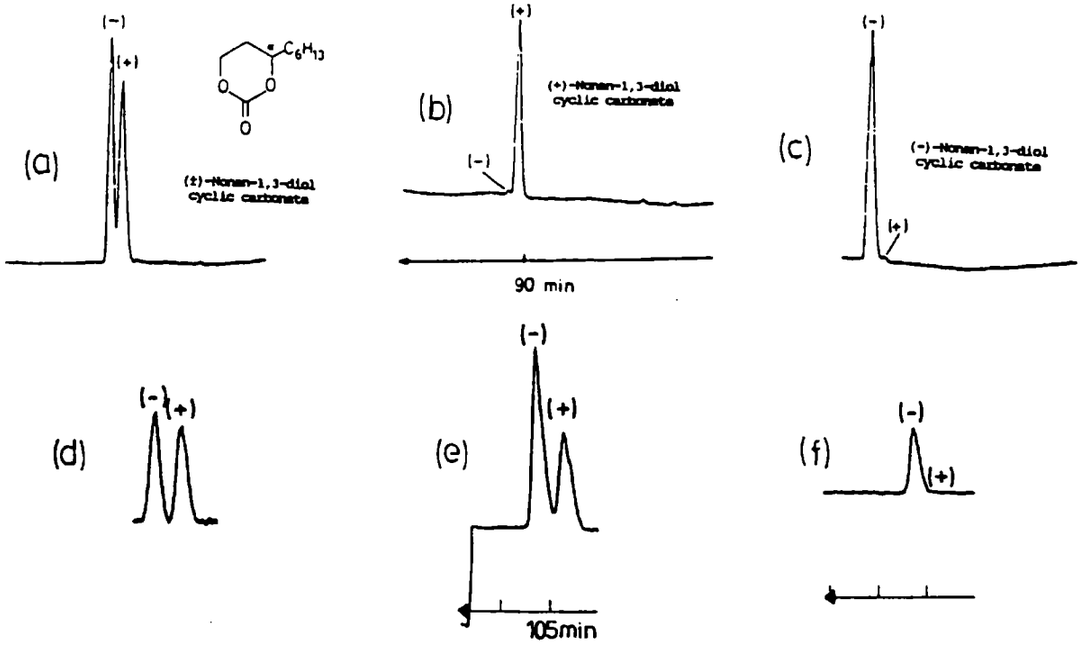
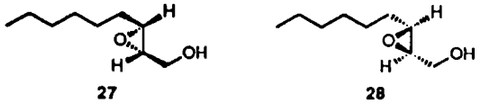
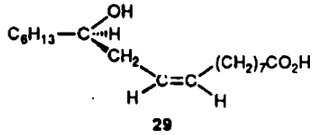


Figure 3. (a–c) Enantiomer separation of the standard samples of (a) (±)-nonane-1,3-diol, (b) predominantly (+), and (c) predominantly (-) enantiomers, as synthesized. Conditions: 50 m fused silica capillary column with XE-60–L-valine–(*R*)-α-phenylethylamide. Column temperature: 100–180 °C, temperature programmed 2 °C/min. Carrier gas: 1 bar H_2. (d–f) Comparison of natural sample: (d) (±)-nonane-1,3-diol, (e) natural sample mixed with (±)-nonane-1,3-diol, and (f) natural sample. Conditions: same column. Column temperature 170 °C. Carrier gas 1 bar H_2. Retention time 105 min.

Thus asymmetric epoxidation in the reported way[37] of (*E*)-2-nonen-1-ol[40] with L-(+)-diethyl tartrate provided (-)-2,3-epoxy-1-nonanol (**27**) (mp 45–45.5 °C; $[\alpha]^{34}_D$ = -38.9°; *c* = 0.0175 in $CHCl_3$), whereas D-(-)-diethyl tartrate yielded the (+) enantiomer ($[\alpha]^{20}_D$ = +38.7°; *c* = 0.0295 in $CHCl_3$) **28**. Precedent would indicate that the (+) enantiomer was the 2*R*,3*R* epoxy alcohol and both enantiomers were obtained in high optical purity on the basis of chiral gas chromatography (Figure 3) of their cyclic carbonates (diol + phosgene).[38] That the (+) epoxy alcohol had the 2*R*,3*R* configuration as shown in **28** was confirmed



27 **28**



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in the following way. Ozonolysis of (*R*,*Z*)-(+)-12-hydroxy-9-octadecenoic acid (**29**) (riconoleic acid) of established absolute configuration,[41] followed by reduction ($NaBH_4$) of the resulting (*R*)-3-hydroxynonanal, provided (*R*)-(-)-1,3-nonandiol ($[\alpha]^{22}_D$ = -5.5°, *c* = 5.8, ethanol) as compared with -5.11° (*c* = 1.04, ethanol) and +6.03° (*c* = 1.2, ethanol) for the (*R*)-(-)- and (*S*)-(+)-1,3-nonandiols obtained by Red-Al reduction of the synthesized 2,3-epoxy-1-nonanols.

Treatment of the glandular secretion extract of male cucumber flies with phosgene (to form the cyclic carbonate of the diol) followed by chiral gas chromatographic analysis (Figure 3) using the carbonates of the (*R*)-(-)- and (*S*)-(+)-1,3-nonanediols as standards demonstrated the presence of the *R*-(-) enantiomer only. This information will permit more soundly based evaluation of the behavior of cucumber flies to the diols, and it is of interest that secondary hydroxylation to form **26** and the (notional) keto diol leading to **7** proceed with the same chiral sense. (The opposite *R* and *S* descriptors result from priority changes.)

Glandular Secretion of *Dacus halfordiae* (Tryon). The major volatile component (~70%) of male rectal glands was (*EE*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (**7**), as observed for the cucumber fly, but of considerable interest was the absence of the *E*,*Z* (**8**) and *Z*,*Z* (**9**) diastereomers. The absence of **8** suggests enantiospecific hydroxylation (in the same chiral sense) in the formation of the notional keto diol intermediate. However, chirality determinations with **7** have not yet been conducted. A minor component (~6%) with M = 198 and *m*/*z* = 169 (M - C_2H_5) and characteristic spiroacetal fragmentation (compared with 7-ethyl-2-methyl-1,7-dioxaspiro[4.5]decane) was considered to be the very unusual even-carbon numbered 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (**30**) apparently occurring as the *E*,*E* diastereomer.[17] This was confirmed by GC-MS comparisons with an authentic sample, originally synthesized in our laboratories by Fletcher.[17] This unusual spiroacetal is also found in specimens of *D. dorsalis* (oriental fruit fly),[17,42] *D. latifrons* (Hendel),[17] and *D. occipitalis* (Bezzi).[17] (Another even-carbon numbered spiroacetal, 2-butyl-8-methyl-1,7-dioxaspiro[5.5]undecane (**31**), is a minor component in *D. latifrons*.[17])

A further significant volatile component (~10%) was demonstrated to be 6-oxo-1-nonanol (**32**) by comparisons with a synthesized sample.[17] This keto alcohol also occurs

(40) For the asymmetric epoxidation of (*E*)-nona-2,8-dienol, see: Bulman-Page, P. C.; Rayner, C. M.; Sutherland, I. O. *J. Chem. Soc., Chem. Commun.* **1986**, 1408.

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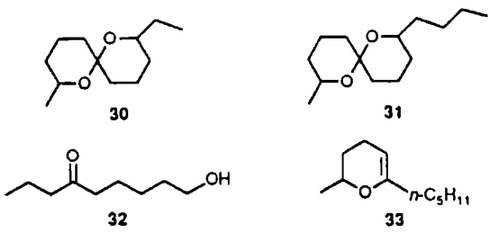

as the major component (65%; 5 μg/fly) in *D. occipitalis*.[17] The demonstration that **30** and **32** are found in both *D. occipitalis* and *D. halfordiae* is of interest, considering that males of the former species are strongly attracted to methyleugenol whereas the latter are not. We are unaware of any previous demonstration of 6-oxo-1-nonanol as an insect component other than in *D. occipitalis*.

A minor component of the gland extract displayed an apparent M = 168 ($C_{11}H_{20}O$) with prominent m/z = 125 and 112 (100%) ($C_7H_{12}O$), indicative of a dihydropyran nucleus. This was shown to be 2-methyl-6-n-pentyl-3,4-dihydro-2*H*-pyran (**33**) by comparison of its mass spectrum with that of an authentic sample.[31b] One side-chain oxygenation of **33** could then lead to the 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane system. **33** is a major component of the male cephalic secretion of *Andrena wilkella* species.[31a] We reported previously[17] that **8** (M = 184) was present in the *D. halfordiae* secretion, but higher quality mass spectra of this minor component revealed it to be 2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane (**13** or **14**).

Since the identification of 2-ethyl-1,6-dioxaspiro[4.4]-nonane as the principal aggregation pheromone of the bark beetle (*Pityogenes chalcographus*) by Francke in 1977,[43] spiroacetals have been identified in three different orders of insects and elicit a broad range of behavior responses. With a few exceptions (some described herein) spiroacetal pheromones (in orders Coleoptera, Hymenoptera, and Diptera) show unbranched carbon skeletons with nine, eleven, or thirteen carbon atoms[44] and hence are closely related to other straight-chain pheromones that are presumably fatty acid derived. Possible biogenetic connections indicate that spiroacetals may be found, for example, in Lepidopteran species where functionalized straight-chain systems abound. As pointed out elsewhere,[44] the possible male sex pheromone of a pyralide moth, (*Z*)-2,6-nonadien-4-olide,[45] possesses the functionality needed for smooth, biogenetic conversion to a spiroacetal. In the wild olive fly, the co-occurrence of 1,7-dioxaspiro[5.5]undecane and ethyl 6-oxoundecanedioate has been reported[46] and the connection here is clear.

Our (and other)[32,42] examinations show that a large variety of spiroacetal types are present in rectal gland secretion of a wide range of Dacus species. In most cases, the exact role and function of these compounds have not been determined, but biological evaluation and field assessments of some of those compounds are currently underway and may lead to specific attractants and controls for some Dacine species.

Experimental Section

Fruit Fly Glandular Extracts. Dissections were carried out on sexually mature male flies that had been laboratory reared on a standard artificial diet and fed as adults on protein hydrolysate, sugar, and water. Dissection of the male flies was performed by gently squeezing (tweezers) the abdomen in the region of the first and second segments, thus forcing the ninth segment containing the genitals to protrude slightly. The whole ninth segment was removed and this included the secretory sac and reservoir. The excised glands were then extracted in a suitable solvent and normally both pentane and acetone were employed.[14]

GC/MS spectra were recorded on a Hewlett-Packard Model 5992B instrument fitted with OV1 or BP5 capillary columns, whereas gas chromatographic analyses were performed on a Hewlett-Packard 5710A gas chromatograph using OV1 or BP5 capillary columns or a Varian Model 3700 gas chromatograph using an OV101 capillary column. Preparative gas chromatography was performed on a Shimadzu gas chromatograph Model GC-9A equipped with OV101 and C-20M columns. Headspace analyses and some GC-MS runs were performed on a Finnigan Mat 1020 automated GC/MS equipped with either the specially designed desorption unit or a Perkin-Elmer ATD50 automatic thermal desorption system. Mass spectra were recorded on an AEI-MS902 spectrometer at an ionizing voltage of 70 eV. IR spectra were recorded on a Perkin-Elmer Model 397 spectrometer. Optical rotations were measured on a Perkin-Elmer 141 MC polarimeter. ^{1}H NMR spectra were recorded at either 100 MHz (CW mode) on a JEOL JNM-PS100 spectrometer or at 100, 300, or 400 MHz in the FT mode on JEOL JNM-FX100, Bruker CXP-300, and JEOL JNM-GX400 spectrometers, respectively. Chemical shifts were references to internal tetramethylsilane (0.0 ppm) or residual $CHCl_3$ (7.24 ppm). ^{13}C NMR were recorded at 25.05 MHz, 75.46 MHz, or 100 MHz and chemical shifts were referenced to the center peak of the solvent ($CDCl_3$) at 77.00 ppm or benzene-d_6 (128 ppm).

Synthesis of (*E*,*E*)-, (*E*,*Z*)-, and (*Z*,*Z*)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane (7, 8, and 9). Undeca-1,10-dien-6-one. To the cooled (0 °C) Grignard reagent prepared from 5-bromo-1-pentene (10 g, 67 mmol) and magnesium (1.8 g, 74 mmol) in ether (60 mL) was added ethyl formate (2.6 g, 34 mmol). The reaction was warmed to room temperature and stirred for 1 h. The reaction was quenched with saturated ammonium chloride and extracted with ether. The separated ether fraction was dried and evaporated to yield a yellow oil, consisting of 1,10-undecadien-6-ol (69%) and the corresponding formate ester (31%). The crude product was refluxed in 15% aqueous KOH solution for 3 h to hydrolyze the ester, after which the cooled solution was extracted with ether. Solvent removal, etc., followed by distillation (112 °C/10 mm) provided the alcohol in 70% yield. ^{1}H NMR: 6.2 (2 H, m, CH=), 5.5 (4 H, m, CH_2=), 4.1 (1 H, br s, C*H*OH), 2.6 (4 H, m, allylic H), 2.0 (9 H, m, including OH). ^{13}C NMR: 138.71, 114.87, 71.58, 36.89, 33.73, 24.92. MS (m/z, rel intensity) (84, 20.2), (81, 98.7), (79, 22.9), (67, 25.1), (57, 39.8), (55, 98.4), (54, 38.0), (43, 60.6), (41, 100), (39, 53.7). Oxidation of the alcohol using Jones reagent was conducted in the standard way to provide the title ketone (100 °C/16 mm; 92%). ^{1}H NMR: 6.4 (2 H, m, CH=), 5.7 (4 H, m, CH_2=), 23–3.3 (12 H, m). ^{13}C NMR: 210.91, 137.99, 115.17, 41.96, 33.12, 22.85. MS: (112, 19.0), (97, 33.4), (84, 24.1), (70, 11.7), (69, 44.7), (58, 38.4), (55, 43.2), (43, 25.8), (41, 100).

Oxymercuration. The conditions under which the oxymercuration/reduction sequence was performed greatly affected the diastereomeric ratio in the product spiroacetals.[14,24,30] The procedure developed to optimize the proportions of the thermodynamically less favored diastereomer is outlined. To a stirred solution of undeca-1,10-dien-6-one (0.5 g, 3.0 mmol) in THF–H_2O (15 mL:15 mL) was added $Hg(OAc)_2$ (1.94 g, 6.1 mmol) in one portion and the homogeneous solution was stirred for 15 min. Benzyltriethylammonium chloride (2.4 g, 10.5 mmol) in 10% aqueous sodium hydroxide (15 mL) and dichloromethane (5 mL) was added followed by $NaBH_4$ (0.09 g, 2.3 mmol) in 10% aqueous sodium hydroxide (5 mL). The grey inhomogeneous reaction mixture was stirred for 15 min or until the solution was clear with a small pool of metallic mercury. The solution was filtered through Celite, which was washed with ether. The aqueous phase was extracted with ether and the combined organic phase was dried ($MgSO_4$) and evaporated and the product purified by Kugelrohr distillation (bp 90 °C; 15 mm (lit.[20] bp 86–87 °C; 17 mm)). Under these conditions, a mixture of *EE* (48%), *EZ* (40%), and *Z*,*Z* (3%) diastereomers of 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane formed, together with some dienone (~1%) and two isomers (~3%) of

(43) Francke, W.; Heemann, V.; Gerken, B.; Renwick, J. A. A.; Vité, J. P. *Naturwissenschaften* **1977**, *64*, 590.
(44) Francke, W. In *Les Mediateurs chimiques*; INRA: Versailles, 1982; p 81.
(45) Kuwahara, Y. *Appl. Ent. Zool.* **1980**, *15*, 478.
(46) Mazomenos, B. E.; Pomonis, J. G. in ref 1b, p 96.

2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane. Increasing the reaction time for oxymercuration to ca. 15 h and use of 1% aqueous $HClO_4$–THF as solvent led to very predominantly *E,E* diastereomer (>90%) with some *E,Z* (~6%) and no *Z,Z* isomer. (The intermediate organomercurials were easily isolated and characterized, and these compounds have been discussed elsewhere.[14])

The mixture of (*E,E*)-, (*E,Z*)-, and (*Z,Z*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecanes (7, 8, and 9) was separated by careful preparative gas chromatography. The *E,E* and *E,Z* diastereomers were each obtained >90% isomerically pure and the *Z,Z* ca. 85% pure. These were characterized by ^1H, ^{13}C, and ^2D NMR and GC/MS, with the salient features of the NMR data being discussed in the text.

(*E,E*)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane (7). ^{13}C NOE δ (C_6D_6): 96.11 (s), 65.23 (d, J_{C-H} = 141 Hz), 35.7 (t, J = 125 Hz), 33.31 (t, J = 123 Hz), 22.34 (q, J = 125 Hz), 19.42 (t, J = 128 Hz). MS (*m/z*, rel intensity): (184, 15.0, M^+), (140, 15.0), (115, 96.1), (114, 36.7), (112, 100), (97, 60.3), (69, 39.4), (55, 55.0), (43, 70.1), (41, 64.8). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.7; H, 10.9. Found: C, 71.3; H, 11.2.

(*E,Z*)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane (8). ^{13}C NOE δ (C_6D_6): included 97.3 (s), 68.5 (d, J = 140 Hz), 65.9 (d, J = 140 Hz), 22.4 (q, J = 120 Hz), 22.1 (q, J = 120 Hz). (See text for full listing). MS (*m/z*, rel intensity): (184, 10.2, M^+), (115, 100), (114, 33.5), (112, 42.6), (97, 62.4), (69, 45.9), (55, 44.5), (43, 48.6), (42, 33.6), (41, 50.4).

(*Z,Z*)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane (9). MS (*m/z*, rel intensity): (184, 11.3, M^+), (115, 100.0), (114, 36.2), (112, 49.4), (97, 66.9), (69, 44.0), (55, 45.9), (43, 45.9), (42, 34.2), (41, 50.2).

Oxymercuration–reduction of 5,5,7,7-tetradeuterio-1,10-undecadien-6-one (obtained by base-catalyzed H–D exchange) led to the 5,5,11,11-tetradeuterio derivatives of the above diastereomers, such deuteration assisting in the analysis of the NMR spectra (see text). MS of tetradeuterioanalogues: (*E,E*) (188, 16.1, M^+), (144, 18.6), (117, 87.0), (116, 100.0), (115, 63.1), (99, 31.3), (71, 25.2), (45, 34.0), (43, 58.1), (42, 37.6); (*E,Z*) (188, 9.6, M^+), (117, 100.0), (116, 64.5), (115, 53.6), (114, 13.2), (99, 44.6), (71, 33.4), (55, 26.9), (43, 55.8), (42, 41.0); (*Z,Z*) (188, 0, M^+), (117, 84.9), (116, 71.7), (115, 56.6), (114, 20.8), (99, 43.3), (71, 45.3), (55, 50.9), (43, 100.0), (42, 73.6), (41, 50.9).

Synthesis of (±)-1,3-Nonanediol (24): Procedure A. 3-(Tetrahydropyranyloxy)propan-1-ol was prepared from propane-1,3-diol as reported[35] and purified by silica gel chromatography. 1,3-Bis(tetrahydropyranyloxy)propane was eluted with hexane and 3-(tetrahydropyranyloxy)propan-1-ol with hexane/ether (2:1). An additional product, considered to be the 1,3-dioxane derivative of 5-hydroxypentanal, was also isolated. ^{13}C NMR: 99.0, 65.80, 62.40, 60.88, 32.04, 30.55, 25.23, 19.55. (Dioxane derivative: 102.19, 66.88 (2 C), 62.67, 34.70, 32.42, 25.81, 20.11.) **3-(Tetrahydropyranyloxy)propanal** was obtained (93%) by pyridinium chlorochromate oxidation of the above alcohol under NaOAc-buffered conditions in dichloromethane, in the usual way. ^{13}C NMR: 201.24, 98.95, 62.21, 61.18, 43.82, 30.46, 25.33, 19.30. The unpurified aldehyde (0.9 g, 5.7 mmol) in dry ether (5 mL) was added dropwise to a stirred solution of n-hexylmagnesium bromide made from the bromide (1.23 g, 7.5 mmol) and magnesium (0.18 g, 7.2 mmol) in dry ether (10 mL), and the solution was then stirred for 1 h and then quenched with saturated ammonium chloride solution. The separated organic layer was combined with the ether extracts of the aqueous phase and then dried ($MgSO_4$), and the ether was removed under vacuum. The crude product was purified by column chromatography (silica, hexane/ether (2:1)) (65%). MS (*m/z*, rel intensity): (244, 0.0, M^+), (159, 6.5, M – 85), (85, 100). Deprotection of 1-(tetrahydropyranyloxy)nonan-3-ol was achieved in the usual way (methanol, H^+) and after addition of H_2O, the solution was extracted with dichloromethane. Standard workup then provided **1,3-nonanediol (60%)** (bp 100–103 °C, 1 mm (lit.[47] bp 90–92 °C, 0.8 mm)). ^{13}C NMR: 72.22, 61.73, 38.24, 37.82, 31.79, 29.26, 25.48, 22.58, 14.03. MS (*m/z*, rel intensity): (160, 0.0, M^+), (113, 30.0), (92, 21.8), (75, 100.0), (70, 21.3), (57, 62.1), (55, 45.1), (45, 47.2), (43, 55.0), (41, 45.4), (29, 60.1).

Procedure B: 2-Nonyn-1-ol[48] was obtained by bubbling dry gaseous formaldehyde (thermolysis of paraformaldehyde at 200 °C) into an ether solution of oct-1-ynylmagnesium bromide, obtained from 1-octyne and ethylmagnesium bromide. Standard workup and distillation provided the alcohol (86%) as a colorless oil (bp 88–90 °C, 7 mm). ^1H NMR: 4.16 (2 H, s), 2.95 (1 H, br s), 2.12 (2 H, tt, J = 7 Hz, 2.3 Hz), 1.1–1.4 (8 H, m), 0.8 (3 H, t, J = 7 Hz). ^{13}C NMR: 86.03, 78.22, 50.82, 31.18, 28.45, 28.40, 22.35, 18.55, 13.81. MS (*m/z*, rel intensity): (140, 0.0 M^+), (93, 37.3), (79, 28.4); (70, 38.0), (69, 32.0), (67, 53.8). **(*E*)-2-Nonen-1-ol:**[49] Non-2-yn-1-ol (3.0 g, 21 mmol) in dry ether (50 mL) was added dropwise to a stirred solution of $LiAlH_4$ (1.63 g, 43 mmol) in dry ether (300 mL). This solution was refluxed for 36 h and then decomposed with wet ether and ice, followed by ammonium chloride solution. The ether extracts of the aqueous phase were combined, dried ($MgSO_4$), and evaporated to provide the *E*-allylic alcohol (bp 102–104 °C, 12 mm, 76%) and 1,2-nonadiene (bp 40–50 °C, 12 mm, 17%). ^1H NMR: 5.61 (2 H, m, vinylic), 4.05 (2 H, d, J = 5.8 Hz, CH_2OH), 1.95 (2 H, dt, allylic), 1.57 (1 H, br s, OH), 1.15–1.40 (8 H, m), 0.85 (3 H, t, CH_3). ^{13}C NMR: 133.53, 128.78, 63.79, 32.19, 31.69, 29.08, 28.84, 22.58, 14.05. MS (*m/z*, rel intensity): (142, 0, M^+), (95, 21.9), (82, 27.1), (68, 22.3), (67, 24.3), (57, 100), (55, 42.5).

(±)-2,3-Epoxynonan-1-ol. (*E*)-2-Nonen-1-ol (1.91 g, 13 mmol) and *m*-chloroperbenzoic acid (MCPBA) (85%; 2.87 g, 17 mmol) were stirred in dichloromethane (50 mL) for ca. 3 h after which the reaction mixture was washed thoroughly with saturated sodium carbonate solution and sodium chloride solution. The organic phase was dried ($MgSO_4$) and solvent removed under vacuum to provide a white solid, which appeared as white needles after recrystallization from hexane (mp 42–42.5 °C; 77%). Anal. Calcd for $C_9H_{18}O_2$: C, 68.3; H, 11.5. Found: C, 67.8; H, 11.6. ^{13}C NMR: 61.75, 58.53, 56.03, 31.66, 31.51, 28.99, 25.84, 22.49, 13.9. MS (*m/z*, rel intensity): (158, 0, M^+), (97, 40.0), (70, 14.2), (69, 18.8), (57, 27.4), (55, 100). The above epoxy alcohol (0.5 g, 3 mmol) was dissolved in dry THF (5 mL) and cooled to –30 °C (dry ice/CCl_4 bath). Red-Al (3.4 M in toluene, 2.6 mL, 9 mmol) was added dropwise and the reaction mixture stored at –10 °C for 2 days.[39] The reaction was then quenched (H_2O) and extracted well with ether and the combined ether extracts were washed with saturated NaCl solution, separated, and dried ($MgSO_4$) and the ether was removed under vacuum. GC analysis indicated the presence of 1,3-nonanediol only. ($LiAlH_4$ reduction produces roughly equal amounts of 1,2- and 1,3-nonanediols.) Distillation provided **(±)-1,3-nonanediol (24)** (104–105 °C, 1 mm, 75%. (lit.[47] bp 90–92 °C; 0.8 mm)), whose spectroscopic properties were identical with those described above. **Sharpless Epoxidation**[37] **of (*E*)-2-Nonen-1-ol: (–)-2,3-Epoxynonan-1-ol.** A round-bottomed flask equipped with a magnetic stirrer and serum cap assembly was flame dried under a N_2 purge and cooled to –20 °C (dry ice, carbon tetrachloride) whence dry dichloromethane (from CaH_2) was added. The following were then added sequentially via syringe (through the serum cap) to the stirred solution: titanium tetraisopropoxide (1.0 g, 3.5 mmol), L-(+)-diethyl tartrate (anhydrous; 0.73 g, 3.5 mmol), which were stirred for 5 min. The (*E*)-2-nonen-1-ol (0.5 g, 3.5 mmol) and *tert*-butyl hydroperoxide (3 M in toluene, 2.4 mL, 7 mmol) were then added and the resulting homogeneous solution was stored in the freezer (–10 °C) for 24 h. To the cooled flask (–20 °C) was added aqueous tartaric acid (10 mL of 10% solution), which caused solidification of the aqueous layer. After 30 min, the cooling bath was removed and stirring continued until the aqueous layer became clear. The organic layer was washed with H_2O and cooled (0 °C) and sodium hydroxide (10 mL of 1 M solution) was added and the whole stirred (30 min). The organic phase was washed (NaCl solution), dried ($MgSO_4$), and concentrated to provide a yellow oil, which was chromatographed on silica gel (hexane/ether 1:1) to yield (–)-2,3-epoxynonan-1-ol. Anal. Calcd for $C_9H_{18}O_2$: C, 68.3; H, 11.5. Found: C, 68.2; H, 11.5. Mp: 45–45.5 °C; $[\alpha]^{24}_D$ = 38.9° (*c* = 0.0175 in $CHCl_3$). Spectral data matched those for the racemic epoxy alcohol. **(+)-2,3-Epoxynonan-1-ol** resulted from a similar procedure except that D-(–)-diethyl tartrate was employed and

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matching spectra, etc., were obtained. $[\alpha]^{20}_D$ +38.7° (c = 0.0295 in $CHCl_3$). ^1H NMR: δ 3.89 (1 H, dd, J = 12.5, 2.4 Hz) and 3.61 (1 H, dd, J = 12.5, 4.2 Hz, CH_2OH), 2.93 (1 H, td, J = 5.6, 2.4 Hz, H_3), 2.89 (1 H, dt, J = 2.4, 4.2 Hz, H_2), 1.2-1.67 (m, 11 H, CH_2 and OH), 0.86 (3 H, t, J = 6.8 Hz, CH_3). (This ^1H spectrum matched those for the (±) and (-) epoxy alcohols.) **Red-Al reductions** of the (+) and (-) epoxy alcohols were performed as described for the (±) alcohol, the (-) epoxy alcohol provided (+)-nonane-1,3-diol (64%), and the (+) epoxy alcohol the (-)-nonane-1,3-diol (53%). **(+)-Nonane-1,3-diol**: $[\alpha]^{20}_D$ = +6.03 (c = 1.2 in ethanol). ^1H NMR: 3.8 (3 H, m, CH-O), 2.2 (2 H, br s, OH), 1.2-1.7 (12 H, m), 0.8 (3 H, t, J = 6.8 Hz, CH_3). The ^{13}C and MS data were essentially identical with those listed for the racemic compound. **(-)-Nonane-1,3-diol**: $[\alpha]^{20}_D$ = -5.4° (c = 1.40 in ethanol) with appropriate ^1H and ^{13}C NMR and MS.

Ozonolysis of (*R*,*Z*)-(+)-12-hydroxyoctadec-9-enoic acid was conducted in the standard way at -70 °C (methanol solvent; dimethyl sulfide present) to provide **(*R*)-3-hydroxynonanal** (Kugelrohr distillation: 120 °C, 1 mm). ^1H NMR: 4.1 (1 H, m, CH-OH), 2.6 (2 H, m, CH_2CO), 2.4 (1 H, br s, OH), 1.3 (11 H, m), 0.8 (3 H, t, CH_3). MS (*m*/*z*, rel intensity): (158, 0, M^+), (73, 28.9), (70, 36.6), (57, 24.4), (55, 66.7), (45, 54.7). **Reduction** of the above aldehyde was effected with $NaBH_4$ in methanol in the normal way to provide **(*R*)-(-)-nonane-1,3-diol** (Kugelrohr: 100 °C, 0.1 mm) (lit.[50] bp 97-99 °C, 0.1 mm)). $[\alpha]^{22}_D$ = -5.5° (c = 5.8 in ethanol) (lit.[50] $[\alpha]^{22}_D$ = -6.30° (c = 10 in ethanol)). MS (*m*/*z*, rel intensity): (113, 22.1), (97, 14.6), (75, 100), (70, 24.4), (57, 53.2), (55, 52.0), (45, 43.3).

Hydroxy-Substituted Spiroketals. The syntheses of some of the various hydroxy-substituted spiroketals have been described elsewhere[14] and will be reported in full in a separate publication.[20]

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Chapter 2.5 Australia and South Pacific Islands

G.H.S. HOOPER and R.A.I. DREW

1 INTRODUCTION

There is a large endemic tephritid fauna in the area defined by this chapter, i.e. Australia, Papua New Guinea and the islands of the South Pacific. The pest species belong to the subfamily Dacinae except for the introduced Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) in Australia. Within Australia 78 species have been described and further new species are known. Within the remainder of the area approximately 200 species are known and since collecting has not been as extensive as in Australia, an increase in species might be anticipated.

Apart from the Mediterranean fruit fly, which was introduced into Australia from Europe around 1897 (but now only occurs in the western coastal fringe of the continent), and more recently the establishment in northern Queensland in 1972 of *Dacus frauenfeldi* Schiner from Papua New Guinea, the pest species of Australia comprise endemic species which proved able to shift from endemic rain forest fruits to introduced crop plants. Similarly, in the islands of the South Pacific the species of concern are endemic with the exception of the Queensland fruit fly, *Dacus tryoni* (Froggatt) which has extended its range, as a consequence of man's activities, as far east as Easter Island from which it was eradicated twice in the early 1970's. However, in Papua New Guinea the introduced melon fly, *Dacus cucurbitae* Coquillett is well established and occasional specimens of *D. tryoni* have been recorded.

There are several aspects to the fruit fly problem in the area under consideration. Firstly, a number of species cause damage to crops and the loss plus control measures are a direct cost to agricultural production. Secondly, there are both intra and international quarantine problems resulting in either denial of potential markets, or the added cost of appropriate disinfestation procedures to farmers in fruit fly areas. Thirdly, just as the major pest species (other than *C. capitata*) in Australia are endemic and have demonstrated an ability to shift from endemic to introduced hosts, it is likely that many developing South Pacific countries will encounter a similar problem with their endemic tephritid species. In many of these countries agriculture and horticulture are currently practised at a subsistence level only. When there is a departure from this to large monocultures it must be expected that more fruit fly species will achieve pest status. Fourthly, the possible establishment within the area of exotic species is of concern.

Table 2.5.1 indicates to which of the male lures, methyleugenol, cue-lure and trimedlure, the species considered in the text respond. Further information on this aspect can be found in Drew (1974, 1982) and Drew and Hooper (1981). An approximate indication of the distribution of the species considered can be

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TABLE 2.5.1

Male lures, cue-lure (CL), methyleugenol (ME), trimedlure (TML), to which the species discussed respond, and the distribution of each species within the areas designated in Fig. 2.5.1

Species	Responding to				Distribution in areas designated in Fig. 2.5.1
	CL	ME	TML	None	
Dacus aquilonis (May)	*				F
Dacus atrisetosus Perkins				*	A
Dacus bryoniae (Tryon)	*				A, B, F
Dacus cucumis French				*	B, C, F
Dacus cucurbitae Coquillett	*				A
Dacus curvipennis Froggatt	*				G
Dacus decipiens Drew				*	A (New Britain)
Dacus dorsalis Hendel		*			A
Dacus facialis Coquillett	*				H (Tonga)
Dacus frauenfeldi Schiner	*				A, B
Dacus jarvisi (Tryon)				*	B, C, F
Dacus kirki Froggatt	*				H, J (plus Niue Is)
Dacus melanotus Coquillett[1]	*				I
Dacus musae (Tryon)		*			A, B
Dacus neohumeralis Hardy	*				A, B, C
Dacus passiflorae (Froggatt)	*				H (plus Niue Is)
Dacus psidii (Froggatt)	*				G
Dacus trivialis Drew	*				A
Dacus tryoni (Froggatt)	*				A, B, C, D, G, J
Dacus umbrosus (Fabricius)		*			A
Dacus xanthodes Broun		*			H, I
Ceratitus capitata (Wiedemann)			*		D, E

[1] Drew (1974, 1982) incorrectly recorded this species as responding to ME; recent work (M.A. Bateman, pers. comm.) confirms the above response.

gained by using the information in Table 2.5.1 in conjunction with Fig. 2.5.1. For presentation in this chapter the South Pacific region is divided into 10 areas.

2 PEST SPECIES AND THEIR DISTRIBUTION

2.1 Papua New Guinea and the Bismarck Archipelago (Area A, Fig. 2.5.1)

A number of serious pest species occur in this area. *Dacus musae* (Tryon) is a major pest of bananas and will oviposit in immature green bananas as well as mature fruit. *Dacus bryoniae* (Tryon) has been recorded from banana and capsicum in Papua New Guinea. *D. cucurbitae* is a major pest of vegetable crops. It occurs in lowland areas of Papua New Guinea and islands to the east as far as Bougainville Island. It was recently introduced into the Shortland Islands but was subsequently eradicated. *Dacus atrisetosus* Perkins occurs at higher altitudes in mainland Papua New Guinea and infests vegetable crops (particularly tomatoes and cucurbits) which are attacked by *D. cucurbitae* at lower altitudes.

Dacus decipiens Drew occurs only on New Britain and is a serious pest of pumpkins. *D. frauenfeldi* occurs in large populations throughout area A and is a serious pest of mango. *Dacus umbrosus* (F.) is abundant in lowland areas and infests citrus and breadfruit throughout the area. *Dacus trivialis* Drew has been bred in large numbers from grapefruit, peach and guava in mainland Papua New Guinea.

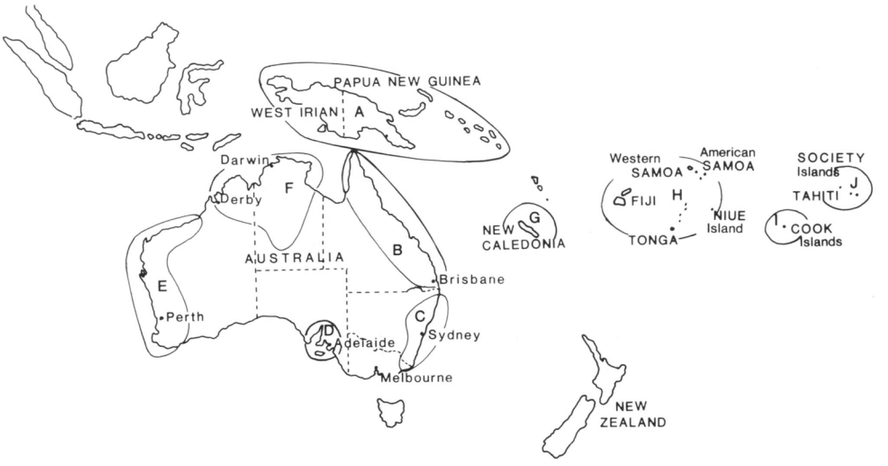

Fig. 2.5.1. Map of Australia and South Pacific Islands designating areas of approximate distribution of fruit fly species referred to in the text and Table 2.5.1.

Dacus neohumeralis Hardy appears to be endemic in mainland Papua New Guinea but to date has not been reared from fruit. Only the occasional specimens of *D. tryoni* have been collected in Papua New Guinea and considerable doubt exists as to whether this species is established there.

The fruit fly fauna of Irian Jaya is virtually unknown. A few specimens were recently received from the western extremity and some attracted to methyl eugenol were *Dacus dorsalis* Hendel.

2.2 Australia (Areas B, C, D, E, F, Fig. 2.5.1)

As might be expected from the size of the Australian continent, and the consequent range of climatic zones, the tephritid problem is rather complex. The most severe problems occur in the wet tropical and sub-tropical areas of eastern Queensland (Area B), in the northernmost third of the Northern Territory (Area F), and the northern tip of Western Australia (Area E). However, because of the extent of horticultural crops in Queensland the problem there is most severe.

In eastern Australia (Areas B, C) the major pest is the Queensland fruit fly, *D. tryoni*. In addition to attacking a wide range of fruit and vegetable crops, *D. tryoni* breeds in numerous native fruits, particularly in areas of rainforest. Another closely related species, *D. neohumeralis* has a more restricted range (Area B), but can be as damaging as *D. tryoni*; in some commercial fruits both species occcur in approximately equal numbers. In Queensland and eastern New South Wales, these tephritids must be controlled on a regular basis. A further species attacking commercial fruit is *Dacus jarvisi* (Tryon). In Queensland it has been recorded from deciduous fruits, persimmons and guava.

D. musae is the major pest of banana, attacking both immature and ripe fruit, but occurs only in northern Queensland. *Dacus cucumis* French is a serious pest of all cucurbits, tomatoes and papaya in north-eastern Australia (Area B).

Other species have been recorded as minor or potential pests in Australia (Drew, 1982) based on incidental occurrences in fruit. It is possible that these could become economic pests with changing patterns of fruit production.

Although efficient control measures are available and implemented to limit direct loss to commercial crops in Queensland and coastal New South Wales,

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movement of vegetables and tropical fruits to southern areas of Australia is subject to quarantine restrictions. During the major period of fruit fly activity (September–May) fruit and vegetables entering Victoria must either be certified as originating in a fruit fly free area or be certified as having received an approved disinfestation treatment. Even more stringent limitations occur with other states.

In the inland fruit growing areas of the Goulburn, Murray and Murrumbidgee River valleys *D. tryoni* is of major economic importance. This is not because of direct damage, but because of loss of markets, or increased production costs arising from disinfestation procedures for fruit destined for export to other Australian states or overseas. In these normally fruit fly free areas the detection of larvae in fruit, or more than 2 flies in a trap (cue-lure) results in post-harvest treatment of all fruit within 3–80 km of the "outbreak" depending on the potential market.

In South Australia (Area D, Fig. 2.5.1) *D. tryoni* and *C. capitata* are the species of concern. Despite inspection at roadblocks and a requirement that fruit from other states be certified as originating from a fruit fly free area, or as having been subjected to a disinfestation treatment, outbreaks of both species have occurred regularly in Adelaide since 1947. To date these outbreaks have not occurred in the commercial fruit areas of the state. The presence of fruit fly in the citrus orchards of the Murray River area, and any consequent eradication program, would present special problems for the existing biological control of California red scale. Each fruit fly outbreak in Adelaide is eradicated by protein hydrolysate baiting and limited cover spraying.

The major tephritid pest species in Western Australia (Area E, Fig. 2.5.1) is *C. capitata*. While it has long been established in the south-western area of the state its range extends up the western coast and recently it has been detected at Derby. There is some concern that it could spread further north. As elsewhere in the world, it is a major pest of a wide range of exotic fruits and some vegetables. In the north-west of the state *D. jarvisi* attacks mangoes.

Of 18 tephritid species recorded from the Northern Territory (Area F, Fig. 2.5.1) 3 are considered as current or potential pests. In recent years there has been a considerable expansion of horticultural crops and the economic importance of fruit flies may be expected to increase as a consequence. *D. jarvisi* is recognised as a pest of mangoes (which is not true for Queensland) and this results in quarantine restrictions to southern markets. Recently this species has been recorded from citrus and again this could complicate the export of citrus, particularly limes. *Dacus aquilonis* (May), which is closely related to *D. tryoni*, also attacks citrus as well as other fruit such as peach and guava. *D. cucumis* was detected in 1980 but its effect on cucurbit crops has yet to be defined. Delimiting its range is difficult because it does not respond to any of the male lures (Table 2.5.1).

On 2 occasions (1976/77 and 1981/82) infestations of *C. capitata* were detected in Alice Springs, and were eradicated by collection and destruction of host fruits, and protein bait and cover sprays.

Tasmania does not have endemic tephritid pest species and has no fruit fly problem. Although *C. capitata* was detected there at the turn of this century it did not establish.

2.3 New Caledonia (Area G, Fig. 2.5.1)

Dacus psidii (Froggatt) has been reared from citrus, mango, granadilla and guava, and potentially could become a serious pest if these hosts were developed commercially. However, it is likely that the introduced *D. tryoni* would

be the more important species. In any event, both species could be managed by the same control measures. Another species, *Dacus curvipennis* Froggatt, is restricted to New Caledonia and infests citrus.

2.4 Fiji, Samoa, Tonga (Area H, Fig. 2.5.1)

Three local species have been recorded from Fiji and Samoa attacking a variety of fruit crops including peach, mango, citrus and guava and vegetable crops such as tomato and capsicum, viz. *Dacus xanthodes* Broun, *Dacus kirki* Froggatt and *Dacus passiflorae* (Froggatt). On Tonga *Dacus facialis* Coquillett is a serious pest of tomatoes and has been recorded from a variety of other fruits and vegetables.

2.5 Cook Islands (Area I, Fig. 2.5.1)

Dacus melanotus Coquillett has been recorded only from this region and is considered a very serious pest of citrus. It also attacks mango and guava. *D. xanthodes* has recently been recorded on these islands (M.A. Bateman, pers. comm.).

2.6 Society Islands (Area J, Fig. 2.5.1)

One endemic species, *D. kirki*, has been recorded from several hosts, viz. peach, mango, guava, and capsicum. However, the exotic species *D. tryoni* is likely to be a greater problem in fruit and vegetable crops.

3 CONCLUSION

This chapter would not be complete without addressing the problem of the introduction of exotic species. That this threat is a serious one is amply illustrated by (i) spread of *D. tryoni* to islands of the South Pacific, (ii) the invasion of northern Australia by *D. frauenfeldi*, and (iii) the establishment of *D. cucurbitae* in Papua New Guinea.

The establishment by *D. dorsalis* in New Guinea and/or Australia would be a very serious matter. However, there are more than 20 species within the "*dorsalis* complex", which all respond to methyl eugenol, and which are difficult to separate on classical taxonomic criteria. The magnitude of the problem became clear after the detection in the Northern Territory in 1976 of flies that at the time were believed to be *D. dorsalis*. Although morphologically they could not be distinguished from *D. dorsalis* existing in south-east Asia and the Hawaiian Islands, they were subsequently defined as a new species probably endemic to the area, *Dacus opiliae* Drew and Hardy, on ecological and cytological grounds. This species has been recorded only from one non-economic native host.

The existence of extensive populations of *D. cucurbitae* in Papua New Guinea, a scant 150 km from the Australian mainland is a matter of continuing concern, given the level of local maritime commerce across Torres Strait. Similarly the spread of *D. xanthodes, D. facialis, D. kirki* and *D. passiflorae* from their current ranges to other islands in the Samoan, Fijian and Tongan island groups should be monitored.

The history of past movements of tephritid fruit flies coupled with an increase in tourism and landfall by itinerant yachts within the area and between this area and south-east Asia, demonstrates the necessity for efficient quarantine services. In 1984 Australia-wide quarantine confiscated 7.1 tonnes of fruit from incoming plane passengers and crew, and this arose from a 5% inspection

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rate. In addition 3.8 tonnes of fruit were discarded in "honesty bins" prior to quarantine inspection (A. Allwood, pers. comm.). While there is no information on the rate of fruit fly infestation of such fruit from Australia, New Zealand does record such data and they have reared seven *Dacus* spp. from produce originating from within the Pacific region, *D. cucurbitae* and *Dacus ciliatus* Loew from India, *C. capitata* from Spain, and *Anastrepha fraterculus* (Wiedemann) from Peru (Keall, 1981). Clearly quarantine efforts in all areas should be backed by extensive and intensive monitoring by appropriate traps to detect incipient invasions of exotic species.

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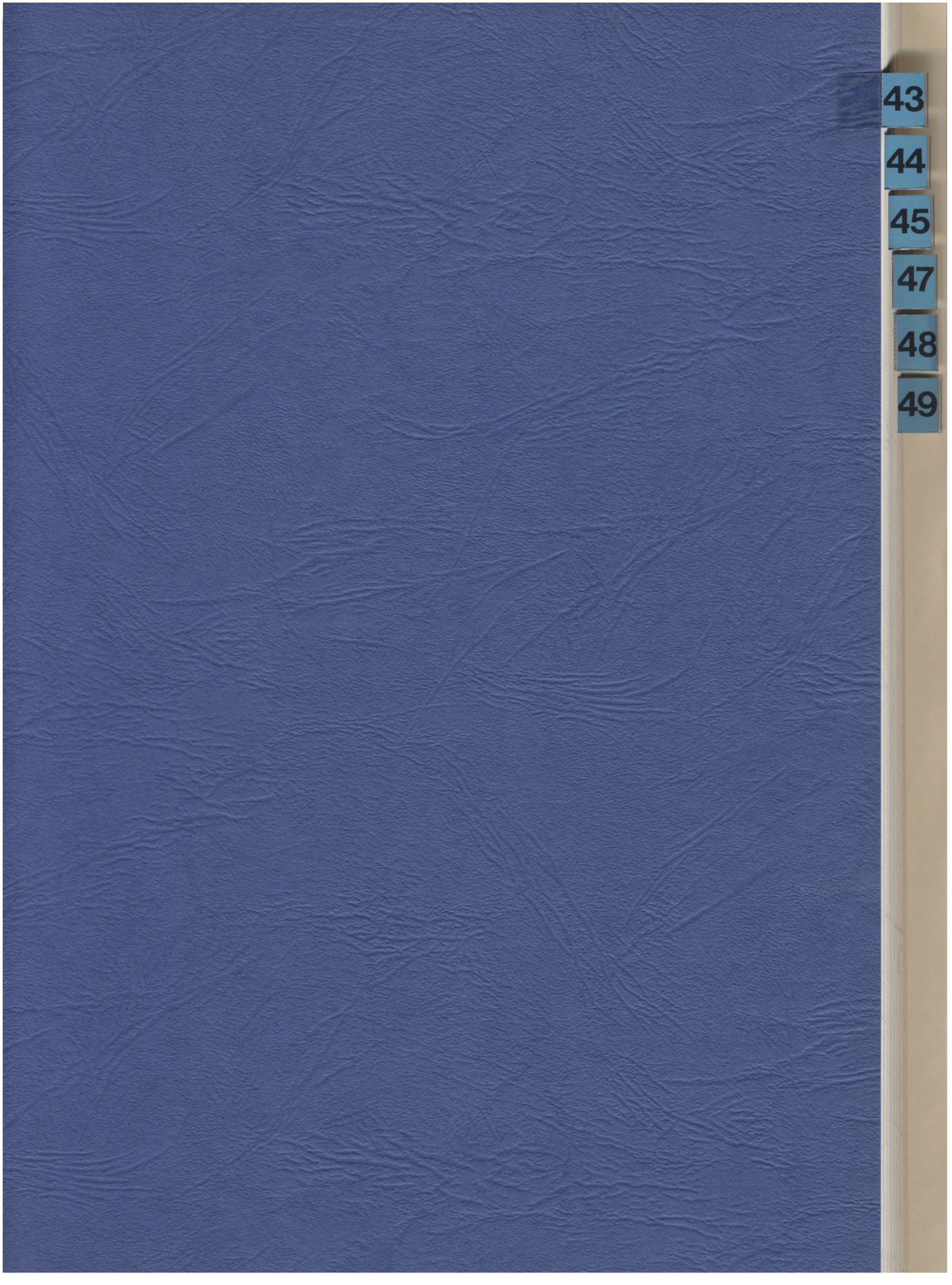
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3.1.3 Bacteria associated with Fruit Flies and their Host Plants

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1 INTRODUCTION

Although it has been recognized for many years that microorganisms may have various non-pathological associations with insects (Steinhaus, 1954), the true biological significance of many of these relationships remains poorly understood. As stressed by Steinhaus (1960), the role of microorganisms in the ecology of insects has been, and still is, largely neglected by entomologists and microbiologists alike.

Recent studies by Drew et al. (1983), Courtice and Drew (1984), Drew (1987), Drew and Lloyd (in press), with tropical and subtropical Dacinae suggest that the bacteria associated with fruit flies and with their host plants play an essential role in the ecological behaviour of these insects.

2 HISTORICAL DEVELOPMENT

Most specific studies on the relationship of bacteria to fruit flies relate back to the early work of Petri (1910) in which the association of the organism "*Bacillus (Pseudomonas) savastanoi*" Smith (the known cause of olive knot disease) with *Dacus oleae* (Gmelin) (the olive fruit fly) was defined as 'symbiosis'. Most studies since then have continued to refer to bacteria associated with fruit flies as obligate or probable symbiotic organisms.

In studying the alimentary tract bacteria of *D. oleae* Petri also described another bacterium, "*Ascobacterium luteum,*" as occurring in association with "*B. savastanoi*". In this work it was stated that the bacteria are smeared onto the egg from rectal glands which open near the oviduct, the bacteria then enter the egg through the micropyle and are thus incorporated into the newly hatched larva. In the larvae, the bacteria develop colonies in four blind sacs at the anterior end of the mid-gut and from here are transferred into the adult when some bacteria are incorporated into the oesophageal bulb which develops in 5-day old pupae. The biological significance of the bacteria was not clearly explained but it was thought that they may be important in larval digestion of olive fruit tissue. Petri presented inconclusive experimental micro-biological data to support his interpretation of symbiosis yet it is upon this study that subsequent workers have built their theories. Stammer (1929) isolated bacteria from 37 species of Tephritidae and further described the bacterial transfer system through each stage of the life cycle of *D. oleae*.

Yamvrias et al. (1970) could not isolate either "*Pseudomonas savastanoi*" or "*Ascobacterium luteum*" from eggs and oesophageal bulbs of field collected adults of *D. oleae* and emphasised that Petri also failed to isolate these bacteria

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from the flies even though he proceeded to call them symbionts. This finding of Yamvrias et al. (1970) also brings into question the conclusions of Hagen (1966) who claimed that the addition of streptomycin in the adult fly diet destroyed the symbiotic bacterium "*Pseudomonas savastanoi.*" Hagen based his conclusions on those of Petri without providing experimental evidence.

Luthy et al. (1983) presented results of scanning electron microscope studies of the oesophageal bulb of *D. oleae* and concluded that one bacterial symbiont was present although the identity of the bacteria was not established conclusively.

Girolami (1973, 1983) defined two different types of symbiosis in Tephritidae, one with bacteria in the adult oesophageal bulb and the other with bacteria in the blind sacs at the anterior end of the larval mid-gut. Girolami did not give any bacterial identification of these symbiotic organisms although the release of compact masses of bacteria from the oesophageal bulb into the mid-gut is described.

Allen and Riker (1932) described the bacterium "*Pseudomonas (Phytomonas) melophthora*" as causing apple rot in association with the larval feeding of *Rhagoletis pomonella* (Walsh) (apple maggot). Allen et al. (1934) identified the same bacterium associated with all stages of *R. pomonella*, oviposition punctures, larval burrows and exit holes in apple fruit. Rossiter et al. (1983) also stated that essential symbiotic bacteria are present and necessary for normal development in most tephritid species. Their work on *R. pomonella* was significant in providing identification of two bacteria, viz., *Klebsiella oxytoca* and *Enterobacter cloacae* and showing that they are capable of causing rot in apples. They were unable to isolate "*P. melophthora*" as previously identified by Allen and Riker (1932).

The bacteria associated with *R. pomonella* were further studies by Baerwald and Boush (1968) and Miyazaki et al. (1968) who stated that "*P. melophthora*" was an obligate symbiont of the fly but they based their conclusion on the work of Allen et al. (1934) who did not mention symbiosis. No experimental evidence was provided.

The work of Dean and Chapman (1973) on *R. pomonella* was the first real attempt to explain the biological significance of bacteria associated with adult fruit flies. *Klebsiella oxytoca* was the most common bacterium isolated and larger numbers of isolates were obtained from the crop of the fly than from the mid-gut and rectal sac. They showed that the only proteinaceous material in the crop was in the form of bacterial cells and that the numbers of these cells decreased through the alimentary canal from the crop to the rectum. If the crop contents are representative of the substances which the fly ingests then such bacterial cells on the plant surface would appear to be an important food for adult fruit flies in nature.

Ratner and Stoffolano (1982) studied the development of the oesophageal bulb in *R. pomonella* and concluded that this organ may contain a feeder culture of bacteria for slow release to the gut. They did not, however, provide any direct evidence for this.

Tsiropoulos (1976) found 15 morphologically different bacteria as a result of isolations from all stages of *Rhagoletis completa* (Cresson) (the walnut husk fly) and rotted walnut pulp. Only a *Pseudomonas* sp. and a *Xanthomonas* sp. were associated with all stages of the fly. He stated that it was hypothetical as to whether or not any of these bacteria were symbiotic in any stage of the fly. In a latter study of the bacteria associated with oesophageal bulbs and ovipositors of wild and laboratory reared adult olive flies, Tsiropoulos (1983) found a wide variety of bacterial species in both types and concluded that a "more complicated system of relationships" existed than was originally assumed. Fitt and

O'Brien (1985) have suggested a lack of strict symbiosis between *Dacus* species and bacteria.

Although there is a growing literature on bacteria and fruit flies, there is very little that provides identification of bacterial species and experimental evidence giving an understanding of the biological significance of their relationships with the flies. Bateman (1972) accepts symbiosis in fruit flies as an established phenomenon, but Prokopy (1977) notes that the role of symbionts and other microorganisms in larval development "remains poorly understood."

3 THE MICROBIOLOGY OF THE PHYLLOPLANE

The phyllosphere or phylloplane is the term used by many workers for the layer of microorganisms growing on the leaf and fruit surfaces. Ruinen (1961) emphasised that this was an "ecologically neglected milieu". Since that time numerous publications on phylloplane microflora have been produced, many of which have concentrated on phytopathogenic organisms. Some properties of non-pathogenic (saprophytic) microorganisms colonizing green leaves have been reviewed (Last and Warren, 1972) and the interaction of such organisms with pathogens has been studied (Blakeman and Brodie, 1976; Blakeman and Fokkema, 1982).

The resident bacterial populations on aerial plant parts consist primarily of Gram-negative rod shaped organisms in the genera *Erwinia, Pseudomonas, Xanthomonas* and *Flavobacterium* and less frequently Gram-positive organisms such as *Lactobacillus, Bacillus* and *Corynebacterium* (Billing, 1976).

The most extensively studied epiphytic microorganisms belong to the ubiquitous *Erwinia herbicola* group. These organisms have attracted attention because of their common association with plant pathogenic *Erwinia* species. Organisms in the *herbicola* group known as *Enterobacter agglomerans* have been recognised as frequently associated with pathological conditions in man and animals (Starr and Chatterjee, 1972; Gibbons, 1978; Perombelon, 1981; Slade and Tiffin, 1984).

Most published works on epiphytic microflora of aerial plant parts are of little direct relevance to our understanding of fruit fly ecology as fruit fly host trees in particular have rarely been the subject of microbiological investigations. The studies of phylloplane bacteria of *Lolium perenne* (rye grass) by Dickinson et al. (1975) described and compared useful quantitative and qualitative methods for the isolation of plant surface microorganisms. The predominant organisms detected were *Chromobacterium, Corynebacterium, Pseudomonas* and *Xanthomonas* but few such studies have been reported on fruit fly host fruit and leaves.

The microflora of olive leaves (the host tree for *D. oleae*) were studied in detail and the predominant organism found to be "*Pseudomonas savastanoi*" (Ercolani, 1978). This bacterium is the cause of olive knot and as mentioned has been reported by some workers as the "symbiont organism" in *D. oleae*, although no mention of this insect association was made by Ercolani.

Leaves and fruit are bounded by an environment rich in microbial propagules and the surrounding atmosphere exerts diurnal, seasonal and random fluctuations influencing the growth of these microorganisms (Dickinson, 1971). Many, if not all, chemicals within the plant are leached from the plant onto the leaf and fruit surfaces. Such leachates include inorganic nutrients e.g. all essential minerals, organic substances, e.g. free sugars, pectic substances, sugar alcohols, all amino acids found in plants, many organic acids, vitamins, alkaloids and phenolic substances (Tukey, 1971; Godfrey, 1976). Soft fruits such

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as mulberry are susceptible to leaching especially just prior to harvest. These leachates provide significant nutrients for the growth of phylloplane micro-organisms.

Fruit flies, particularly Dacinae, require a diet rich in amino acids, B complex vitamins, minerals, sugars and water for survival and reproduction (Hagen, 1953). A high concentration of free amino acids is essential for egg production. Honeydew, believed for many years to be the natural source of food for adult fruit flies, is both nutritionally unsuitable and unavailable for tropical Dacinae in Queensland (Drew et al., 1983). Recent studies on adult fruit fly feeding have shown that certain bacteria isolated from the crops and stomachs of actively feeding field flies provided virtually a complete breeding diet (Drew et al., 1983). The question now raised is what is the availability of these bacteria in the field?

4 RECENT INVESTIGATIONS OF THE ECOLOGICAL RELATIONSHIPS OF BACTERIA TO FRUIT FLIES

The distribution and abundance of bacteria, isolated from both fruit flies and fruit fly host trees and the significance of these organisms in the life cycle of the fly is now the subject of a major research programme by the authors (Lloyd et al., 1986).

Bacterial isolations have been made from a total of 80 adult flies, representing four species [*Dacus tryoni* (Froggatt), *Dacus neohumeralis* Hardy, *Dacus cacuminatus* (Hering) and *Dacus musae* (Tryon)] collected in the field from host trees (wild tobacco, guava, mulberry, peach and banana) during an eighteen month period. All flies examined have been wax-plugged at anal and oral openings and surface sterilized prior to aseptic dissection in which the crop and mid-gut or oesophageal bulb were removed for culturing. Bacteria have also been isolated from faeces of field collected flies, as well as from host fruit surfaces, oviposition sites and larvae-infested tissue in host fruit.

Results of our isolations and subsequent identifications (Table 3.1.3.1) indicate that the predominant microflora within the tropical/subtropical Dacinae comprise bacteria belonging to the family *Enterobacteriaceae*. Mid-guts of field collected flies almost always contained large numbers of bacteria but crops, faeces and oesophageal bulbs were found to contain variable, and sometimes very low, numbers of bacteria.

Of 135 bacterial isolates obtained from adult fly specimens, 120 were identified as *Enterobacteriaceae*. The species *Erwinia herbicola, Enterobacter cloacae* and *Klebsiella oxytoca* were the most frequently isolated, with *Citrobacter freundii, Proteus* and *Providencia* species, *Escherichia coli* and *Serratia* species being less frequently found. The three most common species found in

TABLE 3.1.3.1

Bacteriological examination of the alimentary tract and faeces of field collected *Dacus* species in Queensland

	Crop (No.)	Mid-gut (No.)	Oesophageal bulb (No.)	Faeces (No.)
Specimens examined	52	53	16	30
Specimens with				
> 5 colonies per plate	34	52	12	13
Bacterial isolates obtained	38	65	12	20
Isolates identified as Enterobacteriaceae	30	59	11	20
(as %)	(79%)	(91%)	(92%)	(100%)

TABLE 3.1.3.2

Bacteria isolated from *Dacus tryoni* (Froggatt) and from peach fruit on the tree in which the flies were collected (+ = bacteria present)

Bacterium	*D. tryoni*		Oviposition site and fruit rot	Fruit surface
	Crop	Mid-gut		
Erwinia herbicola	+	+	+	+
Enterobacter cloacae	+	+	+	+
Klebsiella oxytoca	+	+	+	+
Proteus spp.	+		+	+

flies were also the most frequently isolated from oviposition sites and larval induced rot in field stung fruit. Fly species, sex, host tree and seasonal time did not appear to affect the types of bacteria found in field collected flies. No one species of bacteria was found to be consistently associated with any particular section of the alimentary canal or with any one species of fly. Hence the term "symbiosis" does not appear to be appropriate for the association of bacteria with these species of Dacinae and we believe that a more extensive ecological relationship is involved.

One important result of our investigations has been the recovery of the same bacteria from fruit surfaces, fruit rots and within crops and stomach of adult flies when all samples were collected from the same host tree (Table 3.1.3.2).

When surfaces of caged (fruit flies excluded) and uncaged (exposed to fruit flies) guava fruit were examined for presence of *Enterobacteriaceae*, few were present on immature fruit in both situations. However, in more mature fruit, once oviposition has commenced in uncaged (exposed) fruit, many more "fruit fly type" *Enterobacteriaceae* were detected on those fruit surfaces than on caged fruit surfaces.

A similar result was obtained when the microflora of a caged nectarine tree was compared with that of an uncaged nectarine tree exposed to wild *D. tryoni* and *D. neohumeralis*. Uncaged fruit showed a rapid increase in surface bacterial counts from 2.7×10^2 organisms/cm^2 of fruit surface (when ovipositions were first observed) to a maximum of 6×10^6 organisms/cm^2 of fruit surface 15 days later (one day prior to total fruit drop). The large surface populations on stung fruit were almost entirely "fruit fly type" *Enterobacteriaceae*, representative isolates being identified as *E. cloacae, E. herbicola, K. oxytoca* and *C. freundii*. These bacteria were not detected on uncaged leaves or on caged fruit or leaves and these results suggest that flies are introducing their own specific bacteria onto host fruit surfaces.

Further evidence to support this theory was obtained using adult *D. tryoni* fed on a culture of "marked" *E. cloacae* (double antibiotic-resistant mutant) as the only protein source and then released into a cage containing nectarine trees bearing mature green fruit. One week later, large numbers of *E. cloacae* were recovered from fruit surfaces and oviposition sites in stung fruit. Other observations using *D. tryoni* fed on labelled *K. oxytoca* have shown that flies regurgitate alimentary tract bacteria in droplets of spittle and even in the absence of obvious regurgitated fluid, the proboscis was constantly spreading these same bacteria when individual flies were allowed to forage on agar medium.

Another significant finding is that fruit flies are strongly attracted to species of *Enterobacteriaceae*. The attraction of *D. tryoni* to two different protein suspensions with and without *Providencia rettgeri* inoculum was tested in a field cage experiment and replicated 3 times. The protein suspensions attracted a total of 41 and 83 flies while the bacteria innoculated suspensions attracted

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TABLE 3.1.3.3

Number of *Dacus tryoni* (Froggatt) attracted to bait solutions sprayed on avocado trees at Mt. Tamborine, Queensland

Bait	No. females	No. males	Total
Bacteria bait	489	386	875
Mauri protein autolysate	290	229	519
Millers Nu-lure	177	118	295

244 and 248 flies respectively. Also the attraction was tested to protein suspension innoculated with *P. rettgeri* used as spot baits in an avocado orchard in south-east Queensland (Table 3.1.3.3). While this is an area of continuing research in Queensland, these initial results indicate that actively growing bacteria isolated from the flies are powerful attractants. Once attracted the flies feed vigorously on the bacteria. These attractant and feeding responses may play a key role in the behaviour of the flies.

Flies collected in mulberry trees bearing ripening fruit have purple fruit colour visible in the alimentary canal if the flies have been feeding in the tree (Drew et al., 1983). Four species of flies were collected in one such tree, only two of these species being known to oviposit in mulberries. Gravid females of these two species, *D. neohumeralis* and *D. tryoni*, had virtually empty crops and very pale purple colour in the mid-gut, indicating that they had fed at least 24 h before collection. Immature females had distended crops and mid-guts with deep purple contents. Males of both species had brown coloured crop and mid-gut contents indicating that they were feeding on different substances from the females. Females of the other species, viz., *D. cacuminatus* and *Dacus brunneus* (Perkins and May) had deep purple crop and stomach contents, all specimens being immature and actively feeding.

From this it can be concluded that the mulberry fruit surfaces were a significant feeding site for 4 fly species. Mature gravid flies which oviposit in the fruit did not feed on these surfaces after egg maturation (consistent with the fact that flies do not require protein after egg maturation), immature females of all species were actively feeding on the fruit and males of all species were feeding on other substrates. The fruit were at early stages of ripening at the beginning of the fruiting season and there was no fruit breakdown and fluid loss. Our bacterial isolation studies have revealed large quantities of 'fruit fly type' bacteria on the fruit surfaces, indicating that such host fruit surfaces are significant sources of protein and other nutrients for developing flies. It is also possible that proliferating bacteria on the host tree form a powerful attractant drawing more flies into the tree.

The protein requirements of *D. tryoni* have been assessed by feeding 50 males and 50 females separately for 15 days from emergence, then combining the sexes for three days prior to a 5-h egg production test (Table 3.1.3.4). In another experiment the egg production of *D. tryoni* was assessed when cages of 50 males and 50 females were given a single feed of excess protein hydrolysate for 6 h on only one day and egged 15 days after emergence (Table 3.1.3.5). These studies have shown that (a) males require little or no protein to fulfil their role of fertilising eggs, (b) a single protein feed on one day is adequate for a female to produce up to 40 eggs in one oviposition period 3 days after feeding, (c) females accrue most benefit from protein after 4 days from emergence.

From these studies it appears that immature females in the post-teneral dispersal phase are attracted by bacterial odours and these could be an important source of attraction to a host tree. The flies could then utilise bacterial food available in the tree, apparently on the surfaces of maturing fruit. Feeding

TABLE 3.1.3.4

Influence of protein hydrolysate fed to *Dacus tryoni* (Froggatt) males and females on egg production and fertility (all cages fed sugar and water; nil diet = sugar and water only)

Protein fed to ♂♂	Protein fed to ♀♀	No. eggs/♀/h	Egg hatch (%)
Nil	Excess	3.1	72
Excess	Nil	0	0
Excess	Excess	3.6	87
0.01 g/week	Excess	6.8	81
Excess	0.01 g/week	0	0

flies remain in the tree and oviposit when their eggs become mature (within 3 days of feeding). For this behaviour pattern to develop the flies would have to establish a reasonably permanent population within the host plant. This indeed is what happens. Recent observations on *D. tryoni* in peach trees and *D. cacuminatus* in *Solanum mauritianum* have revealed that the flies feed, mate and oviposit in the same host plant.

The biological and ecological significance of these *Enterobacteriaceae* species in the life cycle of the fruit fly remains to be explained. We have shown that at times they are prolific on host fruit surfaces and it appears that the flies carry the bacteria and introduce them to the host plant. In this way, colonies of bacteria are established on specific plant parts, particularly host fruit, when required. This would be particularly significant when rain and resulting plant surface leachates are available and it is the wet summer period when the tropical Dacinae are most active. This system would ensure that, weather conditions permitting, adult food is not limiting. It would also be more economical with respect to the energy budget of the fly to search for oviposition sites prior to maturation and fertilization of eggs. In this respect the bacteria are important in ensuring reproductive success within fruit fly populations.

5 DISCUSSION

It appears that the association of bacteria and fruit flies is complex. It is well known that microorganisms are associated with insects in ways other than as

TABLE 3.1.3.5

Influence of a single feed of protein hydrolysate for 6 h on egg production and fertility in *Dacus tryoni* (Froggatt) of different ages (all flies fed sugar and water)[1]

Age of flies when fed protein (days)	No. eggs/♀/h	Egg hatch (%)
2	0.07	100
4	0.94	78
6	2.86	86
8	5.05	88
10	7.54	92
12	7.95	87
14	0	–

[1] Note: (a) Flies were egged on day 15, and the 14 day old flies were egged again on day 16. (b) 0 eggs produced 1 day after feeding. (c) Small egg production (0.37 eggs/♀/h) 2 days after feeding. (d) Large egg production (7.95 eggs/♀/h) 3 days after feeding.

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pathogens but entomologists have tended to neglect the role of microorganisms in the ecology of insects (Steinhaus, 1960).

The term "symbiosis" was first used by De Bary (1879) who defined it as "a phenomenon in which dissimilar organisms live together". De Bary originally coined the term "symbiont" to refer to either partner of an association and numerous workers including Dindal (1975) have followed this. Brooks (1963) preferred the term "symbiontes" defined as "two dissimilar organisms which live together" and avoids using the term symbiosis for many microorganism/insect relationships because one of the key points of the original meaning "being together as in a partnership" is often missing. Brooks also emphasises that much literature on symbiosis implies mutually dependent symbiosis without rigorous proof. De la Torre-Bueno (1962) defined symbiosis as "a living together in more or less intimate association, or even close union, or organisms of different species". He includes all possible relationships (even parasitism) as symbiosis. Definitions describing interactions between microorganisms and insects have been misused, misinterpreted and confused and before a particular relationship can be classified as symbiosis, ecological criteria should be considered (Dindal, 1975). Under the classification of "Interspecific Relationships" by Dindal (1975), the relationship of bacteria and fruit flies could possibly be called Trophobiosis, where the bacteria supply food and the fly provides protection for the bacteria and moves them to and from the feeding site.

Of the 10 possible relationships between insects and microorganisms outlined by Steinhaus (1954), the known bacterial associations in fruit flies could fall into several groups — free living bacteria serving directly as food; fruit flies and bacteria existing separately but in association, the fly acting as a carrier and specially culturing bacteria to ingest as food; fruit flies acting as hosts to commensal bacteria in the alimentary canal. While some aspects of the fruit fly/bacteria association could come under the original broad definition of symbiosis (De Bary, 1879), viz., "a phenomenon in which dissimilar organisms live together", it appears from present knowledge that the system consists of several diverse aspects and it is therefore not possible to place it under one definitve category. Most workers have inferred an intimate mutually dependent symbiosis essential for the survival of the fly yet to date there is no satisfactory published evidence for this and few have considered that the bacteria could be involved in the ecosystem of the fly.

Considering that the bacteria comprise proteinaceous food for adult fruit flies (and probably larvae), entirely new areas of research become exposed. Studies on the identity, distribution and abundance of the bacteria in the field, the definition and biological significance of the fruit fly/bacteria association, and the attractancy of adult fruit flies to bacteria, will require much attention and are sure to prove most rewarding. Such work would make a valuable contribution to our understanding of fruit fly biogeography, speciation, ecology and control.

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A CENTURY OF FRUIT FLY RESEARCH IN AUSTRALIA

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INTRODUCTION

Frederick Athol Perkins played a prominent role in the development of Entomology in Queensland. His contribution to the establishment of teaching in Entomology at the University of Queensland has been well documented and laid the foundations for that school becoming the foremost training institution for Entomologists in Australia. While I had no experience of Perkins as a teacher, I can comment on his pioneering work in fruit fly research in Queensland.

As George Rothschild commented to me in 1986, fruit fly researchers are unique in having a record of long term establishment in their field. F.A. Perkins was no exception. According to an address that he presented to the Entomological Society of Queensland in 1923, he began his fruit fly research in 1922 at Stanthorpe on a Stanthorpe and District Research Fellowship. He continued this research until 1949, a period of 27 years.

In this lecture, I have chosen to discuss what I believe are extremely important principles to which we must adhere in entomological research. In discussing these principles I will reflect on the history and development of fruit fly research in Australia.

At this time we are passing through a period of major contraction in government expenditure on scientific research. In Entomology, we have an added pressure of extreme public concern over the use of chemicals in agricultural production. It is interesting to note that this public concern has been around for some time. Summerville (1974) in his address to the Jubilee of the Entomological Society of Queensland stated, "Whilst it is obvious that, if the world's population is to be fed and clothed, the control of insect pests is of ever-increasing importance, at the same time public scrutiny of insecticides and their side-effects is likewise increasing .... today's entomologist working with sophisticated techniques and powerful chemicals simply must consider much more than the lethal value of any insecticides as such. This, of course, is particularly so when human food is involved and what residue or degradation products have to be considered". Summerville also stated that "it is the insect in its environment which must be studied" and "behind the economic worker there must be the pure scientist". At the same symposium, Passlow (1974) said that the lasting contributions of entomologists lie in biological investigations and stressed the importance of research into the biology and ecology of insects.

Tonight, I am led to ask - have we seen any change in our approaches to pest control in the past 16 years, or have we only paid lip service to our concerns? What have we done in that time to minimise our dependence on pesticides? Labeyrie (1988) in his review of papers published in *Entomologia experimentalis et applicta* stated, "One painful conclusion is evident; no characteristic change, no fundamental improvement has occurred in applied entomology in the last 30 years".

An aim of our current Queensland Department of Primary Industries (QDPI) fruit fly programme is to emphasise the significance of research in the areas of taxonomy, biology/ecology and genetics as a basis for developing pest control with a minimum of pesticide usage.

HISTORY

Fruit flies have become the major insect pest of horticultural crops in Australia. The major pest species, *Bactrocera tryoni* (Queensland fruit fly), has expanded its host range and distribution in Australia since settlement of the country in 1788. Further, this species has spread through the South Pacific as far as the Society Islands, in recent years.

The development of the fruit fly problem in eastern Australia is a story of endemic insect species becoming pests as a result of their environment being changed by European settlement. The clearing of rainforests (the endemic habitat of the flies) and the introduction of exotic fruits along the coastline produced an environment within which certain fruit fly species underwent marked expansions in distribution and abundance. A large range of introduced fruits and vegetables were established in the Sydney area at the turn of the 19th century, only 12 years after the beginnings of settlement (Wentworth, 1819). Peaches, apricots, nectarines, oranges, grapes, pears, plums and melons, all fruit fly hosts, were grown in abundance. Wentworth stated that peaches were the most abundant and most useful of the fruits grown and the various varieties combined to produce fruit from mid-November to the end of March. Peaches were so plentiful that peach cider was prepared as the most common drink in the colony and the fresh fruit was used for pig food. A variety of insect problems were recorded (Wentworth 1819) but fruit flies were not mentioned. Most likely, the flies were not present in central and southern New South Wales until sometime later.

The earliest records of fruit fly damage were in 1853. Tryon (1889) recorded settlers in the Toowoomba area remembering problems back to 1853. Farwell (1973) reported grazier Edward Ogilvie noting in his diary, mid-February 1853, that maggots were ravaging peaches, apples and grapes at his property on the Clarence River, NSW. Tryon (1889) also recorded fruit fly infestation in peaches at Kiama, south from Sydney, in 1853. From the 1860's to 1880's there were increasing reports of problems with fruit fly infestations in south-east Queensland.

Henry Tryon was the first entomologist to research the fruit fly problem in Australia. In 1883 he was appointed Clerical Assistant at the Queensland Museum. In 1885, he was reclassified as Assistant Curator (Second-in-charge of the Museum) and was responsible for all invertebrates. Whilst in that position, in 1886, he was sent to Toowoomba by the Queensland Government to carry out investigations into insect pests and diseases of plants. Much of his time at Toowoomba was devoted to fruit flies and this year, 1989, marks the centenary of the publication of his findings.

In 1894, after 11 years at the Museum, he was appointed Government Entomologist in the State Department of Agriculture and in 1901 he became the Government Plant Pathologist. Tryon must have been an amazing personality. He was a prominent figure in early scientific life of Queensland and published some 136 papers and reports covering insects, mites, molluscs, plant diseases, animal and fish parasites and geology. Above all, Tryon was an enthusiastic field biologist. He terminated studies in Medicine at London to become involved in Natural History. One of his first ventures was to travel through Sweden in the footsteps of Linnaeus to collect plants and insects. His remarkable aptitude for field biology is demonstrated by his excellent observations on fruit fly biology in his 1889 publication. His last publication was on fruit fly taxonomy in 1927 where he described some of the first known Australian species. Our major pest, *Bactrocera tryoni* (Queensland fruit fly), is named after him.

At the same time as Tryon was undertaking fruit fly research in Queensland, W.W. Froggatt was involved in fruit fly investigations in Sydney, within the New South Wales Department of Agriculture. Froggatt was known worldwide as an entomologist and a prolific writer with a wonderful knowledge of the habits and biology of Australian insects (Perkins 1964). He did a small amount of fruit fly taxonomy but otherwise never devoted much time to these pests. He taught Entomology in Agriculture at the University of Sydney and one of his students, F.A. Perkins, later worked with him in the NSW Department of Agriculture. Froggatt had a major influence on Perkins and I often wonder if this caused him to take an interest in fruit flies in Queensland (Perkins 1964).

F.A. Perkins was appointed to the University of Queensland in August 1922 on the Stanthorpe and District Research Fellowship. This Fellowship was financed by the fruit growers of the Stanthorpe District for the specific purpose of investigating the fruit fly problem. He worked under the general supervision of the Professor of Biology in the University, firstly Professor Harvey Johnston and later Professor E.J. Goddard. Perkins' fruit fly research at Stanthorpe continued full-time until 1926 when he was appointed Lecturer in Entomology at the University of Queensland. He continued his studies at Stanthorpe during each Summer vacation until 1930. In 1923 Perkins presented the

inaugural address at the first meeting of the Entomological Society of Queensland, entitled "The fruit-fly problem in the Stanthorpe district". Henry Tryon believed that the Entomological Society would fail and so never joined it or attended its meetings. Perkins was an excellent field worker and had a specific aptitude for biological investigations. Copies of his inaugural address are still held in the records of the Entomological Society of Queensland and from this it can be seen that he devoted most of his time to field investigations. His first task was to identify the source of fruit fly infestations in the Stanthorpe district. He believed that there were three possibilities :

1. Overwintering flies within the district reproducing when temperatures increased.

2. Importation of larvae into the district in infested fruits.

3. Migration of flies from districts to the east and south-east in early Summer.

He also reported that the adult flies fed on the skin of fruit and on leaves, a behaviour presently being studied in our QDPI bacteriological investigations. Perkins' major published contributions to fruit fly research are on the taxonomy of species in Australia and South-East Asia. He described a number of genera and species and developed keys for the identification of species.

Because of major crop losses in the Stanthorpe district, the Department of Agriculture appointed Hubert Jarvis (brother of Edmund Jarvis) to work together with Perkins. They became very close friends over 5 years of collaboration. Twice per week they engaged in day-long field collecting trips to all parts of the district. Jarvis wrote several notes in the Queensland Agricultural Journal on the fruit fly problem and its control but never produced any research publications. He married the daughter of Henry Tryon who named one of our pest species after him in 1927.

Alan Walter Sydney May was a student of F.A. Perkins while studying Agriculture at the University of Queensland. Upon graduation he was appointed to the Entomology Branch in the Department of Agriculture and Stock in 1939 and served in Normanton, Nambour, Gayndah, Toowoomba and Brisbane.

Whilst in Toowoomba May devoted most of his efforts to the taxonomy and ecology of fruit flies. His first publication on fruit flies was a joint taxonomy paper with Perkins in 1949 in which they described a series of species. He followed this with further papers from 1951 to 1967 in which were described species collected throughout Queensland during extensive ecological studies. Sadly his ecology results were never published, due to his premature death in 1966. He was an experienced field

entomologist and must have been an excellent field naturalist, having pioneered our fruit sampling in rainforests in order to obtain wild host records. Fortunately these records were published and stand as his most significant contribution to fruit fly research. May introduced insecticide cover sprays for fruit fly control, firstly with DDT and later with organophosphates. He believed that protein hydrolysate bait sprays would not be successful under Queensland climatic conditions.

In 1948 Charles Birch was appointed Senior Lecturer in the Department of Zoology, University of Sydney and later as Challis Professor of Zoology on the retirement of P.D.F. Murray. He established a research programme on the ecology of *Bactrocera tryoni* with the aim of testing his theories of insect ecology. Consequently, studies elucidating the influence of climatic factors on the distribution and abundance of species were prominent. The first postgraduate students to be involved in this research were K. Myers, L. Barton-Brown and M.A. Bateman. The latter two were appointed to the CSIRO Division of Entomology and Bateman remained working at the University of Sydney. Birch and Bateman subsequently established the University of Sydney/CSIRO Joint Unit of Insect Physiology and Ecology to specialise in fruit fly research. CSIRO obtained an orchard at Wilton in 1960 for field research and this was closed in September 1989. Notable overseas scientists such as Dobzhansky, Lewontin, Sonleitner, Paul Ehrlich and Henk Wolda spent time on sabbaticals working within the Unit. Gordon Pritchard, a behaviourist, joined the Unit as a CSIRO staff member about 1960 and left in 1965. He was replaced in 1966 by Brian Fletcher while Alfie Meats was appointed to a position within the University in 1968. Many postgraduate students completed degrees in this fruit fly programme. In 1981 the Joint Unit was disbanded when the CSIRO staff were moved to accommodation at Warrawee, a northern Sydney suburb. Bateman retired in 1986 and the Warrawee facility closed in 1987. Bateman, Fletcher and Birch were the most prominent workers and for some time the Unit was the world leader in research into tropical fruit fly ecology.

Gordon H.S. Hooper was employed on the Academic Staff of the Department of Entomology, University of Queensland from 1964 to 1985. He published extensively on aspects of fruit fly biology, ecology, toxicology and the Sterile Insect Release Method for eradication. He spent two periods each of two years (1969-70 and 1983-84) at the International Atomic Energy Agency, Vienna and made a major contribution through the development of gamma radiation in an atmosphere of nitrogen. This system produced sterile males that are considerably more competitive than those eradiated under other atmospheres. Hooper is the only worker to have investigated insecticide metabolism in fruit flies and reasons for the notable absence of resistance in field populations. He and I collaborated in ecological studies in endemic rainforest habitats at Cooloola and Mount Glorious.

Since 1972, Allan J. Allwood, working in the Northern Territory Department of Primary Industry and Fisheries, has undertaken extensive host fruit collecting and trapping surveys. The host fruit surveys have included wild and commercial fruits and are the most extensive that I know for any region of the world. He also led successful eradication programmes against Mediterranean fruit fly in Alice Springs in 1979 and 1981.

In 1967 I began work on fruit flies in the Department of Primary Industries. Not having the opportunity to collaborate with May, I had to piece together an understanding of his research from his field notes, files and collection. Most importantly he left 10 drawers of mounted specimens and this was the beginning of what is now a very large reference collection of Dacinae, comprising some 150 drawers. What has been achieved will be discussed in the following sections.

The early fruit fly researchers, from Tryon to May, placed great importance on the naming of species and the study of their basic biology. Most of these people were trained in Agricultural Science and, in retrospect, we can say that this caused shortcomings in their taxonomy with respect to our present International Code of Zoological Nomenclature. However, they always had a positive approach to the study of the biology of fruit flies.

TAXONOMY

Sound taxonomy is the basis of all successful research programmes in biology. To be able to identify the species is the first step to knowing them - the most significant stage before being able to elucidate their biology. This basic principle has applied throughout history, as in the work of Tryon, Perkins and May mentioned above. Determination of species is vital to biological control programmes, ecology studies of insect/host relationships, regulatory work in Animal and Plant Quarantine and in Integrated Pest Management Programmes. The identification of the insect complex in a crop under IPM is certainly an essential foundation.

Pest control, with or without insecticides, will always be dependent upon an intimate knowledge of species and their biology. Professor Paterson in his Presidential Address to the Entomological Society of Queensland (Paterson 1989) amply demonstrated this point in the example of *Anopheles* species control in Malaysia and Zambia.

A knowledge of species will continue to grow in significance while we are increasingly confronted with environmental issues. It is imperative that we establish biological data on which to intelligently debate issues such as conservation of resources and energy systems. Besides the greenhouse effect, there are many high profile environmental debates presently in process in Australia. These all need the valuable input of biological research.

In my recent revision of the South Pacific Dacinae (Drew 1989), previous workers are credited with describing a number of species - Tryon (10), Perkins (10), Perkins and May (6), May (24). Since 1968 I have described 172 species (14 with Dave Hancock and 1 with Elmo Hardy). In addition, I have now revised the nomenclature of the pioneer workers and developed a workable supra-specific classification. We now know 290 species for the South Pacific region (Australasia and Oceania) and have produced keys and illustrations for identification of species.

We have been able to build on these taxonomic studies and establish host plant records (wild and commercial) for 71 species and distribution records for all known species. Host recording is extremely valuable work that should always be continued. With the larval taxonomy programme of Marlene Elson-Harris we have a continuing need for collecting larvae in infested host fruit with the added advantage of expanding our host records.

Another benefit of our taxonomic research is that we provide Australian Plant Quarantine with an identification service for their northern monitoring programme and data for identifying high risk areas for potential new exotic introductions. In fact, the present Quarantine northern surveillance programme is a direct result of our QDPI fruit fly taxonomic studies. The programme began as an early detection procedure for exotic fruit fly species in the late 1970's and in more recent years has been expanded to include other insect species, plant and animal diseases.

The taxonomic research has progressed to the stage where we now realise that there are numerous sibling species. Prolific speciation in association with rainforest host plants has given rise to many complexes of sibling species. I have identified 20 such complexes in the South Pacific region.

The *tryoni* complex, including *B. tryoni* (Queensland fruit fly) in eastern Australia and *B. aquilonis* in north-western Australia is one of concern to Australian interstate and overseas trade authorities.

Because the Northern Territory Department of Primary Industry and Fisheries (Allan Allwood) had conducted extensive host fruit sampling and we had carried out some taxonomic/genetic studies on both species, prior to 1985, we were in a good position to investigate a marked host range expansion around Darwin which occurred after April 1985. Prior to that time, *B. aquilonis* only occupied 4 cultivated and 12 wild hosts. It has now been recorded from 40 cultivated and 23 wild hosts. The question is - has *B. aquilonis* undertaken a sudden host shift or has *B. tryoni* been introduced from eastern Australia, become established and even hybridised with *B. aquilonis*? This problem is now being investigated with Professor Paterson at the University of Queensland, using genetic techniques.

Since 1986 Allan Allwood and I have been involved in an ACIAR project in Malaysia. Because the fruit fly species were not well known, we undertook firstly an extensive trapping and host fruit survey. Throughout Asia/South East Asia the *Bactrocera dorsalis* complex is large and of major economic importance. Some species in this complex inflict heavy crop losses and hinder international trade in fresh fruits. Countries in the region are keen to have these species identified, establish good representative collections and have local personnel trained in fruit fly identification. It is encouraging to see the acknowledgment of their need for taxonomy.

I have obtained very large fruit fly collections from Borneo, Indonesia, Malaysia, Philippines and Timor, and smaller collections from Burma, China, India, Okinawa, Taiwan, Thailand, Hawaii and Suriname. Type specimens have also been studied. I have identified over 40 species in the *dorsalis* complex, only 11 of which have been described. Seven of the species are of economic importance and this number may increase with further host surveys.

The complex is so extensive that some non-pest species have been confused for pest species. Some misidentifications have been published and these continue to cause serious confusion especially for trade negotiations and entomologists publishing in other areas of research. Consequently it has been necessary to study the taxonomy of all species, not only those deemed to be economic.

In our Dacinae, we need to elucidate the relationship between the morphological characterisations that we make and the real genetic unit that is the species. This is particularly relevant when we suspect that sibling species exist. The methods I have used to identify sibling species of Dacinae are as follows:

1. Adult morphology, including scanning electron microscopy of ovipositors.

2. Morphology of larvae.

3. Chemistry of male pheromones.

4. Tissue enzyme electrophoresis.

5. Biology, especially endemic host records.

1. Adult morphology. Taxonomy of Dacinae will always be dependent on external body colour patterns of adults. In general, these characters express intraspecific variation but are satisfactory. With an 'experienced' eye the normally acceptable variations within species can be recognised and understood.

The major problem is to ascertain the validity of recognisable differences between sibling species. For some sibling species this has been achieved by scanning electron microscopy and measurements of ovipositors, plus aspects of methods 2 to 5. For example, two sympatric species of the *dorsalis* complex in Malaysia possess minor colour differences in the costal band and abdomen but major consistent differences in the length of the ovipositor.

It has not been, and probably will never be, possible to study and compare all sibling species within the *dorsalis* complex as intensively as has been done with a few S.E. Asian pest species. However, the experience gained in studying a few key species has provided confidence for using the standard body colour pattern characters within the entire complex.

2. Morphology of larvae. At the QDPI laboratory in Brisbane, Marlene Elson-Harris has studied larvae of 6 *dorsalis* complex species. Briefly, good structural diagnostic characters are present on the larvae. These usually vary markedly between species that are almost inseparable on adult morphology. Because the characters are structures used for feeding and locomotion within the host fruit, there is sound argument to believe that they are species specific.

The research of Marlene Elson-Harris is aimed at developing a species key for the immature stages of the world's economic Tephritidae. Excellent results have been obtained and the final product will be widely used by Quarantine authorities as well as contributing to the development of important expertise within QDPI. The data are already being used in the current *B. tryoni* eradication programme in Perth where officers need to separate Mediterranean fruit fly and *tryoni* larvae in fruit for early detection of new infestations.

3. Chemistry of male pheromones. An example of the importance of male pheromones as taxonomic characters is in the *B. dorsalis* complex. For these analyses, field collected males (except *D. dorsalis*) were frozen alive in an ultra-low deep freeze and airfreighted in dry ice to QDPI, Brisbane. Male pheromone glands were dissected, placed in pentane and the solution analysed in GCMS in collaboration with Dr W. Kitching, Department of Chemistry, University of Queensland. Four species were studied - two from Malaysia (coded Malaysian A and Malaysian B), one from Philippines, and *B. dorsalis*. The *dorsalis* specimens were from the USDA culture in Honolulu, Hawaii.

The compounds identified in the pheromone gland contents were amides, diols, esters, fatty acids, ketoalcohols and spiroacetals. Malaysian A was unique in that the major component of the secretion was a ketoalcohol which was not present in the other species. Malaysian B, Philippine B and *B. dorsalis* were similar in that the major component of the gland

contents was a mixture of long chain fatty acids none of which occurred in Malaysian A. These three species differed from one another in the types of fatty acids, fatty acid ethyl esters and spiroacetals that were present.

Malaysian A and Malaysian B are sympatric, have some uniquely different host plants (endemic and cultivated) but also infest the same hosts in a few instances. Interspecific mating has not been detected in our field studies. This is probably due to the marked difference in the male pheromones which are used during courtship within the host plant. Consequently I believe that the chemical composition of the male pheromones is an important character for differentiating sibling species.

4. Tissue Enzyme electrophoresis. Tissue enzymes of adults and larvae of the two Malaysian species and adults of one Philippine species were studied using starch gel electrophoresis. The work was carried out by C.S.Ooi (University of Malaya) during his Sabbatical leave at QDPI, Entomology laboratory, Brisbane. Patterns for two enzymes (Isocitrate dehydrogenase and Aldox) indicated that the sympatric populations of the two Malaysian species do not interbreed in the wild. Some form of species mate recognition must be present, particularly as both species can coexist in the same host plant and both mate at dusk. Also larvae of both species can be found in the same piece of cultivated fruit. Nei's genetic distance coefficient was estimated at 0.8763 based on 18 loci representing 18 enzymes.

5. Biology. The host records for the two Malaysian species have proven useful. With wild hosts, 10 are common to both species, 9 are specific to one species and 11 specific to the other species. For the cultivated hosts, 7 are common to both species, 1 specific to one and 9 specific to the other species. In our biology studies we have found that dacine species always mate in their host plants. The host plant is significant to the recognition of the sexes before mating and consequently host plant specificity particularly the endemic wild (or forest) plants are valuable in helping to decide on the specific status of the fly populations.

Sibling species must exist in large numbers throughout the Insecta, including major economic groups. When Entomologists become confronted with separating these species, techniques in genetics will be important tools. To date, cytology has not been applied widely in fruit fly taxonomy but tissue enzyme studies have been useful.

In the early 1950's the United States Department of Agriculture carried out a survey of fruit fly parasites in South East Asia and the South Pacific region. In particular parasites of Oriental fruit fly were collected. We now know that the parasites could have been reared from any of five or more species within the complex and not *B. dorsalis* alone. This work should be revised before future attempts at biological control of fruit flies.

It is interesting to note that a *dorsalis* complex species was introduced into Suriname in the early 1970's. Our taxonomic assessment, based on our present research is that it is one of the Malaysian species. Host records from Suriname place *Averrhoa carambola* (starfruit) and a *Eugenia* sp. as the primary hosts and guava as a secondary host. These data correlate with our Malaysian records.

The results of our taxonomic research have the following important applications:

- defining target species and host fruits for post-harvest disinfestation studies

- determining species of major concern to plant quarantine authorities

- accurate identification of introduced species which is basic to the application of the Sterile Insect Release Method of eradication

- species attractant records which are essential to the male annihilation method of eradication

- a basis upon which future fruit fly surveys can be developed

- valuable resource data for use in fruit fly training workshops. There is considerable interest in the ASEAN region for workshops providing tuition in fruit fly identification

- a valuable basis upon which to build future research into the biology, ecology and genetics of species.

BIOLOGY

Labeyrie (1988) emphasised that a precise understanding of an insect ecosystem and its biology is not a futile academic exercise but information essential to the establishment of a rational control programme. It is difficult to imagine that we need to keep repeating this message. An aim of all entomologists should be to make some contribution to knowledge of insect biology.

In the past decade we have been studying the ecology of fruit fly species in their endemic rainforest habitat because I am convinced that this is the only way we can understand the ecology of these insects, and particularly pest species. Most pest species are encountered only in the commercial situation which does not reflect the complete ecology. For example, only when we were studying the flies in the rainforests did we learn that vertebrate predators were the primary biotic factor causing mortality - not parasitic Hymenoptera. We can see now why attempts at biological control using parasites have been unsuccessful.

In 1982 while I was undertaking ecological studies on fruit flies in the Mount Glorious rainforests, I began collaborating with Tony Courtice. During discussions he proposed that plant surface yeasts may provide proteinaceous food for adult flies. With the assistance of David Teakle in the Department of Microbiology, University of Queensland, we investigated the adult food sources within host plants and came to the conclusion that certain bacteria are utilised as the primary food. Annice Lloyd was employed, firstly at the University and later at QDPI, to provide additional microbiological expertise and the study has now expanded into a programme investigating aspects of fruit fly - host plant relationships. In particular, adult feeding and mating behaviour are being investigated and the results highlight the value of such biology to understanding species and developing control programmes.

Bacteria isolated from the crop and midgut of field collected flies have been identified and used in experiments. The bacteria belong to the family Enterobacteriaceae and the most commonly isolated species are *Enterobacter cloacae, Klebsiella oxytoca, Erwinia herbicola, Proteus* spp, and *Providencia* spp. Since Petri (1910), these microorganisms have been considered 'obligate symbionts' and that adult flies ingested honeydew and plant secretions for food. We now believe that certain bacteria are significant in the food chain of the fly and that they play a basic role in the insect-host plant relationships.

Leachates, which may contain all inorganic and organic chemicals that occur within a plant (Tukey, 1971), are exuded onto the plant surface during wetting. Leaching is most prolific on soft fleshy fruits during the ripening stage and under conditions of light rain and dew. These leachates provide nutrients for plant surface microorganisms and are probably important to the growth of the fruit fly type bacteria that proliferate on ripening fruit. The bacteria may be important as a means of concentrating plant surface nitrogen in leachates so that it becomes available as an insect nutrient. Our investigations have shown that these bacteria are important sources of protein for female maturation and egg development and that they are probably significant in the fly/host plant relationships. For example, the bacterial odours combined with fruit odours are probably the olfactory cues used by the flies to detect the host fruit. The fact that warm moist conditions are necessary for bacterial survival and growth explains the distribution of the Dacinae. They occur in the tropics and subtropics where warm moist seasons follow cooler dry seasons. It is in the warm moist seasons that the flies and their host plants are reproductively active.

At our QDPI laboratory in Brisbane, we have carried out a sequence of studies to elucidate the fruit fly - bacteria - host plant relationships.

Certain bacteria have been isolated and identified from the alimentary canal of field-collected flies and from various

parts of the fruit fly habitat. Further, experiments have been carried out to

- determine the influence of bacteria as food on fly development and egg production

- locate sources of food in the environment

- define methods of distribution of the bacteria onto the host plant by the flies

- describe the transmission of the bacteria across generations by the use of antibiotic resistant mutant strains

- observe digestion of the bacteria after ingestion

- determine the relationships of the flies, their bacteria and host plants (including seasonal abundances).

Summarising our biology studies and some deductions from them:

a. Certain species of 'fruit fly type' bacteria, when fed to flies as the only protein source, provide a complete breeding diet.

b. Flies collected in a fruiting mulberry tree showed by crop and midgut content colour that developing females feed on fruit surfaces and possess large quantities of bacteria in their crops, mature gravid females do not feed of fruit surfaces, males feed on non-fruit surfaces.

c. Males had few bacteria in their crops and had brown crop contents.

d. Males and females feed on different substrates

e. Adult flies (females) regurgitate large quantities of bacteria onto surfaces upon which they feed

f. There is a major build-up of these bacteria on the host fruit surfaces after the flies enter the tree and the fly population increases.

g. It appears that flies arrive in the tree, inoculate fruit surfaces with specific bacteria, the bacteria proliferate and provide food for female egg development.

h. Females can produce eggs 3 days after a single protein feed.

i. Flies seek and ingest protein for egg production only when suitable fruit is available for oviposition.

j. The development of eggs after the flies arrive in the host tree would be most economical in the energy budget of the insect as eggs are costly, in terms of energy, to produce.

k. The odours that attract flies to the host trees probably serve as feeding attractants to females and sex attractants to males (because mostly immature females and mature males respond to the fruiting host tree).

l. The host tree appears to be the centre of activity for a fruit fly population. It is the site of adult feeding, female maturation, mating, oviposition, larval feeding and pupation.

m. The significance of the host plant, especially for mating, is exhibited in many tephritids. There are records of 45 species of Tephritinae mating on host plants and, in some experiments, if the sexes do not meet on their specific host plants they are not able to recognise conspecific partners.

n. The males utilise the larval host plant as species specific waiting places and as territories for courtship and mating.

o. The flies search for mates has much in common with their search for food. Mate encounter sites have evolved in areas of resource value to females.

p. Host plant mating strategies must be important in maximising reproductive success and in maintenance of the species gene pool.

These biology studies have two important applications -

a. In developing studies to understand the ecology of the species - I believe that the availability of nitrogen for reproduction is an important factor governing the distribution and abundance of species, and bacteria in the food chain probably play a significant role; the bacteria may be important in concentrating plant surface nitrogen, in leachates, for insect nutrition.

b. The bacteria have been shown to be highly attractive to fruit flies when inoculated into proteinaceous suspensions. We believe that a new group of baits and synthetic lures for fruit fly control can be developed from the bacteria. It will require specific research in chemistry and microbiology before this can be achieved.

In recent years much of the QDPI field testing of potential fruit fly attractants has been carried out by Bruce Sabine of Entomology Branch. A tropical nectarine orchard has recently been established at the Redlands Horticultural Research Station to enable more extensive field testing programmes.

FRUIT FLY BIOGEOGRAPHY AND SPECIATION

The knowledge of taxonomy and biology that we have developed is now providing an understanding of biogeography and speciation.

The tropical and subtropical rainforests comprise the endemic habitat of the Dacinae and the worldwide distribution of these flies parallels that of the forests. In comparing the fruit fly faunas and rainforest floras of Papua New Guinea and north east Australia, the following observations can be made:

a. The endemic dacine faunas and rainforest floras of Papua New Guinea and Australia are each unique and different.

b. There are a low number of shared species and numerous species endemic to each area, suggesting independent speciation uninfluenced by migration. Speciation has been more vigorous in Papua New Guinea than in Australia.

c. Both communities within eastern Australia change markedly from north to south, at the species level.

Speciation in the Dacinae in Papua New Guinea and Australia is a similar pattern to that in the tropical rainforests. Probably speciation in the Dacinae and the rainforests has proceeded together and it is possible that speciation in the forests has influenced that in the Dacinae. This conclusion is supported by the data on fruit fly - host plant relationships, reproductive biology and species distributions.

CONCLUSION

I have attempted to present a discussion on the history and aspects of current fruit fly research in Australia. In particular our studies on the taxonomy and biology of species have been discussed and I have used fruit flies as an example of how we must apply ourselves to understanding the biology/ecology of insects. This as our chief goal will provide new control techniques for pest species and the knowledge of 'how', 'when' and 'where' to apply them. Although this approach will never supply immediate short term answers as do insecticide applications, it will provide solutions of long term value.

Basic biological research is not expensive. The field studies we completed in the nectarine and peach trees cost merely $300 (excluding wages) but provided us with so much information on fly activity that we can now recommend, with confidence, improved methods of bait spray applications and trapping for control purposes.

In future we should take certain steps to ensure that Entomology contributes lasting benefits to our Community. Some of these are:

1. Teach Entomology courses in our tertiary institutions that educate students in basic biological principles. In this we treat Entomology as a biological science, not as a means of pest control.

2. Avoid converting Entomology into a system of routine insect pest control. Here we must use our teaching and research for education and the development of thought.

3. Learn to integrate basic and applied research.

4. Develop an ability to read and observe insect ecological systems. This will be achieved by spending long periods on observation within the specific habitat of the insect one wishes to study.

5. Work to maintain basic research that will have lasting applied values.

Entomology in Australia has a rich heritage based on the lives of many enthusiastic and dedicated people. I am sure that many current workers will continue to be inspired by these pioneers as well as be entertained by stories of some unusual characters.

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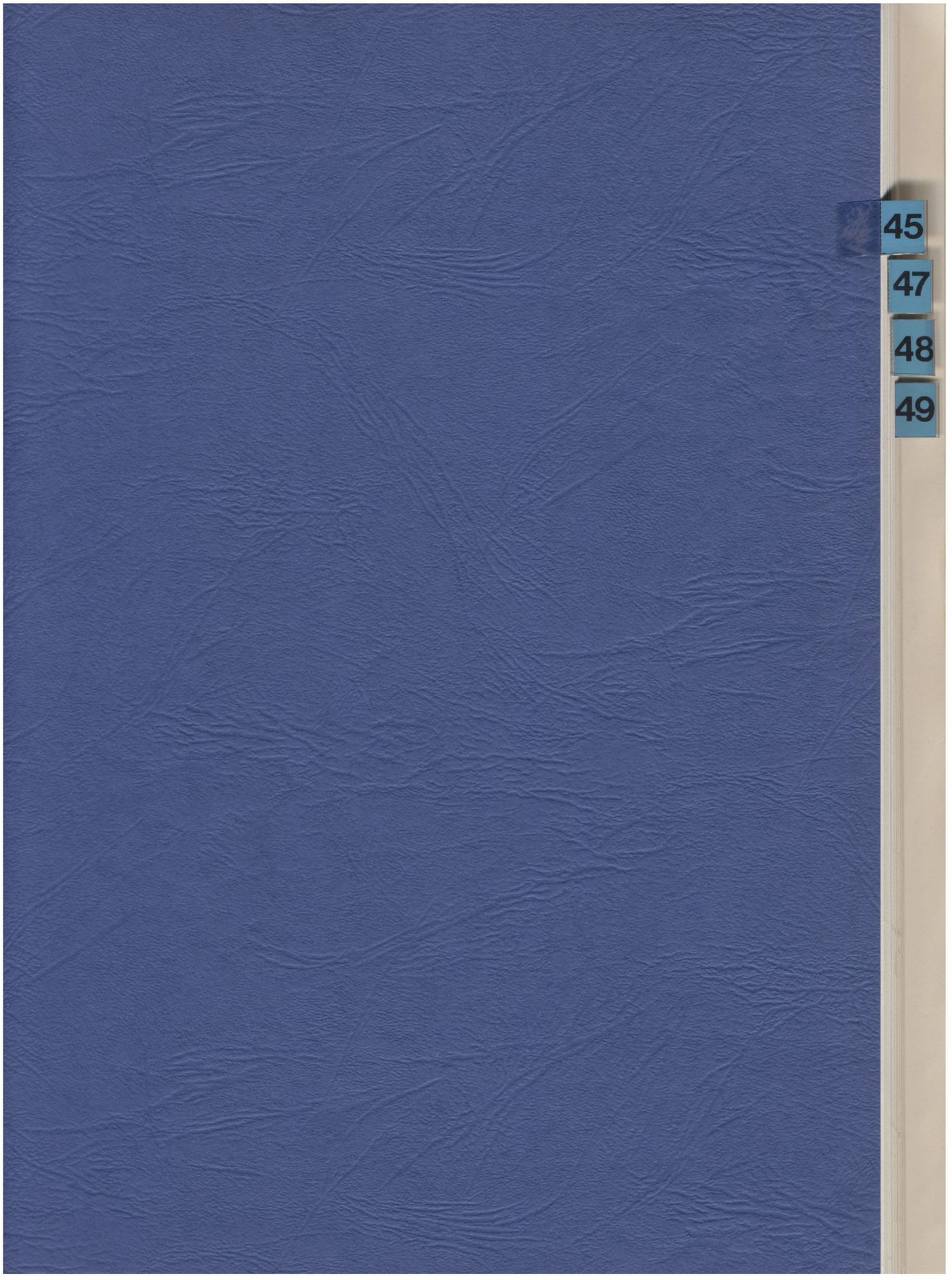
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BACTERIA IN THE LIFE CYCLE OF TEPHRITID FRUIT FLIES

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1. INTRODUCTION

Fruit flies of the family Tephritidae are worldwide as pests of horticultural crops. The problem is immense in the tropics and sub-tropics where there is a continual struggle to produce adequate food for large human populations. In this region up to 100 percent crop loss due to fruit flies, occurs in areas where there are no control programs. Extensive research has been carried out since the turn of the century on fruit fly taxonomy, biology, ecology and control. Because most research has been aimed at control of endemic species and eradication of introduced species, significant areas of fruit fly biology have been overlooked. In particular, there is a paucity of information on the biology of these insects in their endemic habitats, and on fruit fly-host plant relationships. Research in this area is essential for improved knowledge of fruit fly ecology.

Recent studies on the Dacinae have provided valuable data on the role of microorganisms in host plant relationships and fruit fly biology (Courtice and Drew, 1984; Drew, 1987; Drew and Lloyd, 1987; Drew et al., 1983). Ingested bacteria have been shown to satisfy the protein requirements of females for egg maturation. Fruit flies introduce their alimentary tract bacteria into the host tree, onto the host fruit surface and subsequently into the host fruit during oviposition. These bacteria may enhance attractancy of host trees because odors produced by fruit fly-associated bacteria are highly attractive to flies. These studies have emphasised that the host plant and associated microorganisms are significant components in the biology of the fly. The role of bacteria in the interaction between fruit flies and their host plants is a new and exciting area of research. Recognition of its importance has been the catalyst for a whole new field of study which may lead to the development of new and improved methods of fruit fly control.

Significant advances in fruit fly control that lead to implementation of efficient and environmentally acceptable integrated pest management programs are predicted on detailed knowledge of host plant-fruit fly interactions. In this chapter, our current knowledge of fruit fly-host plant biology is discussed and the importance of specific bacteria in this relationship is emphasised. Areas of future research in which major advances can be expected are proposed. Because this is a new field of study, it is necessary and important to be speculative in some areas. It is our hope that we will stimulate research that will improve our knowledge of fruit fly biology and thus produce insights that have valuable potential for the control of a major problem in world food production.

2. HOST PLANT ASSOCIATIONS OF TEPHRITID SUBFAMILIES

The family Tephritidae contains over 4000 known species and is divided into eight subfamilies. The major subfamilies are the Tephritinae, Toxotrypaninae, Trypetinae, Ceratitinae and Dacinae (Hancock, 1986a,b). The Tephritinae and Trypetinae are most diverse in the temperate regions of the world and their species occurring in tropical and subtropical areas are usually found at higher altitudes. In contrast, the Dacinae, Toxotrypaninae and Ceratitinae have speciated prolifically throughout the tropics and sub-tropics where they often occur in high densities.

The endemic habitats of the Tephritinae and many Trypetinae are grasslands and open forests, whereas tropical and subtropical rain forests are the endemic habitat of the Dacinae. Only occasional species of Trypetinae, such as *Dirioxa pornia* (Walker) breed in rain forest fruits. In temperate regions, e.g., southern Australia, the Tephritinae and Trypetinae are mostly restricted to grasslands and open forests. In the tropics, e.g., Papua New Guinea, these temperate forest habitats occur at higher altitudes, generally above 2500 m.

Most host plants of the Tephritinae belong to the families Asteraceae, Acanthaceae, Labiatae and Verbenaceae. The flies oviposit in the flower heads and the larvae feed on developing seeds. In some species the larvae feed within stem galls. Larvae of the Trypetinae exhibit a greater range of feeding behaviours; species breed in flower heads (the larvae feeding on both seeds and flower buds), stem galls, leaf mines, bamboo shoots, under bark and in fruits. In the Nearctic region, *Rhagoletis* species (Trypetinae: Trypetini) utilize species of Solanaceae as wild hosts (Foote, 1981). The Oriental-Australasian Dacinae are largely restricted to the soft, fleshy fruits of the rain forests, except one species recorded from the stem of a *Terminalia* species in Papua New Guinea (Drew, 1989). In the Dacinae, larval feeding occurs within the fruit and is accompanied by bacterial decay. As certain bacteria appear to be significant in the Dacinae, as adult and possibly larval food, it is probable that bacteria are also equally significant in the Tephritinae and Trypetinae.

The subfamily Dacinae has been recently reclassified (Drew, 1989) into two genera, *Dacus* and *Bactrocera*. The genus *Dacus* contains all but 5 of the 175 African species and has fused abdominal terga, while the genus *Bactrocera*, with approximately 450 species from the Asian, South East Asian and Pacific areas contains species with free abdominal terga. In the Asian to Pacific region there are approximately 30 species that belong to *Dacus*. These two genera also have different host plant associations. The *Dacus* species in Africa and the Asia/Pacific region breed only in host plants of the same families, such as the Asclepiadaceae and Cucurbitaceae. The *Bactrocera* species breed in hosts belonging to approximately 45 families of tropical rain forest plants. The host families utilized by *Bactrocera* in the Asian/Pacific region are utilized in Africa by the Ceratitinae (Hancock, 1986b). In the New World these species are hosts of members of the genus *Anastrepha* (Toxotrypaninae). Most species of the Tephritidae are restricted to specific families, genera or even species of plant hosts. Historically, the host plant has been considered primarily in its role as a larval food source. It is now recognised that the host plant plays a more significant role in providing the adults with an aggregation site, shelter, food and the site for courtship and mating. Future research programs need to develop a concept of the fruit fly-host plant relationship that embraces all aspects of fruit fly biology.

Fruit fly courtship and mating activities, in the great majority of species, are restricted to the host plant and as such are host plant dependent. This has been described for the Tephritinae by Friedberg (1981), Grewal and Kapoor (1984) and Zwolfer (1974); the latter reporting on 45 species belonging to 18 genera. Bush (1969, 1974) and Boller and Prokopy (1976) noted that mating in *Rhagoletis* species was confined to the host plant whereas Drew (1987) recorded this same phenomenon in the Dacinae. The only data to the contrary are in a limited number of studies on cucurbit-infesting *Dacus* species. These flies are reported to spend most of their time in non-host (so-called) rest plants and only gravid females have been reported to visit host plants for oviposition (Nishida and Bess, 1957; Steffens, 1983).

These studies concluded that mating occurred in the non-host plants, but no actual observations of mating pairs were reported.

Various types of mating behaviour have been reported. In general, species with highly ornamented wings possess an elaborate courtship behaviour based on visual cues, whereas species with clear wings appear to be more dependent on pheromone communication for mating. The mating behaviour of *Schistopterum moebiusi* Becker involves a system called pre-mating "trophallaxis" whereby the male secretes a white frothy fluid through the proboscis and builds a vertical pillar on the host leaf surface. The female is attracted to and feeds on the pillar and while she is doing so the male mounts and begins copulation (Friedberg, 1981). This system has been recorded in five tephritid species within the Tephritinae and Trypetinae (Friedberg, 1981).

In some Tephritinae, such as *Dioxyna sororcula* (Wiedemann), courtship and mating occur on the disc of the flower head (Grewal and Kapoor, 1984). Mating in Dacinae was recorded on the lower leaf surfaces of the host tree by Drew (1987) who emphasized that host-restricted mating had a number of significant advantages to the fly species: (1) it maximizes reproductive success, particularly in times of low population numbers, (2) it is important in maintaining the energy budget of the fly in that the female can develop fertile eggs after she has discovered the oviposition site, (3) it is important in the maintenance of the species gene pool, and (4) it is significant to the process of speciation. In summary, male tephritid flies exhibit a characteristic rendezvous behaviour. They use the larval food plants as species-specific waiting places and as localities for courtship and mating. The males must recognize the specific host plant, at the stage of development susceptible to oviposition, independent of the females. The females apparently recognise the host plant by different stimuli (Drew, 1987). If the sexes do not meet on the host plant they are not able to recognize conspecific partners (Zwolfer, 1974). Thus, the search for mates has much in common with the search for food, and mate encounter sites have evolved in areas of resource value to females. Females aggregate for food as well as for egg production and subsequent oviposition in these areas. The selection of a suitable host plant is also important for the larvae. In contrast to some Lepidoptera larvae which can move from one feeding site to another, tephritid larvae must remain at the same site (see also Barbosa and Wagner, 1989; Leufven, 1989; this volume).

It is evident that detection of the host plant is of vital importance for reasons of courtship, mating, oviposition and larval feeding (Prokopy, 1977a). However, the processes by which the adult flies detect their host are not well known and deserve further intensive research. Both chemical and visual stimuli are believed to be involved in the process. The chemical stimuli in the host probably act as attractants and arrestants while the visual cues are probably attractants.

It is clear that the host tree is the primary center of activity of a tephritid population. Certain aspects of the interaction between the insect and plant, particularly adult feeding, mating, oviposition and larval feeding have been extensively studied (Bateman, 1972; Fletcher, 1987) but many questions remained unanswered. For instance. details of larval and adult nutrition, various aspects of sexual behaviour including the role of pheromones and the significance of lekking behaviour, host detection mechanisms and general foraging strategies are poorly understood.

3. FRUIT FLY-BACTERIA RELATIONSHIPS

Studies on bacteria associated with fruit flies generally have not been related to the behaviour of the insect on the host plant (Rossiter et al., 1983; Rubio and McFadden, 1966; Tsiropoulos, 1976, 1983; Yamvrias et al., 1970). In many instances, bacteria isolated from flies have been identified but the distribution or acquisition of such bacteria in the flies' environment, in particular the host tree, has not been studied.

In discussing insect-microbe-plant interactions, Jones (1984) stressed that little research had been done on the role of commensal bacteria in the insect alimentary canal and few studies have examined microphagy on the phylloplane. This particularly applied to tephritids where, until recently, the three-way interaction of fruit fly, bacteria and host plant had largely been ignored. Four kinds of interactions between microorganisms, insects and plants have been defined (Jones, 1984, i.e., mutualism, commensalism, competition and predation/parasitism). However, attempts to classify the fruit fly - bacteria - host plant interactions in terms of these categories would appear premature at this time since so little is known about the bacteria - host plant aspect of the association.

Steinhaus (1960) stressed the importance of considering "environmental factors," in evaluating the possible two-way relationships between insects and microbes. In the case of the tephritid-microorganism interaction this must include the host tree. Steinhaus arranged insect-microorganism relationships in a number of arbitrary categories, ranging from obligate parasitism (insect disease) to obligate symbiosis (mutualism) in which insects are hosts to intracellular symbionts necessary for the normal life of the insect. Intermediate degrees of intimacy between insect and microbe may involve several of these categories as exemplified by the relationship between fruit flies and their bacteria. The particular species in the *Enterobacteriaceae* present in the alimentary tract of wild fruit flies can provide a suitable protein food. These bacteria are carried by the fruit fly and are introduced into the host tree where bacterial odours appear to play a role in enhancing host attractancy. The introduced bacteria are subsequently inoculated into the host fruit during oviposition where they may play a role in larval nutrition. Whether or not these bacteria commonly associated with fruit flies should be categorized as extracellular symbionts (i.e. mutualists) will be discussed below. Intracellular symbionts have not been reported in Tephritidae.

3.1 Bacteria as Symbionts

For many years, the bacteria associated with Tephritidae were considered to be obligate symbionts involved in producing supplementary nutrients for both adults and larvae (Girolami, 1983; Hagen, 1966; Luthy et al., 1983; Miyazaki et al., 1968; Petri, 1910). Such a strict symbiotic relationship, has now been questioned (Drew et al., 1983; Fitt and O'Brien, 1985; Howard et al., 1985; Lloyd et al., 1986). The reported symbiont of *D. oleae*, "*Pseudomonas savastanoi*," is now thought to be a misidentification (Luthy et al., 1983) and the bacteria associated with this species have not been identified conclusively (Manousis and Ellar, 1988).

Field collected *Dacus* species from various Pacific and Asian countries (Drew and Lloyd, unpublished data) have the same predominant species of bacteria as those in Australian Dacinae (Lloyd et al., 1986) and *Rhagoletis pomonella* (Rossiter et al., 1983). Although this small group of species in the *Enterobacteriaceae* appears to be common to Tephritidae around the world, no one species of bacteria appears to be associated consistently with one fruit fly species. The presence of a relatively small number of bacterial species in adult flies, oviposition sites and developing larvae undoubtedly indicates a close specific association between fruit flies and their bacteria. Whether or not these bacteria should be referred to as "symbionts" is debatable.

The term symbiosis has been widely used to refer to insect-microbe associations but has not been clearly defined when used to refer to fruit fly - bacteria associations (Drew and Lloyd, in press). Petri (1910) called the bacteria associated with *D. oleae* "symbionts" and most researchers continued to use this term for any bacteria commonly associated with any species of fruit fly. In its broadest definitions, symbiosis can mean "the phenomenon in which dissimilar organisms live together" (de Bary, 1879). In this sense, it may be acceptable to use the term "symbiont" for bacteria associated with fruit flies. However, most studies of fruit flies have used symbiosis in such a way as to imply a "mutually beneficial obligatory relationship" (Dindal, 1975) despite the fact that an obligatory relationship between fruit flies and their bacteria has not been demonstrated.

Attempts to determine if such an obligatory relationship exists between fruit flies and their bacteria have been based entirely on larval studies. In naturally infested fruit, larval development is always accompanied by heavy growth of fruit fly-type bacteria (Lloyd et al., 1986). However, when larvae are reared on an artificial diet most of the normal alimentary tract microflora are inhibited (Lloyd, unpublished data), and larvae continue to thrive provided hydrolyzed protein is available. It should be noted that good larval growth, development and survivorship on artificial diets, that are nutritionally optimal, are commonly found for many insects but does not preclude an important facultative role for microorganisms on nutritionally sub-optimal natural hosts (Jones, 1984). The protease.producing bacterium, *Serratia marcescens* had a detrimental effect on the larval growth of *D. jarvisi* in artificial medium (Fitt and O'Brien, 1985). However, Lloyd et al. (1986) reported that this organism was not normally present in wild *Dacus* flies but was frequently associated with laboratory colonies, particularly if *Drosophila melanogaster* was present. Experiments with *D. oleae* reportedly demonstrated the essential role of unidentified "symbiotic" bacteria because the application of the antibiotic streptomycin to olives inhibited larval development (Tzanakakis et al., 1983). Further research is required to clarify these aspects of fruit fly-bacteria interdependence in both the larval and adult stages of the life cycle.

In the fruit fly-microbe association, the physical benefits of protection and transport which the insect provides for the bacteria are obvious, but the nutritional benefits to the bacteria are as yet unknown. Until the precise interaction of fruit fly and bacteria is better understood, it may be somewhat restrictive to call the normal alimentary tract microflora "symbionts." It would appear that for many years the use of the term "symbiont" with its mutualistic connotations, has hindered a broader view of bacteria in the life cycle of fruit flies. The importance of bacteria in the host environment as adult food and as odor attractants for *D. tryoni* has now been demonstrated. Further research is needed to determine if any bacteria associated with other fruit fly species are strict mutualistic symbionts and whether bacteria constitute a primary adult food source for other fruit fly species.

3.2 Bacteria as Larval Food

The specific introduction of alimentary tract bacteria into the host tree by tephritid adults is of primary ecological significance, not only in providing adults with food and facilitating host detection but also in providing suitable larval food in the host fruit.

Using marked fruit fly-type bacteria, Drew and Lloyd (1987) showed that alimentary tract bacteria inoculated onto host fruit surfaces by adults provided a source of inoculum for introduction into the fruit during oviposition. A number of theories have been proposed to explain the introduction of bacteria into larvae infected fruit. With *D. oleae* a specialized means of bacterial inoculation of eggs via bacteria secreted from rectal glands has been described (Girolami, 1983; Petri, 1910) although the bacteria involved have not been conclusively identified (Manousis and Ellar, 1988). With other species such as *R. pomonella*, faecal contamination has been suggested as the means by which bacteria are inoculated into host fruit (Ratner and Stoffolano, 1982). Experiments with *D. tryoni* using marked strains of fruit fly-type bacteria showed that these bacteria are introduced into the host fruit as a result of the mechanical insertion of the ovipositor through the surface layer of bacteria deposited during proboscis exploration. There is no evidence in *D. tryoni* to indicate bacteria are introduced through the ovipositor, on the egg, or in the egg. After insertion of the ovipositor the introduced bacteria spread through the fruit tissue in advance of the developing larvae (Lloyd et al., 1986).

It has not been generally accepted that bacteria associated with fruit fly larval development provide essential nutrients absent from the host, or otherwise assist in larval utilization of host tissue (Bateman, 1972; Prokopy, 1977a). Bacterial inoculation of the host fruit during oviposition is likely to be the means by which an adequate nitrogenous source is ensured for larval growth. Normal host fruit tissue is known to be low in nitrogen, but there is a marked increase in essential amino acids in fruit fly infested fruit tissue while attached to the host plant (Drew, 1988). This is possibly due to the plant increasing nutrient flow to the damaged tissue which subsequently may enhance bacterial growth. The bacteria, in turn, most likely provide essential nutrients for the larval diet or may be ingested directly as food (see Section 3.3). Other possible functional roles for bacteria in fruit fly larval development have been suggested but not widely investigated. Howard et al., (1985) suggested that bacteria may have pectolytic activity in the host fruit, or they may detoxify host fruit chemicals (see Dowd, 1989: this volume), both of which could be beneficial to larval development.

Because only one or two species of fruit fly-type bacteria are found in association with developing larvae in an intact infested host fruit (Lloyd et al., 1986), a more specific association other than just a causal invasion by saprophytic plant surface organisms seems to exist. However, after larval development and associated bacterial rot is advanced, the skin of infested fruit breaks down allowing other plant organisms to invade the rotting tissue, thus creating a more diverse microbial flora.

3.3 Larval Adaptations for Digesting Bacteria

Tephritid fruit flies belong to the cyclorrhaphous Diptera whose larvae normally develop in microbe infested environments and are uniquely adapted to ingest and digest bacterial cells as their primary food (Espinoza-Fuentes and Terra, 1987). Although little is known about the structure and function of the fruit fly larval digestive system, it is likely that processes similar to those in other cyclorrhaphous

Diptera are taking place. Ridges on the floor of the pharynx, which are believed to selectively filter bacterial cells from ingested liquid food, have been demonstrated in onion fly larvae (Dowding, 1967) and in *D. oleae* (Keilin, 1913). Cyclorrhaphous larvae generally have a very acid region in the midgut where it is believed that ingested bacteria are lysed to be used as food (Espinoza-Fuentes and Terra, 1987). The findings of Fitt and O'Brien (1985) on fruit fly larvae are similar to those of Greenberg (1968) on house fly larvae, *Musca domestica* (L.), which demonstrate that the fore-midgut and hind-midgut are approximately neutral while the mid-midgut is strongly acid (pH2.3). In *M. domestica* larvae the crop pH is not buffered and fluctuates with the pH of ingested food. Water is secreted into the fore and hind-midgut and absorbed in the midgut (Espinoza-Fuentes and Terra, 1987). This, together with a cycle of endo-ectoperitrophic circulation of digestive enzymes, makes house fly larvae uniquely suited to killing and digesting bacteria as a primary food source. Further research is required to determine if these digestive adaptations are present in tephritid larvae.

3.4 Bacteria as Adult Food

The possibility that adult flies ingest bacteria as food was first suggested by Dean and Chapman (1973) who found that crop contents of field collected *R. pomonella* (Walsh) adults included large numbers of bacteria. This idea was not taken seriously because of the widespread belief that aphid and coccid honeydew was the principal food source for adult fruit flies in nature (Bateman, 1972; Fletcher, 1987), with supplementary nutrients being supplied by microorganisms. However, since the demonstration that certain species of bacteria, isolated from the alimentary tract of wild flies, could provide an adequate breeding diet for *Dacus tryoni* (Froggatt) under laboratory conditions (Drew at al., 1983), many new aspects of the relationship between fruit flies and their bacteria have been studied. It has been suggested that alimentary tract bacteria of fruit flies may have additional nutritional or physiological functions such as fixing atmospheric nitrogen, protecting the fly against invading pathogens (Howard et al., 1985) or detoxification of host chemicals (Dowd, 1989; Jones, 1984). Such nitrogen fixation activity has been reported to be absent in *R. pomonella* (Howard et al., 1985) but present in *D. tryoni* (Murphy et al., 1988).

An extensive survey of bacteria in the alimentary tract of field collected adults of *D. tryoni*, *Dacus neohumeralis* Hardy, *Dacus cacuminatus* (Hering) and *Dacus musae* (Tryon) in Queensland showed that *Klebsiella oxytoca*, *Erwinia herbicola* and *Enterobacter cloacae* were the predominant isolates with *Proteus* species, *Providencia rettgeri* and *Citrobacter freundii* being less frequent (Lloyd et al., 1986). These six species, which were also commonly associated with oviposition sites, host fruit surfaces and larvae-infested tissue, are hereafter referred to collectively as "fruit fly-type" bacteria. Field studies using caged and uncaged host nectarine trees demonstrated that wild *D. tryoni* and *D. neohumeralis* introduced their alimentary tract bacteria into the host tree, particularly on to host fruit surfaces prior to oviposition. All bacterial species included in this fruit fly-type group have been isolated from plant environments (Billing, 1976) but the predominance of these bacteria in the host tree, after flies begin utilizing the host, indicates a purposeful pattern of bacterial inoculation by the insect.

Marked bacteria (i.e., double antibiotic-resistant mutant strains of fruit fly type bacteria) that can be subsequently screened in antibiotic containing media have been used to investigate the role of

bacteria in fruit fly biology. This work showed that these bacteria colonize the gut of *D. tryoni* after a single meal. Some of these ingested bacteria are digested to provide protein necessary for egg maturation (Drew and Lloyd, 1987). The flies distribute these alimentary tract bacteria during the process of proboscis exploration (or foraging) and also when they produce long lines of regurgitated fluid droplets (Drew and Lloyd, 1987; Lloyd, 1988). Proboscis probing is characteristic of female behaviour prior to oviposition and, although believed to serve a chemosensory function, also provides a means of inoculating the host fruit surface with a layer of alimentary tract bacteria. Excessive regurgitation of up to 120 small drops of fluid deposited methodically in long lines usually occurs after feeding and is frequently followed by reingestion. The crop deflates during regurgitation and inflates during reingestion indicating the involvement of this organ in the process. In wild fly populations, regurgitation by males and females appears to occur more often on leaf surfaces than on fruit surfaces.

This particular regurgitation-reingestion behaviour has not been widely reported in other Diptera species and its precise function is as yet uncertain. However, a similar process of bacterial distribution onto a host seems to occur with the face fly, *Musca autumnalis* De Greer (Glass and Gerhardt, 1984). This fly transmits the bacterium *Moraxella bovis*, the causative agent of infectious bovine keratoconjunctivitis, by regurgitation of crop contents into the eye of uninfected hosts. With *Dacus tryoni* the frequent and often total reingestion of the regurgitated fluid suggests that the process is not primarily involved in regulation of fluid intake. The regurgitated fluid contains large numbers of alimentary tract bacteria (Drew and Lloyd, 1987), hence it appears that both the proboscis exploration and regurgitation behaviours involve the release of bacteria containing fluid from the alimentary tract onto the host plant surface. Fresh feces collected in sterile tubes from wild flies were found to contain, at most, only small numbers of alimentary tract bacteria (Lloyd et al., 1986). Sometimes no bacteria were present in feces. It would appear that the distribution of bacteria into the host tree occurs primarily via the mouthparts and is a probable means of establishing both adult and larval food supplies as well as enhancing the attractancy of the host tree.

This hypothesis was supported by a study of both bacterial and fly populations in an isolated peach tree during the fruiting season (Drew and Lloyd, 1987). Most of the wild flies initially arriving in the tree were immature females and mature males. During the 7-10 days after flies first arrived in the tree, the populations of fruit fly-type bacteria on the fruit surfaces increased markedly. At the same time, the female population changed from predominantly immature to mature. Because wild flies ingest fruit fly-type bacteria, as indicated by crop contents, it appeared that immature females, in particular, can obtain the protein necessary for egg maturation from the bacteria inoculated into the host tree. Previous observations on wild fly populations in fruiting mulberry trees also confirmed that immature females were actively feeding on host fruit surfaces because of the purple mulberry color of crop contents containing large numbers of bacteria (Drew et al., 1983).

The inoculation of a host with alimentary tract microorganisms, for the subsequent cultivation of food, is not unknown in insects. The ambrosia beetles of the genus *Xyleborus* excrete or regurgitate fungal spores from the crop when preparing a fungus bed in galleries in the host tree and the resulting fungal growth provides the beetle with its primary food source (Barbosa and Wagner, 1989; Imms, 1957).

3.5 Bacteria Digestion in Adult Flies

No physiological studies have been reported on the digestive processes in adult Tephritidae, mainly because of difficulties in collecting contents from alimentary canal sections other than the crop. Consequently, it is not known if bacteria-digesting features, typical of cyclorrhaphous larvae, occur in adults. However, evidence suggests that adult *Dacus* species are adapted to use bacteria as a protein food source.

When marked fruit fly-type bacteria were supplied to *D. tryoni* as the only source of protein, the bacteria were found to colonize the midgut and were utilized as food for egg production (Drew and Lloyd, 1987). Ingested marked bacteria heavily colonized the midgut region of *D. tryoni*, however, only small and variable numbers were recovered from the rectum and feces. It seems that growth and colonization by bacteria may occur in one part of the midgut, while digestion of bacterial cells and subsequent release of nutrients occurs in another portion of the midgut. In the laboratory, the use of bacteria as adult food has proven important in the early establishment of new colonies of flies (Drew, Lloyd and Hamacek, unpublished data). It has been possible to establish, for the first time, colonies of endemic *Dacus* species by feeding the adults pure colonies of certain fruit fly-type bacteria in addition to the normal hydrolysed yeast protein. These results would appear to emphasize the importance of bacteria as a natural food source for adult flies.

3.6 Bacterial Odors as Attractants for Other Insects

The attractiveness of bacterial odors in other species of Diptera is well documented and both ovipositional and feeding attractants are believed to be involved. Pools of water inoculated with certain bacteria stimulated ovipositional responses by *Aedes aegypti* (L.) (Schreck and James, 1968), while the response of screwworm fly, *Cochliomyia hominivorax* (Coquerel) to various blood products is enhanced by bacterial action (De Vany et al., 1973). The bacterium *Providencia rettgeri* which is commonly associated with adult screwworm flies, larvae, pupae and eggs, produces a bacterial metabolite attractive to gravid females (Bromel et al., 1963). The attraction of both immature and gravid females to feed on exudate from wounds indicated that wounds might contain chemically distinct ovipositional and feeding attractants.

Bacterial odors have been implicated in host selection in a number of other species. Female onion flies, *Hylemya antiqua* (Meigen), prefer damaged and decomposing onions for oviposition and bacteria are beneficial, although not essential, for larval development (Dindonis and Miller, 1980; Eymann and Friend, 1985; Hough et al., 1981). The Australian sheep blowfly *Lucilia cuprina* (Wiedemann), also responds to bacterial odors as ovipositional stimulants (Eisemann and Rice, 1987; Emmens and Murray, 1982). Bacterial odors from *Flavobacterium* sp., *Erwinia herbicola* and *Xanthomonas campestris* stimulate oviposition in the seedcorn maggot *Delia platura* (Meigen) (Hough-Goldstein and Bassler, 1988). A bacterial-produced odor, defined as an aggregating pheromone, is believed to be involved in the complex communication system used by bark beetles (Scolytidae) to locate a new host to feed, mate and reproduce (see Barbosa and Wagner, 1989; Leufven, 1989: this volume). Volatiles from the host plant act as primary attractants to lure a small number of individuals that feed and then produce the aggregation pheromone which, in turn, attracts larger numbers of beetles to the host (Brand et al.,

1975; Wood, 1982). The New Zealand grass grub beetle carries a sex pheromone producing bacterium in the female collateral glands (Hoyt et al., 1971). These records indicate that the attraction of adults to hosts for food and oviposition may result from responses to products from specific microorganisms.

3.7 Bacterial Odors as Attractants for Fruit Flies

The attractancy of fruit flies to protein solutions containing bacteria was first reported by Gow (1954) when *Dacus dorsalis* Hendel in Hawaii responded strongly to solutions containing a *Proteus* species. Cultures of fruit fly-type bacteria growing on peptone-yeast extract agar (Drew et al., 1983) and hydrolyzed protein solutions inoculated with these bacteria are strong attractants for *Dacus* species (Drew and Fay, 1988). When plates inoculated with these bacteria are exposed in host trees, wild flies are attracted to and feed on the bacteria. The attractive components emitted by hydrolyzed protein solutions, with and without bacteria, are not known, although various protein bait formulations have been used in fruit fly control programs for many years. Bateman and Morton (1981) stated that ammonia was the most significant component. Drew and Fay (1988), on the other hand, deduced that ammonia was only a weak attractant and that certain bacterial metabolites were the primary attractants. With the Dacinae, Drew (1987) proposed that bacterial volatiles, such as 2-butanone were important attractants and served as two different stimuli, a feeding attractant to females and a sex attractant to mature males.

Evidence from field studies supports the theory that bacterial odors enhance host attractancy. An extended field study of a wild fly population in a peach tree in Queensland (mentioned in Section 3.4) indicated that the host tree appeared to became more attractive to flies after a short period of occupation by low numbers of flies (Drew and Lloyd, 1987). During this time of increased host attractancy, the bacterial populations on the fruit surfaces reached a peak, suggesting the probable involvement of bacterial odors in fly attraction. It is not clear whether these bacterial odors arose specifically from inoculated fruit or from regurgitate containing bacteria and deposited on leaf surfaces by feeding flies. The fruit fly-type bacteria introduced into the host tree do not appear to become established on leaf surfaces, as large numbers of these bacteria are found only in freshly deposited regurgitated fluid but not in dried droplets. However, flies have been observed to congregate in small groups on particular leaves where dried regurgitate drops were present. It is possible that certain components of bacteria odors serve as either feeding or ovipositional stimulants. Under laboratory conditions, flies frequently return to the same spot to regurgitate and reingest several times (Lloyd, 1988). This behaviour may involve some form of host marking system, and because some fruit fly-type bacteria have been shown to remain on a leaf surface immediately after reingestion of regurgitated fluid, it is likely that bacterial odors are involved.

The above responses and the bacterial attractancy reported for other insects (section 3.6) suggest that a system of bacterial attraction for fruit flies probably exists in nature and plays a vital role in fruit fly behaviour.

4. RELEVANCE OF FRUIT FLY - HOST PLANT - BACTERIA INTERACTIONS TO UNDERSTANDING FRUIT FLY ECOLOGY

4.1 Factors Which Influence the Ecology of Species

The major factors which determine the geographic distribution and seasonal abundance of fruit flies include temperature, moisture, light, food, availability of hosts, symbionts, competition and natural enemies (Bateman, 1972; Fletcher, 1987). Two of these factors, food and host availability, are significant components of the tephritid-host plant association. Prokopy (1983) stated that plants furnish tephritids with essential resources, some of which (e.g., feeding, mating and shelter sites) occur on or are provided by host as well as non-host plants and others (e.g., oviposition and larval development) are only provided by and occur in host plants. Nishida (1980) also believed that non-host as well as host plants could supply adult flies with food whereas host plants could provide the vegetative parts and fruits upon which larvae feed. Thus, both host and non-host plants were seen as playing similar roles in providing adult food, believed to be fruit juices, extra floral exudates, nectar and honeydew from homopterous insects.

Although the nutritional requirements for adult survival and reproduction in the laboratory are known, little research has been done to establish the natural source of these nutrients. Hagen (1953) defined the essential nutrients as free amino acids, carbohydrate, minerals and B-complex vitamins and reported that *Ceratitis capitata* (Wiedemann) could transfer some of these nutrients from their immature stages to the next generation of adults, however, *Dacus* species could not. Hagen (1958) later reported that *Rhagoletis* species and *C. capitata* could produce some eggs on an adult diet of carbohydrate and water alone, and *Dacus* and *Anastrepha* species always require amino acids. Differences in nutritional requirements between males and females have been recorded for *R. pomonella* (Webster et al., 1979) and *D. tryoni* (Drew, 1987). In *D. tryoni* males can fulfill their reproductive role in fertilization on a protein-free diet whereas females require protein for egg production. In addition, the temperate species possess fewer ovarioles per ovary (e.g., *Dioxyna sororcula*, Tephritinae has 9 ovarioles per ovary and *Dirioxa pornia*, Trypetinae, has 27). In contrast, tropical species in the Dacinae possess more ovarioles per ovary; *D. tryoni* has 42. Furthermore, temperate species have one generation per year compared with 6-8 generations per year in the Dacinae. Tropical species have a short one month life span, in contrast to temperate species which usually have a 6-12 month life span. It is reasonable to assume that the Tephritinae and Trypetinae have lower reproductive rates and that the females therefore have a much lower protein requirement for egg production than the Dacinae.

Honeydew has been argued to be the primary natural food source of adult fruit flies (Hagen, 1958; Neilson and Wood, 1966; Nishida, 1980) however, some doubts exist about the nutritional suitability of honeydew. Hagen (1958) and Craig (1960) recognized that essential amino acids were absent or in low concentrations and thus honeydew could not provide a complete diet. Furthermore, there are few published observations of flies feeding on honeydew, in contrast to a greater number of observations of flies feeding on fruit surfaces (Drew and Lloyd, 1987; Drew et al., 1983; Malavasi et al., 1983). These authors stated that honeydew was not utilized as food in their studies on *Dacus* species and *Anastrepha fraterculus* (Wiedemann), respectively.

Recent studies indicating that host plant associated bacteria are an important adult food source emphasize that the "environmental factors," listed by Steinhaus (1960), do have an important effect on this insect-plant interaction. These findings also recognize a broader concept of the role of the host plant, as a site of mating, and as the primary source of adult and larval food. The principal factors known to influence the ecology of Tephritidae must now be reassessed in terms of their influences on the specific bacteria introduced into and associated with the host plant.

Although *D. tryoni* does not normally congregate in non-host plants, certain other tephritid species such as *D. cucurbitae* and *D. zonatus* are reported to feed and shelter in non-host plants and to visit host plants solely for the purpose of oviposition (Bateman, 1972; Fletcher, 1987). *D. oleae* adults have been reported to utilize non-host fruit-bearing fig trees as an adult food source (Katsoyannos, 1983). In this instance, large numbers of gravid females were captured in the fig trees adjacent to a heavily infested olive grove. Because the figs were infested with *C. capitata* it is possible that the *D. oleae* were feeding on these bacteria rich, non-host fruit as a food source. To date, the Queensland study on the interaction between *Dacus* species, their host plants and bacteria is the only example of this multi-trophic relationship that has been investigated in some detail. Research to determine if other *Dacus* species are distributing bacteria or ingesting bacteria from host or non-host trees would be extremely worthwhile.

4.2 Fruit Fly Feeding and Availability of Bacteria on Host Plants

Fruit fly-type bacteria on host fruit surfaces increase in number as the fly population increases in a host tree (Drew and Lloyd, 1987). As yet, it is not known if this is merely an accumulation of deposited regurgitate or if the bacteria actually colonize the fruit surface. The leachates from soft fruit surfaces are known to contain all the nutrients available in a fruit (Tukey, 1971) and these could presumably serve as a suitable nutrient source for bacteria inoculated by adult flies onto the fruit surface. Plant surface moisture in the form of rain or dew may also leach bacteria-infested fruit juice from the oviposition holes in stung fruit. In some fruit such as peaches, a plug of gum may act as an effective seal over oviposition holes, but in soft fruit such as mulberries, bacteria-rich juice frequently oozes from infested ripe fruit.

If the fruit fly-type bacteria introduced into the host tree constitute the primary proteinaceous food for adults and larvae, then the availability of both host plants and adult food must be considered together. The host tree attracts immature females and mature males and becomes a significant site for female feeding, mating and egg maturation (Drew and Lloyd, 1987). It also appears that flies seek and ingest protein for egg production only when fruit is available for oviposition (Drew, 1987). The ability to develop eggs and mate after the female discovers fruit for oviposition would be an essential energy conservation mechanism, avoiding considerable flight for the female, while carrying eggs. Crop content colors of fruit fly species in Hawaii were found to be identical to the colors of the various ripe host fruits (Nishida, 1980) indicating that the flies were feeding on the fruit surfaces, as was the case with *Dacus* species in Queensland that fed on mulberry trees. This indicates that the adult feeding site and oviposition site are the same and that both are available at certain times of the plant growth season.

Almost nothing is known about how much food fruit flies require in nature. The fecundity of wild flies and the quantity and quality of protein required to maintain fecundity have rarely been studied. Pritchard (1970) found that *D. tryoni* had adequate food for reproduction within an orchard, while Nishida (1980) claimed that adult food in nature was limiting, based on size of crop contents and fecundity data. Because "normal fecundity" under field conditions is not known, it is impossible to define what constitutes an adequate diet in nature. The quantity of protein fed to flies in laboratory rearing, and the consequent fecundity, is probably far in excess of that required to maintain a successful field population.

4.3 Transmission of Bacteria Across Generations

Because bacteria appear to play a significant role in fruit fly host detection and feeding, the mechanisms by which the continuity of this specific bacterial association is maintained across generations is of vital importance. Studies with marked strains of fruit fly-type bacteria (Drew and Lloyd, 1987) have shown that the bacteria are transmitted from one generation to the next. Bacteria probably survive in certain areas of the mid-gut for transmission from one adult generation to the next via the larvae and pupae. In *D. oleae*, bacteria which accumulate in the oesophageal bulb at the end of metamorphosis are claimed to be released in membranous bodies into the mid-gut of the adult fly (Girolami, 1983). Thus it has been suggested that the oesophageal bulb acts as a type of feeder organ to replenish bacterial symbionts in the alimentary tract (Ratner and Stoffolano, 1982). Because the bacterial population in the oesophageal bulb is small and variable in Queensland Dacinae (Lloyd et al., 1986), it seems unlikely that this organ serves as a bacterial transmission site in these species. The effect of environmental conditions on survival of alimentary tract bacteria in pupae under field conditions has not been investigated.

4.4 Influence of Bacteria on Resource Foraging Behavior

The factors influencing tephritid foraging for plant resources have been discussed by Prokopy (1983) and Prokopy and Roitberg (1984). The marked increase in host plant attraction, one week after the first few flies arrived and began "working" within a host tree (Drew and Lloyd, 1987) may be vital to rapid host finding and may then reduce mortality due to exposure, predators and depletion of energy resources. Two hypotheses have been proposed for host plant odor attraction (Visser, 1986): (1) odors are highly specific and composed of chemicals not present in non-hosts and (2) odor specificity is achieved by a particular ratio of certain chemicals that are widespread among plant species. In addition, insect pheromones emitted within the host plant have been recognized as plant-associated attractants (Prokopy, 1983).

Here we propose a third possibility that some host plant attractants are produced by certain microorganisms colonizing the plant surface. In Tephritidae this involves specific bacteria introduced by the foraging flies onto the host fruit and possibly leaf surfaces. Research into host plant chemistry and associated microorganism emissions would be most valuable in our search for insect attractants. Also, a better understanding of how these factors influence the resource foraging process would provide an explanation of species distributions, seasonal abundance, host range changes and speciation.

Little is known about the role (if any) that bacteria play in competitive interactions between fruit fly species. There is evidence, however, that bacterial odors attractive at low concentrations may be repellent at high concentrations (Lloyd, unpublished data). This may account for the observed preference of female *Dacus* for oviposition sites on fruits free of larvae and the associated bacterial growth (Fitt, 1984). The existence of an oviposition deterring pheromone such as that found in *R. pomonella* (Averill and Prokopy, 1987; Prokopy, 1977b) has not been demonstrated in *Dacus* species. However, the characteristic proboscis exploring on the host fruit surface, that accompanies oviposition in *Dacus* species, also involves the distribution of bacteria. The possible marking function of this behavior is not known.

4.5 Influence of Physical Factors

The influence of the physical parameters, temperature, moisture and light, on the distribution and survival of fruit fly species has been widely studied (Bateman, 1972; Fletcher, 1987). However, the indirect effect that these factors may have on the bacterial component of fruit fly biology has not been considered. Bacteria introduced into the host tree become exposed to the environmental factors which normally influence growth and survival of plant saprophytes and pathogens (Last and Warren, 1972; Leben, 1981, 1988). Much is known about the effects of temperature, exposure to light, availability of moisture, competition and growth inhibitors on plant surface microorganisms (Last and Warren, 1972), but the influences of these factors on an insect-introduced microbial population has not been studied. It is possible that climatic factors which directly influence the growth of bacteria on the host plant may account for geographic distribution of insect species (Courtice and Drew, 1984). Further research in this area is warranted.

4.6 Speciation and Host Selection

Drew (1987) proposed that the odors emitted from bacteria on the host plant surface may play a role in the mating behaviour of a species and, in turn, influence the process of speciation. It is significant that for *Dacus* species the host tree with mature fruit attracts mostly sexually mature males and immature females. Males have different nutrient requirements and feed on different substrates to the females. Within the host tree there is probably a feeding attractant to the immature females and a sex attractant to the males. Courtship and mating occur within the tephritid host plants. Visser (1986) noted that when adults and larvae of phytophagous insects share the same food plant, it also serves as the rendezvous and copulation site. Host plant mating is vital to the maintenance of the species gene pool and the host plant odors probably serve as "Specific Mate Recognition Systems," proposed by Paterson (1985) as fundamental to speciation.

The possibility that bacteria associated with fruit flies may be involved in host race formation and speciation has been investigated with *R. pomonella* (Howard et al., 1985). Results showed that there was no clear-cut pattern to the distribution of *K. oxytoca* genotypes among seven *Rhagoletis* taxa, thus providing indirect evidence that the bacteria associated with *Rhagoletis* were not important determinants of host plant specificity. No such studies have been reported with other tephrited species.

5. THE IMPORTANCE OF FRUIT FLY ECOLOGY TO UNDERSTANDING INFESTATION AND PEST MANAGEMENT

The relevance of understanding the tephritid-bacteria-host plant relationships to the management of infestations cannot be over-emphasized. Because the host plant is the focal point of fruit fly behaviour, biological facets of this association must be manipulated in order to reduce population numbers.

There is great potential for the development of food baits based on bacterial emissions. Also, some of these chemicals produced by bacteria may act as repellents at high concentrations. Research on the influences of male pheromones released in the host plant during courtship needs to be performed. Ultimately male pheromones could be used as attractants or even for mating disruption as part of an integrated pest management program.

A knowledge of the basic interaction between fruit fly and host plant will also give valuable guidance in the application of management procedures. Understanding the population buildup in relation to fruit development and the daily pattern and location of adult feeding, will allow for a refined approach in the application of new control methods. This is particularly important in eradication programs. For instance, if the target species only feeds in host plants, then it is not only unsound environmentally to treat non-host vegetation, but also inefficient and wasteful of resources.

Eradication programs are generally applied against infestations that are introduced into non-endemic habitats, e.g., *D. tryoni* in southeastern Australia and *C. capitata* and Dacus species in California. In formulating such programs, the ecological factors which enable an introduced species to establish in a non-endemic area must be considered. The adaptive mechanisms involved in tephritid host shifts are, for the most part, poorly understood. In the case of *D. tryoni*, the bacteria - host plant interaction and subsequent provision of protein food in the form of introduced bacteria would be a limiting factor. Hence, the ability of species to establish in a new area may depend not only on availability of suitable hosts, but also on the ease with which a plant surface bacterial food supply can be established. It may be postulated that if flies were dependent on finding food on non-host plants then invasion of new localities would be less successful. Such an hypothesis may account for the case with which *D. tryoni*, originally endemic to the rain forests, spread south from Queensland into southeastern Australia in the early 19th century. As European settlements spread along the east coast, suitable host fruit trees such as peach and guava were introduced. It is possible that environmental conditions allowed the fruit fly-introduced bacteria to flourish in these host trees, thus providing adequate adult food and facilitating the southward spread of this pest.

With temperate-species of lower reproductive potential, such as *C. capitata* and *R. pomonella* which probably have a lower demand for protein (see Section 4.1), bacteria feeding may be more important for the larvae than for the adults. This may explain the observation that *R. pomonella* does not respond to hydrolyzed protein baits (Prokopy and Roitberg, 1984) whereas more tropical *Dacus* species are highly attracted to them. Further research is required to elucidate these aspects of host plant interaction and food resources in the temperate species.

6. SUMMARY AND CONCLUSION

Since Petri (1910) first described bacteria in *D. oleae*, there have been several studies of the bacteria associated with fruit flies, but it is only in recent years that research has been designed to investigate in detail the bacteria associated with the insect and its host tree. Many aspects of this tephritid - plant - bacteria interaction are still poorly understood. Studies with *Dacus* species in Queensland have elucidated the following aspects of this insect-bacteria relationship: (1) adult flies can utilize certain species of Enterobacteriaceae as a protein source; (2) adult flies introduce these bacteria onto fruit and leaf surfaces in the host tree by regurgitation of crop contents and proboscis foraging or exploring; (3) these bacteria in the host tree appear to provide a natural protein source which allows immature females to mature in the host tree; (4) the fruit surface bacteria are introduced into the host fruit during oviposition; (5) larvae develop in a "soup" of bacteria in the fruit, probably ingesting bacteria as an essential nutrient source; and (6) odors produced by these fruit fly-type *Enterobacteriaceae* are attractive to fruit flies and are believed to play a role in enhancing host attractancy.

The benefits to the fruit fly which arise from this interaction are evident, but the advantages to the bacteria are less apparent. The fruit fly provides protection; transport and probably nutrients for the bacteria, but details of the bacteria - plant interaction are largely unknown. Leachates from fruit tissue probably provide essential nutrients for surface bacterial growth, but plant defense systems (if they exist in this situation) could be detrimental to bacterial colonization. Environmental conditions which affect the survival of bacteria on plant surfaces also must play an important role. More research is needed to define these aspects of interaction between host plants and insect-introduced microorganisms.

Fruit flies are a world wide problem, involving expensive management and eradication programs in developed countries, huge crop losses in less developed countries and export limiting quarantine restrictions in many parts of the world. To improve management and eradication procedures a better understanding of the interaction between fruit flies and their bacteria and their host trees is essential. The urgent need to reduce excessiva pesticide application, particularly with food crops such as those attacked by fruit flies, emphasizes the need to develop IPM programs which minimize pesticide usage. Current knowledge of the fruit fly-bacteria-host plant interaction suggests a number of potential control strategies which could be included in such programs, e.g., protein baits incorporating live bacteria, synthetic lures based on bacteria-produced volatiles and application of bacteriacidal agents to inhibit bacterial food growth in the host plant. The possibilities that virus pathogens might be genetically engineered into essential fruit fly bacteria and that some bacterial odors may act as repellents should also be considered in future research planning.

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Chemistry of Fruit Flies: Composition of the Male Rectal Gland Secretions of some Species of South-East Asian Dacinae. Re-examination of *Dacus cucurbitae* (Melon Fly)

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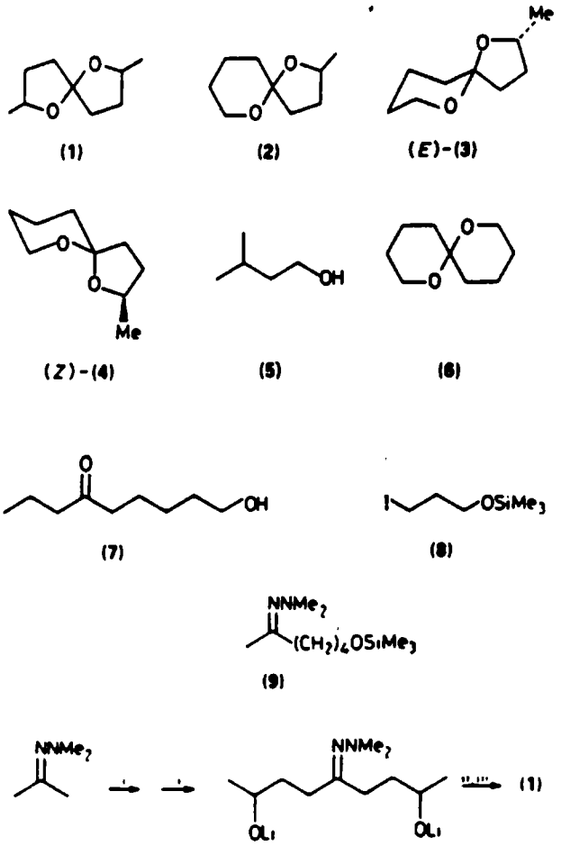
The major components of the rectal glandular secretions of male *Dacus* (*Bactrocera*) *umbrosus* (jack fruit fly), *D.* (*Bactrocera*) *nigrotibialis*, *D.* (*Bactrocera*) *albistrigatus*, *D.* (*Zeugodacus*) *tau* and *D.* (*Zeugodacus*) sp. (taxonomically similar to *D. tau*) have been identified. Alcohols, spiroacetals, and amides are the dominant components. The major component in the rectal gland secretion of *Dacus* (*Zeugodacus*) *cucurbitae* (melon fly) is shown to be ethyl 4-hydroxybenzoate and not 2-ethoxybenzoic acid.

In contrast to temperate species of fruit flies, which have a low capacity for dispersal and are monophagous or oligophagous, tropical Tephritidae have a high capacity for dispersal, and are usually polyphagous, with an expanding host range which exacerbates the problem of control.[1] Chemical cues regulate many phases of the biology of fruit flies, thus providing several points for chemical intervention and potential control.[1,2] With respect to mating, this is not simple, particularly among the tropical polyphagous species. In addition to pheromonal signals targeted at mate-searching females, there may be associated visual and/or other stimuli which should be considered in association with pheromone based methods for control or monitoring purposes. Nevertheless, the potential for pheromones to contribute to overall fruit fly monitoring and control in the Orient is substantial, and as a start in this general area, we have examined the rectal glandular components of a number of species that are of pest status in South East Asia.[3,4] (The male Tephritids store a pheromone in a reservoir and secrete it from a sac, both organs being located in the rectal region and appearing in the male about two days after the pupal–adult apolysis).[5,6]

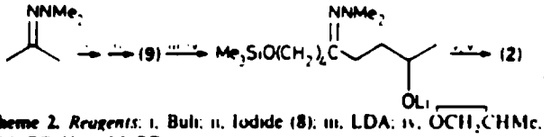
The species examined were *Dacus umbrosus* Fabricius, *D. tau* (Walker), *D. nigrotibialis* (Perkins), *D. albistrigatus* de Meijere and an undescribed *Dacus* (*Zeugodacus*) species. Clarification of the identity of the major component of the *D. cucurbitae* Coquillett secretion is also presented. The taxonomy of these species is presently being researched.[7]

Results and Discussion

Dacus umbrosus (*Jack-fruit Fly*).—The procedures for dissection and examination of glandular extracts have been described elsewhere.[8,9] *Dacus umbrosus* (jack-fruit fly) is widely distributed throughout Malaysia, Indonesia, Thailand, New Guinea, and the South-West Pacific areas,[4] and was reported as unique among Oriental and South Pacific *Dacus* species in being attracted to both male lures, methyl eugenol, and Cue-Lure.[10] The jack-fruit fly is, however, attracted to methyleugenol only, and infests various species of Artocarpus and has been bred from citrus and bread fruit.[11] GC–MS examination of the acetone extract of the rectal glandular secretion indicated that two isomeric compounds (26 and 18%) were the major components, with apparent M = 156, m : 141 ($M - CH_3$) and characteristic spiroacetal fragmentations.[12] Consideration was given to systems (1) and (2) below, with the latter being confirmed by synthesis of both systems by sequential epoxide alkylation of acetone-*N*,*N*-dimethylhydrazone (Schemes 1, 2). To the best of our knowledge, no isomer of (1) has been identified as a natural product.



Scheme 1. *Reagents*: i. OCH_2CHMe; ii. $MeCO_2H$; iii. $MgSO_4$, Amberlite IR-120(H)

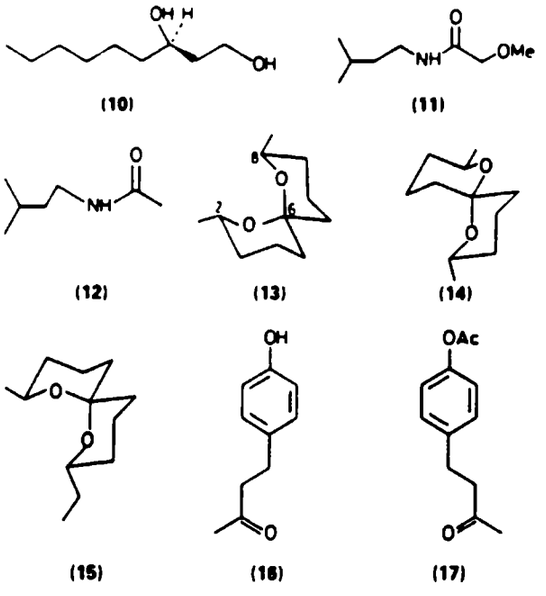


Scheme 2. *Reagents*: i, Bu^{n}Li; ii, Iodide (8); iii, LDA; iv, OCH_2CHMe; v, $MeCO_2H$; vi, $MgSO_4$ *etc*

The mass spectra of the diastereoisomers of (2) were identical with those reported by Francke,[12b] who established the presence of (2) in workers of *Paravespula vulgaris*, the common wasp.[13] Chiral gas chromatography, using a camphoratonickel(II) chelate as stationary phase,[14] of synthetic racemic (2), and of the natural product showed the latter to consist primarily of one enantiomer of each of the (*E*) and (*Z*) diastereoisomers of the 2-methyl-1,6-dioxaspiro[4.5]decanes. Use of (*S*)-(−)-propylene oxide in Scheme 2 provided the (2*S*) enantiometers of the (*E*) and (*Z*) diastereoisomers of (2), and chiral gas chromatography established that the natural spiroacetals were predominantly (85% e.e.) the (2*R*,5*S*) (*E*) and (2*R*,5*R*) (*Z*) stereoisomers, (3) and (4) respectively, *i.e.* epimeric at the spiro centre. 3-Methylbutanol (5) (10%) and 1,7-dioxaspiro[5.5]undecane (6) (14%) were also present, along with 6-oxononan-1-ol (7) the latter being the major constituent in *D. occipitalis* (Bezzi).[15] The chirality of (6) has not been determined, but if results from examination of female *D. oleae*[16] and male *D. cacuminatus*[15] [in which (6) is the dominant glandular component] are a guide, (6) is almost certainly racemic. Several other unidentified components were present at a very low level in the extract.

Dacus tau.—*Dacus tau* is widespread in South East Asia and is a severe pest of cucurbits,[3,4] and an edible species of *Eugenia* (lilly-pilly) is an important host plant for this fly.[11] The rectal glandular secretion of *D. tau* (collected in Malaysia) consisted largely of one component (80%), exhibiting highest m/z = 113 (30%) and 75 (100%) in the EIMS. This component was shown to be nonane-1,3-diol by comparison with an authentic sample,[8] and further shown to be the *R* (−) enantiomer (10) by chiral gas chromatography, using a cyclodextrin-based phase. This diol, with the same configuration, is a minor (~10%) component in *D. cucumis*.[8] Two other components were the unusual methoxymethyl amide (11) (10%) which had been identified previously as a component of *D. cucurbitae* by Baker[17] and Lewis,[9] and the amide (12) (~2%) which is found also in *D. cucurbitae*,[9,17] *D. tryon*,[9,18] *D. aquilonis*,[9] and *D. neohumeralis*.[9,18] Five unidentified components, each *ca.* 1% were also present.

Dacus nigrotibialis.—*Dacus nigrotibialis* is located throughout Malaysia, Thailand, and Laos but this species has not been reared, and its host preferences are undefined,[11] although *Coffea robusta* has been suggested as a significant host.[19] The extract of this fly is rich in (*E*,*E*)-2,8-dimethyl-1,7-dioxaspiro-[5.5]undecane (85%) which was shown to be enantiomerically pure by chiral gas chromatography, with the (2*S*,6*R*,8*S*) configuration (13), as already established for this component in *D. cucumis*.[8] Of particular interest was the absence of the (*E*,*Z*)-diastereoisomer of this system (14), requiring enantiospecific hydroxylation in the formation of the notional keto-diol precursor. The unusual[20] even carbon-numbered spiroacetal (15), 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane was also present (3%) and shown to be the (*E*,*E*) diastereoisomer as drawn in (15). This compound is present at a low level in other *Dacus* species, *e.g. D. halfordiae*,[8,15] *D. dorsalis*,[8] *D. latifrons*,[8] and *D. occipitalis*.[8] Enantiomers of (15) are currently being synthesized to permit chirality determination in the natural product. The 4-phenylbutanone derivative (16), structurally related to Cue-Lure (17), was a significant

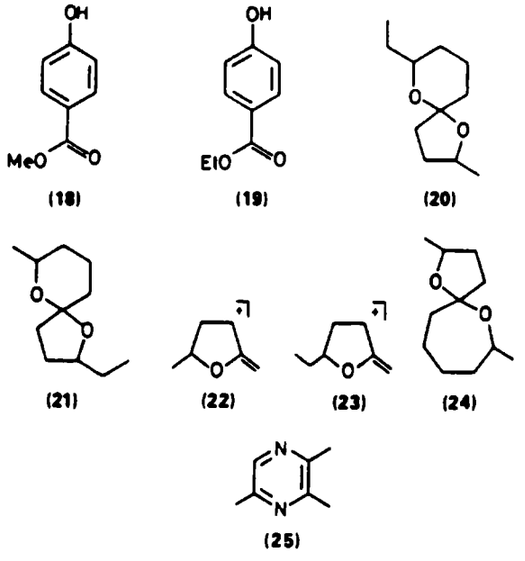


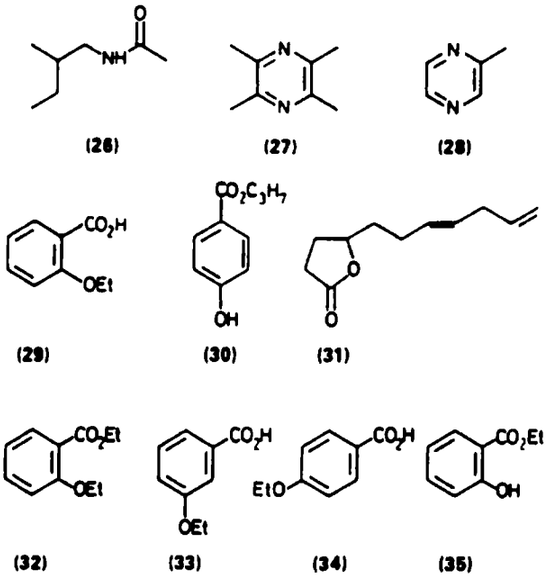
component (12%) but it is unclear whether this is a metabolite of (17), used as an attractant in the trapping of this species.

Dacus albistrigatus.—*Dacus albistrigatus* is distributed throughout Indonesia, Thailand, and Malaysia and is of minor pest status.[4] In Malaysia, the rain forest wild fruit *Terminalia catappa* is an important host, although in Indonesia specimens have been bred from guava.[11] (There is a possibility that the Indonesian variety is a sibling species.[11]) The acetone glandular extract was rich in methyl 4-hydroxybenzoate (18) identified by mass spectral comparisons with an authentic sample and fully discussed later. The (*E*,*E*)- and (*E*,*Z*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecanes (13) and (14), both of undetermined chirality were also present. [Note that the absolute configuration shown in (13) has been determined only for the (*E*,*E*) diastereoisomer in *D. nigrotibialus*.] The interesting point is that the *EE*:*EZ* ratio is 30:70, whereas in all other cases, the (*E*,*E*) diastereoisomer predominates, usually substantially.[21–23,8] This requires (on the assumption that a keto diol is involved biosynthetically) hydroxylation to occur predominantly with opposite chiralities at C_2 and C_8 along the undecane chain. However, there is little definite information on fruit-fly pheromone biosynthesis, and within a single species the 'pheromone blend' contains compounds that seem to require different biosynthetic routes.

Dacus (Zeugodacus) *sp.*—An undescribed, large *Dacus* (*Zeugodacus*) species was also collected in Malaysia and the major component (66%) of the acetone extract was ethyl 4-hydroxybenzoate (19) the mass spectral behaviour of which is discussed later. The pentane extract contained predominantly spiroacetals with (*E*,*E*) (13) (25%) (undetermined chirality) predominating along with the (*E*,*Z*) (14) (1%).

A significant component (8.6%) exhibited apparent M^+ = 184 (7%) with ions m/z = 169 ($M - CH_3$), 155 ($M - C_2H_5$), and other ions characteristic of the spiroacetal arrangements,[12] with the base peak m/z = 101. This component was suspected to be a diastereoisomer of 7-ethyl-2-methyl-1,6-dioxaspiro-[4.5]decane (20) and this was confirmed by the identity of the mass spectrum with the reported one,[12] and also with that of an independently synthesised sample.[24] The spiroacetal (20) is distinguished from its structural isomer 2-ethyl-7-methyl-1,6-dioxaspiro[4.5]decane (21) by the presence of the ion at m :





98, whereas (21) exhibits an ion at *m/z* 112. These ions are considered to be (22) and (23) respectively.[12] Only one diastereoisomer of (20) was detected. A very minor component (~1%), while apparently lacking a molecular ion in the low resolution mass spectrum, exhibited a fragmentation pattern again strongly suggestive of a spiroacetal structure.[12] Based on gas chromatographic behaviour etc. and an ion *m/z* 169, a molecular weight of 184 was considered likely, with *m/z* 169 being $M - CH_3$. Other features of the spectrum, *e.g.* unusually intense ions *m/z* 140 and 111 and a very weak or absent molecular ion, indicated spiroacetal (24), *i.e.* 2,7-dimethyl-1,6-dioxaspiro[4.6]undecane, and this was confirmed by essential identity with the spectrum displayed by Francke[25] and the listed spectrum of a sample prepared by Mori.[26] Diastereoisomers of (24) occur as minor components of the complex volatile secretion from the mandibular glands of *Andrena haemorrhoa* (Hym., Apoidea).[25] The pyrazine (25) (3%) (found also in *D. cucurbitae*)[9,17] occurred along with substantial levels of C_{16} and C_{18} fatty acids, as have been observed in other *Dacus* species.[13]

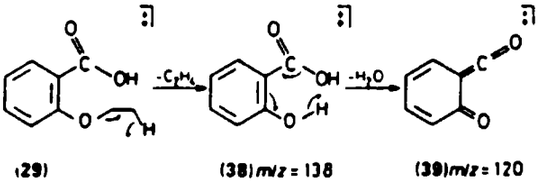
Dacus cucurbitae (*Melon fly*).—*Dacus cucurbitae*, the melon fly, is the major fruit-fly pest of melons and other cucurbits, and, world-wide, is one of the most active and destructive fruit-fly pests. The distribution range encompasses East Africa, South East Asia, Hawaii, and South Pacific Islands, but this species does not occur in Australia. Male melon flies are attracted to Cue-Lure (17) and thus monitoring of populations and infestations is possible. Several chemical studies of melon-fly populations have been published and another reported in thesis form. Baker, Herbert, and Lomer[17] studied the rectal glandular secretions of sexually mature male flies and showed that three amides were present, including the previously unreported 2-methoxy-*N*-3-methylbutylacetamide (11) along with (12) and (26). [(11) and (12) were shown above to be present in *D. tau.*] The pyrazines (25), (27), and (28) were reported, as well as ethyl esters of a number of fatty acids. However, the major component was concluded to be 2-ethoxybenzoic acid (29) (~4 μg insect), on the basis of comparison of mass spectral data of the natural product and an authentic sample.

Most of the conclusions arrived at by Baker were confirmed by Lewis[9] in a study of wild male melon flies collected in the Phillipines. However, the amide (26) and the pyrazine (28) were not observed in this latter study, whereas a very minor component was concluded tentatively to be propyl 4-hydroxybenzoate (30). This raised the question whether the major component, concluded by Baker to be (29), was possibly ethyl 4-hydroxybenzoate (19). This matter was not pursued by Lewis.[9]

Studies of 'volatiles' emitted by melon flies have also been conducted. Prior to mating, male melon flies emit a 'smoke' like substance[27,28] from erectile ampoules on their rectum and analysis of this 'smoke' by Ohinata[27] indicated large quantities of trisodium phosphate, together with the hydrocarbons pentacosane, heptacosane, and nonacosane and the unusual lactone (31). Amides were not detected in the 'smoke'. Baker and Bacon[29] examined the volatile secretion produced by *female* melon flies ('aeration technique') and the major component was identified as the amide (12) with minor amounts of the spiroacetals (13) and (14) of undetermined chirality.

Our recent examination of the rectal glandular secretion of male melon flies requires that the constitution of the major component be revised from (29)[17] to (19), *i.e.* ethyl 4-hydroxybenzoate. This conclusion is based primarily on mass spectral fragmentation behaviour[30–32] and also GC retention comparisons. Authentic (29) was acquired by basic hydrolysis of (32) which resulted from treating salicylic acid with diethyl sulphate.

2-Ethoxybenzoic acid (29), was characterised from its ^1H and ^{13}C NMR spectra which were fully consistent with the structure and in agreement with those in a ^{13}C NMR data file.[33] In a similar way, the *meta* and *para* analogues of (29), *i.e.* (33) and (34) were obtained. The ethyl esters of *ortho*-, *meta*-, and *para*-hydroxybenzoic acids, *i.e.* (35), (36), and (19), were obtained by treating the appropriate hydroxybenzoic acid with



Scheme 3.

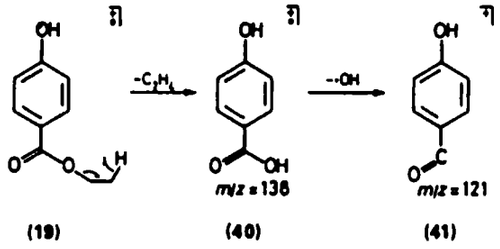
Table. Mass spectra (relative ion intensities) and relative retention times of hydroxybenzoic acid derivatives.

	(19)	(29)	(33)	(34)	(35)	(36)	(37)	(18)
m/z								
92	2.6	64	6.4	3.3	52.6	4.9	4.8	3.7
93	19.0	8.6	22.5	13.6	10.8	34.3	43.7	27.5
105(?)	—	4.8	—	—	—	—	—	—
120	—	*100*	4.7	—	*100.0*	—	—	—
121	*100.0*	14.0	65.3	*100*	27.7	*100*	*100*	*100*
138	23.0	2.5	*100.0*	63.7	2.5	25.5	—	—
151	2.5	17.9	—	—	—	5.5	—	—
152							47.6	33.0
166	18.8	14.5	54.9	44.3	34.0	34.5		
Relative retention time on SGE-BP5 column: 100 °C/min. Increase 16 °C/min.								
	1.71	1.76	1.55	1.65	1.00	1.62	1.44	1.53

ethanol and acid. The ^1H and ^{13}C NMR data were consistent with the structures and the ^{13}C spectra agreed with those in the ^{13}C NMR data file.[33,34]

The mass spectra of (29) and (19) are strikingly different. Compound (29) has its base peak at *m/z* = 120, which corresponds to $C_7H_4O_2$, *i.e.* (39) (Calc. for $C_7H_4O_2$: 120.0211. Observed 120.0210), which can be envisaged to arise by a double hydrogen transfer[30] (characteristic of *ortho* substituted systems) involving the ion (38) with *m/z* = 138 (3%) (Scheme 3).

In contrast, (19) exhibits the base peak at *m/z* = 121 which corresponds to (41). (Calc. for $C_7H_5O_2$: 121.0289. Observed 121.0284). Importantly, the mass spectrum of (19) lacks an ion at *m/z* = 120) (Scheme 4).



(19) (40) (41)

Scheme 4.

The mass spectra of (19) and its *meta* analogue (36) are similar in that both exhibit ions at *m/z* = 138, 121, and 93 but are, nevertheless, distinguishable on the basis of relative intensities (see Table). As noted above, ethyl salicylate (35) gives ion (39) (*i.e.*, *m/z* = 120) ('*ortho* effect') whereas the spectra of *meta*- and *para*-ethoxybenzoic acids (33) and (34), while somewhat similar to that of (19) (*i.e.* ions at 138, 121, and 93) are readily distinguished by relative intensities. The mass spectrum of the natural product is identical with that of (19).

This conclusion is supported by carefully measured retention times of non-derivatised samples on a non-polar capillary column (see Table). It should be noted that in *D. albistrigatus*, methyl 4-hydroxybenzoate (18) was a major component, and (19) is also present in the undescribed *Dacus* species alluded to above. There also seems little doubt that the minor component in *D. cucurbitae*, tentatively identified by Lewis[9] as propyl 4-hydroxybenzoate (30) is, in fact, (30),[30b] so that, in general, simple alkyl 4-hydroxybenzoates are the natural products, and these show some structural resemblance to the attractant Cue-Lure (17). However, care must be exercised with this analogy, as males of one of the major cucurbit-infesting flies in Southern Africa, *D. vertebratus* (taxonomically quite distinct from *D. cucurbitae*) are attracted[35] to methyl 4-hydroxybenzoate (18) (called Vert-lure), but not to Cue-Lure (17) or methyl eugenol (3,4-dimethoxyallylbenzene). In this region, Cue-Lure (17) does attract other economically important species, *e.g.* *D. brittatus*, *D. punctatifrons*, and *D. frontalis*.[35]

Most studies of glandular secretions and volatile emissions of male Tephritid fruit-flies have concerned relatively few species, most of which are of commercial pest status.[36a] Nevertheless, it is already clear there is considerable chemical diversity, and more varied biosynthetic routes appear to operate than for example in *Lepidopteran* species where the female utilises blends of similar compounds (to attract conspecific males) which are, in the main, of fatty acid origin. More extensive examination of fruit-fly species (some of which may not be serious pests) are warranted to define more precisely the chemistry and then biochemistry involved in the life-cycles of these insects, and possibly contribute also to taxonomic clarifications.[1,4] Chemical studies are continuing, and evaluations of the biological roles of certain components are being conducted.

Experimental

Spectra.—^1H NMR spectra were recorded at 400 MHz (FT mode) on a JEOL JNM-GX400 spectrometer, or in some cases at 60 MHz (CW mode) on a Varian EM360 spectrometer. Deuteriochloroform was employed as solvent, unless otherwise stated and chemical shifts (δ values) are relative to internal tetramethylsilane (0.0 ppm) or residual $CHCl_3$ (δ 7.24). ^{13}C NMR spectra were recorded at 100 MHz, utilising deuteriochloroform as solvent and chemical shifts are relative to the central component of the $CDCl_3$ triplet at 77.00 ppm, unless otherwise stated. Low resolution mass spectra refer to combined GC-MS measurements, recorded on a Finnegan Mat 1020 GC-MS system. High resolution mass spectra were recorded on a Kratos MS25-instrument. Optical rotations were recorded using a Perkin-Elmer 141 MC polarimeter. Preparative gas chromatography was performed using a Shimadzu gas chromatograph model GC-9A equipped with an OV101 column. Chiral gas chromatographic analyses were performed using either a 40 metre glass capillary column with hexakis (3-*O*-acetyl-2,6-di-*O*-pentyl)-α-cyclodextrin as the stationary phase or a 25 m bis(3-heptafluorobutyryl-(*R*)-camphorate)-nickel(II)/OV-1 fused silica column.

Isolation and Combined Gas Chromatography–Mass Spectrometry.—The flies were trapped in the field in the Gombok Rain Forest, Malaysia, using lure-baited traps. Cue-Lure attracted *Dacus tau*, *nigrotibialis*, *Zeugodacus* and methyleugenol attracted *D. umbrosus*. The *D. cucurbitae* were field collected (using Cue-Lure) in the Philippines. The design of the traps was such that the flies could not feed on the attractant. The flies were snap-frozen and stored in an ultra deep freeze (−80 °C) and then transported to Australia in dry ice and stored at −80 °C until dissection. The rectal glands were excised and extracted into acetone and in some cases, pentane.[8,9] Combined GC-MS examinations were performed using a Finnegan Mat 1020, employing a non-polar column.

Synthesis of Compounds

2,7-Dimethyl-1,6-dioxaspiro[4.4]nonane (1).—To a stirred solution of acetone-*N*,*N*-dimethylhydrazone[37] (1.95 g, 19.5 mmol) in dry THF (25 ml) (N_2 atmosphere; −78 °C) was added dropwise a solution of butyl-lithium in hexane (12.6 ml, 20.4 mmol). On completion of addition, the reaction mixture was stirred for 1 h, during which time a white solid formed

Propylene oxide (1.2 g, 20.7 mmol) in THF (5 ml) was then added to the cooled (−78 °C) solution, after which the reaction mixture was slowly brought to room temperature (20 °C) and then stirred overnight. The reaction mixture was recooled to −78 °C and again treated with butyl-lithium (13.0 ml, 20.8 mmol) after which warming to room temperature occurred. After being stirred for 4 h at this temperature, the recooled solution (−78 °C) was treated dropwise with propylene oxide (1.25 g, 21.5 mmol) in THF (5 ml) and allowed to warm to 20 °C; it was then stirred overnight.

This mixture was neutralised with glacial acetic acid (2.4 g, 40 mmol) and filtered to remove the precipitated lithium acetate; the latter was then rinsed with dry THF. The filtrate, Amberlite IR-120(H) ion exchange resin (29 g), and anhydrous $MgSO_4$ (20 g) were stirred and refluxed for 5 h, the reaction being monitored by GLC. The reaction mixture was filtered and the THF removed (rotary evaporator) to yield an oil which was extracted into methylene dichloride. This organic phase was washed with saturated aqueous sodium carbonate and water, separated, dried ($MgSO_4$), and evaporated to yield a volatile oil (1.6 g; 52%). Final purification by preparative GC yielded the compound as a diastereoisomeric mixture (*EE*:*EZ*:*ZZ* = 30:50:20) (Found: C, 68.4; H, 10.55. $C_9H_{16}O_2$ requires C, 69.19; H, 10.32); δ_C(100 MHz) (*E*,*E*): 21.10, 32.17, 35.82, 73.87 or 74.04, and 114.91; (*E*,*Z*): 21.32, 22.75 or 22.72, 31.84, 32.64, 35.38, 36.85, 73.87 or 74.04, 75.77, and 114.76; (*Z*,*Z*): 22.72 or 22.75, 32.56, 36.62, 75.79, and 114.53; δ_H(400 MHz) (mixture of *E*,*E*, *E*,*Z*, and *Z*,*Z*): 1.16 (d, 6.0 Hz, CH_3, *E*,*E* 6 H or *E*,*Z* 3 H), 1.18 (d, 6.0 Hz, *E*,*E* 6 H or *E*,*Z* 3 H, CH_3), 1.25 (d, 6.0 Hz, *E*,*Z* 3 H, CH_3), 1.27 (d, 6.0 Hz, *Z*,*Z* 6 H, CH_3), 1.36–2.14 (m, 24 H, CH_2, *E*,*E*, *E*,*Z*, *Z*,*Z*), 4.0–4.34 (m, 6 H, CH–O, *E*,*E*, *E*,*Z*, *Z*,*Z*); *m*/*z* (*EZ*) 156 (M^+, 5.4%), 141 (15.8), 112 (33.1), 101 (100), 100 (20.1), 85 (39.5), 83 (42.9), 56 (36.8), and 55 (31.0); *m*/*z* (*ZZ*) 156 (M^+, 7.2%), 141 (16.2), 112 (34.3), 101 (100), 100 (20.9), 85 (44.3), 83 (43.9), 56 (42.7), and 55 (32.3); *m*/*z* (*EE*) 156 (M^+, 4.0%), 141 (13.2), 101 (100), 100 (19.4), 85 (35.6), 83 (43.9), 56 (37.4), and 55 (39.8) (Found: M^+, 156.1148. $C_9H_{16}O_2$ requires *M*, 156.1150).

1-*Iodo*-3-*trimethylsiloxypropane* (8).—To a stirred solution of 3-bromopropanol (7.0 g, 50 mmol) and 2,6-lutidine (5.89 g, 55 mmol) in carbon tetrachloride (90 ml) at 0 °C, was added chlorotrimethylsilane (7.0 ml, 55 mol). This solution was stirred at room temperature for 3 h and then filtered through basic alumina/Celite (1:1). Solvent was removed (rotary evaporator) and the resulting oil was distilled (60 °C/8 mmHg) to provide 1-bromo-3-trimethylsiloxypropane (6.73 g, 64%). This product was added dropwise to sodium iodide (5.26 g, 35 mmol) in dry acetone and the mixture stirred for 3 h after which time it was filtered (basic alumina) and then distilled (65 °C/5 mmHg) to give the title compound (8) (5.16 g, 62%), δ_C −0.54, 3.33, 35.93, and 61.75; δ_H 0.08 (s, 9 H, $SiCH_3$), 1.95 (p, 6.3 Hz, 2 H, $CH_2CH_2CH_2$), 3.22 (t, 6.7 Hz, 2 H, CH_2I), and 3.59 (t, 5.9 Hz, 2 H, CH_2O).

6-*Trimethylsiloxyhexan*-2-*one Dimethylhydrazone* (9).—To the lithium derivative of acetone *N*,*N*-dimethylhydrazone[37] (1.0 g, 10 mmol) generated with butyl-lithium (4.4 ml; 11 mmol) in the manner described above, was added 1-iodo-3-trimethylsiloxypropane (8) (2.6 g, 10 mmol) in THF (5 ml), and the reaction mixture was allowed to warm to room temperature; it was then stirred overnight. The reaction mixture was then diluted with ether–hexane (1:1), filtered through basic alumina, and evaporated to provide an oil which was distilled (65 °C/0.3 mmHg) to give the title compound (1.54 g, 67%); δ_C (major isomer) −0.69, 16.17, 23.12, 32.02, 38.49, 46.78, 62.07, and 167.37; δ_H −0.04 (s, $SiCH_3$), 1.40 (m, 4 H), 1.80 (s, 3 H, CH_3), 2.06 (m, 2 H), 2.28 (s, 6 H, NMe_2), and 3.44 (m, 2 H); *m* *z* 230 (M^+, 16.9), 186 (8.6), 172 (10.4), 171 (25.2), 147 (11.2), 129 (8.7), 113 (13.1), 103 (13.4), 100 (30.8), 98 (21.7), 83 (10.9), 75 (53.5), 73 (100), and 60 (61.6) (Found: M^+, 230.1822. $C_{11}H_{26}N_2OSi$ requires M^+, 230.1814).

2-*Methyl*-1,6-*dioxaspiro*[4.5]*decane* (2).—To a solution of lithium di-isopropylamide (prepared from butyl-lithium [2.5M solution; 2.2 ml, 5.5 mmol] and di-isopropylamine (0.5 g, 4.9 mmol) in dry THF (20 ml) (at −78 °C) with an argon atmosphere] was added 6-trimethylsiloxyhexan-2-one dimethylhydrazone (9) (0.7 g, 3 mmol) in THF (5 ml); the reaction mixture was then maintained at 0 °C for 3 h after which it was recooled to −78 °C. Propylene oxide (0.6 g, 10 mmol) was then added dropwise after which the mixture was allowed to slowly warm to room temperature when it was stirred overnight. Acetic acid (0.6 g, 10 mmol) was added to the mixture and the precipitated lithium acetate was removed by filtration through Supercell; the filtrate was then stirred and refluxed with anhydrous $MgSO_4$ (5 g) and Amberlite IR-120(H) (3.5 g) for 5 h.[38] This mixture was worked-up in the manner detailed previously and the resulting oil was distilled (120 °C/100 mmHg) to provide (2) (0.3 g, 64%) as a mixture of *E*- and *Z*-diastereoisomers (62:38); δ_C (*E*-isomer) 20.20, 21.16, 25.21, 31.31, 34.13, 37.66, 61.49, 73.92, and 105.75; (*Z*-isomer) 20.26, 23.07, 25.30, 31.62, 33.98, 38.90, 61.35, 76.65, and 105.55; δ_H 1.18 [d, 6.3 Hz, 3 H, CH_3(*E*)], 1.25 [d, 6.1 Hz, 3 H, CH_3(*Z*)], 1.3–2.1 (m, 20 H, ring CH_2), 3.52 (m, 2 H), 3.79 [t of d, 11.3, 3.0 Hz, 1 H, 7-H (axial) (*E*)], 3.86 [t of d, 11.5, 3.0 Hz, 1 H, 7-H axial (*Z*)], and 4.16 (m, 2 H); *m*/*z* (*E*-isomer) 156 (M^+, 5%), 141 (3.3), 128 (4.6), 112 (12.9), 111 (11.9), 101 (100), 100 (33.5), 98 (46.36), 83 (41.5), 56 (31.9), 55 (49.8), and 43 (38.9); *m*/*z* (*Z*-*isomer*) 156 (M^+, 6.2), 141 (3.6), 128 (4.8), 112 (10.3), 111 (10.7), 98 (41.7), 83 (39.8), 56 (31.6), 55 (50.1), and 43 (37) (Found: M^+, 156.1139. $C_9H_{16}O_2$ requires M^+, 156.1150).

(2*S*,5*RS*)-2-*Methyl*-1,6-*dioxaspiro*[4.5]*decane* (3) *and* (4).—The procedure employed was identical with that for the racemic material except that (*S*)-(−)-propylene oxide (Aldrich Chemical Co.) was used. The product exhibited spectroscopic properties identical with those obtained for the racemate and had $[\alpha]_D^{20} = -10.5°$ (*c* 3.3, methanol). Chiral gas chromatography established e.e. = 98% (lit.,[39] $[\alpha]_D^{20} = -10.2°$, e.e. = 95.2%, *E*/*Z* = 65:35).

2-*Methoxy*-N-3-*methylbutylacetamide* (11).[17]—To a cooled solution (0 °C) of triethylamine (3.03 g, 30 mmol) in dry ether (30 ml) was added dropwise chloroacetyl chloride (2.82 g, 25 mmol) in dry ether (30 ml). A white precipitate formed. 3-Methylbutylamine (2.63 g, 30 mmol) in dry ether (30 ml) was added dropwise to the mixture, which was then warmed to 20 °C and stirred overnight. The reaction mixture was washed with water (100 ml) and separated, and the organic phase was dried ($MgSO_4$) and evaporated to provide 2-chloro-*N*-3-methylbutylacetamide (1.2 g, 30%); δ_C 22.23, 25.69, 37.81, 38.33, 42.43, and 169.94. This material (1.0 g, 6.1 mmol; crude) in dry ether (20 ml) was added dropwise to a stirred solution of sodium methoxide (from 0.5 g of sodium in dry methanol). The reaction was monitored by GC and after 2 days at *ca.* 20 °C the mixture was diluted with water and the methanol/ether removed (rotary evaporator). The residue was extracted with ether (2 × 50 ml) and the extract dried ($MgSO_4$) and evaporated to yield 2-methoxy-*N*-3-methylbutylacetamide (11) (0.5 g, 51%); δ_C 22.13, 25.53, 36.78, 38.16, 58.83, 71.74, and 169.06; δ_H: 0.78 (d, 6.7, 6 H, Pr^i), 1.28 (q, 7.0 Hz, 2 H, $CHCH_2CH_3$), 1.49 (m, 1 H), 3.17 (q, 6.5 Hz, 2 H, CH_2N), 3.27 (s, 3 H, OCH_3), 3.73 (s, 2 H, CH_2O), and 6.45 (br s, 1 H, NH); *m* *z* 159 (M^+, 2.3), 129 (27.6), 114 (18.4), 103 (19.5), 102 (18.0), 73 (27.5), 71 (49.12), 55 (13.3), 45 (88.64), 44 (22.6), and 43 (100).

Methyl 3-Hydroxybenzoate (37).—This compound was prepared from 3-hydroxybenzoic acid and BF_3·MeOH (20%) in anhydrous methanol. It was recrystallised from benzene–hexane, m.p. 68 °C;[34] δ_C 52.48, 116.47, 120.61, 121.77, 129.76, 131.14, 156.21, and 167.89; δ_H 3.90 (s, 3 H, OMe), 7.09 (ddd, *J* 8, 2.5, 1.0, 4-H), 7.28 (s, OH), 7.28 (t, *J* 8, 5-H), 7.57 (dt, *J* 8, 1.4, 6-H), and 7.61 (m, br, H_2); *m/z* 152 (M^+, 47.6), 121 (100), 93 (43.7), 65 (30.7), and 39 (38.5).

Methyl 4-Hydroxybenzoate (18).—This compound was available as a commercial sample;[34] *m/z* 152 (M^+, 33.0), 121 (100), 93 (27.5), 65 (27.7), and 39 (26.4).

Ethyl 3- and 4-Hydroxybenzoates (36) *and* (19).—To either of the hydroxybenzoic acids (2.75, 20 mmol) in ethanol (50 ml) was added concentrated H_2SO_4 (2 drops) and the mixture was refluxed overnight. After neutralisation with aqueous $NaHCO_3$, the ethanol was removed (rotary evaporator) and on cooling, the ethyl esters crystallised from solution.

Ethyl 4-hydroxybenzoate (19). M.p. 116–117;[34] δ_C($CDCl_3$/DMSO) 13.01, 58.70, 114.10, 118.87, 130.06, 161.59, and 164.85; δ_H(60 MHz) ($CDCl_3$/DMSO) 1.4 (t, *J* 6, CH_3), 4.33 (q, *J* 6, CH_2O), 6.83 (d, *J* 8, 3-, 5-H), 7.87 (d, *J* 8, 2-, 6-H), 7.95 (s, OH); *m/z* 166 (M^+, 18.8), 138 (23.0), 121 (100), 93 (19.0), 65 (22.5), and 39 (21.2) (Found: 121.0284. $C_7H_5O_2$ requires 121.0289).

Ethyl 3-hydroxybenzoate (36). M.p. 72–73 °C;[34] δ_C 14.08, 61.45, 116.34, 120.43, 121.56, 129.60, 131.32, 156.14, and 167.37; δ_H(60 MHz) 1.4 (t, 6 Hz, CH_3), 4.36 (q, 6 Hz, CH_2O), and 6.95–7.66 (m, 4 H, aromatic H); 166 (M^+, 34.5), 138 (25.5), 121 (100), 93 (34.3), 65 (25.0), and 39 (34.5).

Ethyl 2-hydroxybenzoate (ethyl salicylate) (35). This compound was available as a commercial sample;[34] *m/z* 166 (M^+, 34.0), 138 (2.5), 121 (27.7), 120 (100), 93 (10.8), 92 (52.6), 65 (19.5), and 39 (24.9).

2,3- *and* 4-*Ethoxybenzoic Acids* (29), (33), *and* (34).—Each of the 2-, 3-, and 4-hydroxybenzoic acids (2.75 g, 20 mmol), NaOH (2.4 g, 60 mmol), diethyl sulphate (9.24, g, 60 mmol), and benzyltriethylammonium chloride (0.7 g) in a dichloromethane (50 ml)–water (50 ml) were stirred at 20 °C for 40 h. The organic layer was separated and the water layer extracted with dichloromethane (2 × 20 ml). The organic layers were then combined and evaporated and the residue was taken up in ether (50 ml). This solution was washed with aqueous ammonia (30 ml) and 10% aqueous NaOH, dried ($MgSO_4$), and evaporated.

The crude ethyl ethoxybenzoates were stirred with 10% aqueous NaOH for *ca.* 2 days after which time the basic solutions were washed with ether (2 × 50 ml) and acidified with HCl. The precipitated acids were collected by filtration although for 2-ethoxybenzoic acid (29) (m.p. 19 °C), the product was extracted into ether, and the extract dried ($MgSO_4$), and evaporated.

2-Ethoxybenzoic acid (29). M.p. 19 °C,[34] b.p. 170 °C/0.1 mmHg; δ_C 14.38, 65.77, 112.59, 118.98, 121.79, 133.28, 134.85, 157.41, and 165.96; δ_H(60 MHz) 1.53 (t, *J* 6 Hz, CH_3), 4.35 (q, *J* 6 Hz, CH_2O), 6.95–8.27 (m, 4 H, ArH), and 9.33 (br s, OH); *m/z* 166 (M^+, 14.5), 151 (17.9), 121 (14.0), 120 (100), 93 (8.6), 92 (64), 65 (15.3), 64 (16.1), 63 (12.1), and 39 (22.5).

3-Ethoxybenzoic acid (33). M.p. 137–138 °C;[34] δ_C($CDCl_3$/DMSO) 13.99, 62.80, 114.12, 118.78, 121.18, 128.55, 131.48, 158.06, and 167.50; δ_H 60 MHz ($CDCl_3$/DMSO) 1.27 (t, 6 Hz, CH_3), 3.93 (q, 6 Hz, CH_2O), 6.83–7.67 (m, ArH and OH); *m/z* 166 (M^+, 54.9), 138 (100), 121 (65.3), 93 (22.5), 65 (26.9), 64 (10.6), 53 (10.24), 43 (14.5), and 39 (25.1).

4-Ethoxybenzoic acid (34). M.p. 198–199 °C;[34] δ_C($CDCl_3$, DMSO) 13.84, 62.78, 113.12, 122.18, 130.83, 161.69, and 167.26; δ_H(60 MHz) ($CDCl_3$/DMSO) 1.30 (t, 6 Hz, CH_3), 4.06 (q, 6 Hz, CH_2O), 6.8 (d, 9 Hz, 3-, 5-H), 7.87 (d, 9 Hz, 2-, 6-H); *m/z* 166 (M^+, 44.2), 138 (63.7), 121 (100), 93 (13.6), 65 (21.1), and 39 (21.2).

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CHEMICAL STUDIES OF THE RECTAL GLAND SECRETIONS OF SOME SPECIES OF THE *BACTROCERA DORSALIS* COMPLEX OF FRUIT-FLIES (DIPTERA: TEPHRITIDAE)

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ABSTRACT: Male-produced rectal gland secretions of a number of species now considered to be members of the *Bactrocera dorsalis* complex of fruit-flies, have been examined by combined gas chromatography-mass spectrometry. The structures of a number of previously unreported compounds have been confirmed by synthesis and chromatographic comparisons. Compounds identified in these secretions include fatty acids, esters, amides, keto alcohols, diols and spiroacetals. The significance of these findings in relation to taxonomic revisions is discussed.

Key words - Bactrocera dorsalis, Bactrocera occipitalis, Diptera, Tephritidae, male pheromone, spiroacetal, ketoalcohol.

INTRODUCTION

The *dorsalis* complex of fruit-flies comprises a large number of species bearing a taxonomic resemblance to *Bactrocera*[#] *dorsalis* (Hendel), and many are major pests of a wide variety of fruit and vegetable crops. Members of the complex extend throughout Asia, the Oceanian region and into Australia. The taxonomy of this complex is being reviewed (Drew, unpublished) and the differentiation of close species has been greatly facilitated by techniques such as electron microscopy and tissue enzyme analysis in addition to morphological and biological data. In a number of cases, species within the complex have been incorrectly identified. Consequently distribution and host records have been wrongly attributed, and some species declared as pests have no economic significance, and more restricted distributions.

B. dorsalis, a member of the complex, is restricted in habitat from India to southern China, Taiwan and Hawaii, and is not as widespread as previously reported (Drew 1982). *B. occipitalis* (Bezzi) was originally described from the Philippines and later recorded as widespread over South-East Asia (Hardy 1974). It is in fact, confined to the Philippines. Three sibling species, in the past confused with *B. dorsalis* or *B. occipitalis*, occur in the Philippines and Malaysia, but these species have not, as yet, been assigned scientific names. These will be referred to as Malaysian A (Mal A), Malaysian B (Mal B) and Philippine B (Phil B). Mal B and Phil B closely resemble *B. dorsalis* while Mal A resembles *B. occipitalis*. The major purpose of this work was to characterise chemically the volatile components of the glandular secretions of these species and thus possibly support any taxonomic revisions, as well as to extend the pheromone profile of these economically important Tephritidae.

[#] Bactrocera is the new genus name applied, in the general taxanomical revision (Drew 1989), to a large number of fruit fly species previously classified in the Dacus genus

METHODS AND MATERIALS

Bactrocera dorsalis specimens from the USDA culture, Honolulu, Hawaii were air-freighted to Brisbane in dry-ice. Mal A, Mal B and Phil B specimens were trapped in the field in Malaysia and the Philippines, using male lure traps. The traps were designed to prevent the attracted flies from feeding on the lures, and to maintain the flies in a live condition until freezing. The flies were snap-frozen and stored in an ultra low deep freeze (-80°C) and transported in dry-ice to Australia and stored at -80°C until dissection.

Gland Secretion Analysis and Identification

The rectal glands of sexually mature adult male flies were excised and extracted into acetone and/or pentane as described earlier (Kitching 1989). Combined GC-MS examinations were performed using a Finnegan Mat 1020 or Hewlett Packard HP5992 instrument, employing a non-polar column. Low-resolution mass spectra refer to combined GC-MS measurements, and high resolution mass spectra were recorded on a Kratos MS-25RFA spectrometer.

Proton magnetic resonance spectra were recorded at 400 MHz (FT mode) on a JEOL JNM-GX400 spectrometer, or in some cases at 60 MHz (CW mode) on a JEOL PS100 spectrometer. Deuterochloroform was employed as solvent and chemical shifts (δ values) are relative to internal tetramethyl silane (0.0 ppm) or residual $CHCl_3$ (δ 7.24). ^{13}C nmr spectra were recorded at 100 MHz, utilising $CDCl_3$ as solvent and chemical shifts are relative to the central component of the $CDCl_3$ triplet at 77.00 ppm.

Synthesis of Certain Glandular Components (See Schemes 1,2)

6-Oxo-1-nonanol. The Grignard reagent, from n-propyl bromide (21.4 g) and magnesium turnings (4 g) in ether (50 ml), was cooled to 0°C, and cyclohexanone (17 g) in ether (50 ml) was added at such a rate that the temperature did not rise above 5°C. This mixture was stirred overnight and then poured onto ice and dilute sulphuric acid (15%) was added to dissolve the magnesium salts. The ether layer was separated, and the aqueous layer was extracted with ether (2 x 50 ml), and the combined ether fractions were dried ($MgSO_4$) and evaporated to yield an oil. This was fractionally distilled to provide the required tertiary alcohol, 6.5 g. (B.P. 76-82/12 mm). ^{13}C nmr: 14.5, 16.0, 22.1 (2C), 25.7, 37.2 (2C), 44.7, 71.2. This alcohol (6.5 g) was placed in a distillation flask with finely powdered $KHSO_4$ (6.5 g) and the mixture was stirred and heated at 120°C for thirty minutes followed by thirty minutes heating at 160-170°C. During this time, water and the product distilled, with the latter purified by passing down a short (2 x 1 inch) silica column and eluting with hexane. The alkene obtained was a 4:1 mixture of the desired 1-propyl-1-cyclohexene (endo-dehydration) and the alternative exo-alkene. These alkenes were characterised by their ^{13}C nmr and mass spectra. 1-Propyl-1-cyclohexene: ^{13}C nmr: 13.8, 20.9, 22.7, 23.1, 25.3, 28.3, 40.3, 120.7, 137.8. Mass spectrum: M^+ 124 (34), 95 (33), 82 (62), 81 (100), 79 (26), 77 (13), 68 (19), 67 (63), 65 (10). Exo-alkene: 14.8, 20.4, 27.1, 27.9, 28.6, 28.8, 37.2, 123.2, 138.9. Mass spectrum: M^+ 124 (34), 95 (32), 82 (62), 81 (74), 79 (22), 77 (12), 68 (24), 67 (100).

The above alkene mixture (4:1, 0.5 g) was dissolved in dichloromethane (50 ml) and *m*-chloroperbenzoic acid (1.2 g) was added, while stirring with 0.5 M sodium bicarbonate solution (20 ml). After *ca* three hours, the layers were separated and washed with 10% KOH solution (2 x 20 ml) and then H_2O (4 x 20 ml). The dried ($MgSO_4$) organic layer was evaporated to yield a clear oil. These mixed epoxides (2.0 g) were not purified but were added to a solution of periodic acid

(4.88 g) in dry ether (400 ml) and after *ca* 1 hour, the desired ketoaldehyde, 6-oxononanal, was the predominant product (>80% by gc). The filtered reaction solution was washed with H_2O, 10% $NaHCO_3$, H_2O again and then dried and evaporated. The desired 6-oxo-nononal showed the aldehydic proton in the ^1H nmr spectrum at δ 9.80 (narrow triplet). ^{13}C nmr: 13.7 (CH_3), 17.3, 21.6, 23.1, 42.3, 43.7, 44.8, 202.2 (CHO) and 210.7 (>=O). Mass Spectrum: M^+ 156 (4), 128 (8), 113 (15), 112 (7), 99 (8), 95 (23), 87 (5), 86 (19), 85 (17), 71 (76), 67 (55), 58 (24), 57 (18), 55 (15), 43 (100). Very careful reduction with $NaBH_4$ in ethanol (~0°C) (provided 6-oxo-1-nonanol as a clear oil with very slight contamination with 1,6-nonanediol from reduction of both carbonyl functions. *6-Oxo-1-nonanol*: Mass spectrum: M^+ 158 (2), 140 (5), 115 (14), 112 (5), 99 (6), 97 (30), 86 (32), 79 (8), 73 (12), 71 (68), 70 (9), 69 (58), 67 (6), 58 (48), 57 (10), 55 (36), 43 (100). ^{13}C nmr: 13.7, 17.3, 23.4, 25.4, 32.4, 42.7, 44.8, 62.5, 211.8. ^1H nmr: 0.84 (3H, t of d, J = 7.3 Hz, 1.7 Hz, CH_3), 1.29-2.35 (12H, m), 2.56 (1H, br OH), 3.56 (2H, t of d, J = 6.6, 2.0 Hz, $\underline{CH_2}OH$). (This compound correlated well (0.994) with the natural product on mass spectral comparison).

1,6-Nonanediol resulted from reduction of both carbonyl functions of the intermediate 6-oxononanal. Mass spectrum: M^+ 160 (0), 117 (14), 99 (34), 81 (64), 73 (41), 71 (125), 70 (19), 57 (37), 55 (100). ^{13}C nmr: 14.1, 18.8, 25.4, 25.8, 32.6, 37.3, 39.7, 62.5, 71.5. ^1H nmr: 0.92 (3H, t, 7 Hz, CH_3), 1.25-1.52 (10H, M), 1.58 (2H, m), 3.58 (5H, m including -OH).

The above synthesised samples of 6-oxo-1-nonanol and 1,6-nonane-diol were identical with samples synthesised by a completely different route (O'Shea 1989).

2-Ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane:

5-Oxo-9-decenal was acquired in a manner analogous to that described above for 6-oxo-1-nonanol except that cyclopentanone was reacted with the Grignard reagent from 5-bromo-1-pentene in the first step. The details of this synthesis have been desribed elsewhere (Nishiyama 1989). The Grignard reagent (ether) from ethylbromide (0.55 g) was added dropwise to a solution of 5-oxo-9-decenal (~1 g) in ether at -50°C and the solution allowed to warm slowly (3 hrs) to room temperature. The reaction mixture was poured onto ice and 5% H_2SO_4 was added to dissolve salts. The ether layer was separated, washed (with H_2O), dried and evaporated. GC-MS examination showed two major components, the first eluting being unreacted ketoaldehyde and a longer retention time component appearing as a broad peak. Chromatography on silica (hexane/ether, 3:1) provided fractions rich (~80%) in the presumed unsaturated ketoalcohol resulting from predominant Grignard addition to the aldehyde function. That selective Grignard addition to the aldehyde carbonyl had occurred was shown by the ^{13}C nmr spectrum of the purified alcohol which retained the ketonic carbonyl at 210.6 ppm and revealed a signal in the ^{1}H nmr spectrum at δ 3.60 (1H, quintet), appropriate for the desired 7-oxo-11-dodecene-3-ol. ^{1}H nmr: δ 1.0 (3H, t, J = 7 Hz, CH_3), 1.1-2.7 (15H. m, CH_2). 3.60 (1H, q, J = 7 Hz, >*CH*OH), 5.1 (2H, m), 5.8 (1H, m). (This sample was contaminated slightly with unreacted ketoaldehyde). ^{13}C nmr: 9.9, 19.7, 22.8, 30.2, 33.1, 36.3, 41.9, 42.6, 72.8, 115.4, 137.7, 210.6. (These chemical shifts are consistent with the overwhelming predominance of the open chain hydroxyketone form). Mass Spectrum: M^+ 198(O), 180 (13), 126 (49), 111 (13), 97 (34), 84 (33), 83 (30), 81 (10), 79 (10), 70 (18), 69 (34), 68 (60), 67 (16), 57 (18), 55 (100).

Alternative Synthesis of 7-Oxo-11-dodecene-3-ol: Diethyl 3-oxo-glutarate was alkylated with 4-bromo-1-butene in the manner described (Nasoshima 1984) to yield diethyl-2-(but-3'-ene)-3-oxoglutarate in *ca* 75% yield after chromatography on silica, eluting with hexane-ether, 4:1. Mass Spectrum: M^+

256 (0), 211 (M-C_2H_5, 3), 156 (36), 128 (31), 123 (15), 101 (22), 95 (14), 73 (20), 55 (40), 29 (100). ^{13}C nmr: 14.1 (2C), 27.0, 31.3, 48.4, 58.0, 61.5, 61.6, 116.0, 137.0, 166.7, 169.1, 197.5. ^{1}H nmr: 1.2 (6H, t, J = 7 Hz, CH_3), 1.9-2.1 (4H, m), 3.5-3.7 (3H, m), 4.1 (4H, m, CH_2), 5.0 (2H, m), 5.7 (1H, m). This diester (4 g) was dissolved in dry toluene (30 ml) and added dropwise to a suspension of sodium hydride (50% mineral oil dispersion, 0.77 g) and 18-Crown-6 (0.4 g) in dry toluene (50 ml) with constant stirring at room temperature for about one hour. To this solution was added the tetrahydropyranyl ether of 1-chloro-3-pentanol (4 g) (from $NaBH_4$ reduction of commercial available (Aldrich) 1-chloro-3-pentanone) and finely powdered NaI (2 g), after which the mixture was stirred and refluxed for 15 hours (GC monitoring). The solvent was removed by vacuum distillation and the residue heated with 15% aqueous NaOH (100 ml) for 20 hours. The cooled hydrolysed mixture was acidified with concentrated HCl, and the solution saturated with salt and extracted with ether. The dried ether solution was evaporated to provide a brown liquid which was dissolved in methanol (80 ml) to which were added concentrated HCl (2 drops) and H_2O (1 ml). This solution was filtered and evaporated to leave a brown liquid which was distilled (60°C/1 mm) to provide 1.5 g of a colorless oil which was the methoxy ketal of 7-oxo-11-dodecan-3-ol on the basis of the ^{13}C signal at 99.3 pm and the lack of carbonyl absorption. ^{13}C nmr: 10.0, 19.0, 22.7, 29.1, 30.5, 32.6, 33.9, 36.1, 47.1, 71.4, 99.3, 114.6, 138.6.

Both forms of the 7-oxo-11-dodecen-3-ol (i.e. as open hydroxyketone or cyclic methoxy ketal) were subjected to Hg(II) cyclisation to generate the 1.7-dioxaspiro[5.5]undecane skeleton. Thus the methoxyketal (0.5 g) was added to a stirred solution (room temperature) of $Hg(OAc)_2$ (1.5 g) in THF (30 ml) and 1% aqueous $HClO_4$ (30 ml). After thirty minutes (during which time a white precipitate formed), sodium chloride (excess) was added (to form the chloromercury derivative) and the solution extracted with CH_2Cl_2 (3 x 100 ml). This organic phase was washed with water (50 ml) dried ($MgSO_4$) and evaporated without heat. A white solid (0.75 g, 70%) m.p. 105° (colorless needles) was obtained and presumed to be

the chloromercurial. This was confirmed by the mass spectrum and ^{13}C and ^{1}H nmr spectra. Accurate Mass: Calcd. for $C_{12}H_{21}O_2$. $^{202}Hg^{35}Cl$ = 434.0936. Observed 434.0932. The ^{13}C nmr spectrum showed that predominantly one diastereomer of 2-(chloromercuri)methyl-8-ethyl-1,7-dioxaspiro[5.5]undecane had formed, and this was clearly the (E,E)-isomer on the basis of comparisons of its ^{13}C nmr shifts with those of similar 2,8-dialkyl substituted spiroacetals of known relative configurations (Kitching 1989). ^{13}C nmr: 10.2, 19.0, 19.1, 29.3, 30.8, 35.1 (2C), 35.4, 39.5, 68.2, 71.3, 96.8. (Lower intensity signals probably correspond to the two possible (E,Z) diastereomers). ^{1}H nmr: 0.9 (3H, t, J 7 Hz, CH_3), 0.9-2.5 (m, ~16H), 3.3 (1H, m), 3.9 (1H, m).

The above mercurial (150 mg), dissolved in benzene (1 ml) was treated with Bu_3SnH (1 ml) and a small crystal of AIBN at room temperature. After 15 minutes, the solution was filtered through celite to remove Hg residues etc, and washed with CH_2Cl_2. This was stirred with aqueous KF (10%), separated, and evaporated to provide 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane predominantly as the (E,E) diastereomer. Demercuration with sodium borohydride has also been employed and avoids some purification problems that arise when Bu_3SnH is used. Pure samples of this spiroacetal are readily obtained by preparative gas-chromatography. GC-MS examination revealed the presence of two diastereomers of the spiroacetal which exhibit very similar mass spectra. Mass Spectrum (E,E): M^+ 198 (5), 169 (6), 129 (21), 126 (17), 125 (9), 115 (41), 114 (11), 112 (38), 111 (15), 97 (26), 84 (14), 83 (27), 69, (38), 55 (72), 43 (66), 42 (39), 41 (100). The spectral properties agree well with those of a sample subsequently obtained by another route (O'Shea 1989) and full nmr spectral details are reported there.

RESULTS AND DISCUSSION

GC-MS analysis of the acetone extract of the rectal gland of sexually mature males of *B. dorsalis* indicated that the major components were long chain fatty acids, with one as the ethyl ester. A number of minor compounds of higher volatility were also present. Treatment of the extract with diazomethane resulted in the observation of the methyl esters of the fatty acids shown in Figure 1, and of these new compounds the major one was the trimethyl ester of citric acid (1), along with the trimethyl ester of phosphoric acid (2) and dimethylsuccinate (3).

The more volatile very minor components were of interest with one showing an apparent M = 198 (5%) and loss of 29 and 15 mu, corresponding to loss of C_2H_5 and CH_3 respectively. Intense ions at m/z = 112 and 115 and other features of the mass spectrum suggested the structure to be a 2,8-dialkyl-1,7-dioxaspiro[5.5]-undecane, specifically 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (4), presumably as the more stable (E,E)-diastereomer (5). This was confirmed by comparisons with the spectra and chromatographic properties of an independently synthesised sample, and represents an example of the unusual class of even carbon-numbered insect derived spiroacetals. A low level of 3-hydroxy-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (6) was also observed and confirmed by mass spectral comparisons with an authentic sample (Kitching 1989). A full listing of compounds is shown in Figure 1.

A "smoke-like" substance emitted by males of *B. dorsalis* at dusk (the mating period of these tephritids) has been reported (Ohinata 1982) and *ca* 90% of the smoke collected on Millipore filters was (tri) sodium-phosphate, in agreement with our identification of the phosphate ester (from the acid). A minor component of the "smoke" was N-(2-methylbutyl)propanamide (Ohinata 1982) which was absent from the glandular secretion. (N-(3-methylbutyl)acetamide (7) was a glandular component).

The volatile secretions produced by *female B. dorsalis* from culture in Hawaii, have also been studied (Baker and Bacon 1985). The volatiles were collected on charcoal filters and GC-MS analysis of the solvent extracts showed the presence of one major compound, N-(3-methylbutyl)-acetamide (7) and two minor spiroacetals in addition to (5). These were 2,8-dimethyl and 2-n-propyl-8-methyl derivatives (8) and (9) respectively of the 1,7-dioxaspiro[5.5]undecane system. An homologous series of ethyl esters of the C_{12},C_{14} and C_{16} saturated fatty acids, as well as of the C_{16} unsaturated fatty acid were also identified. These compounds are shown in Figure 2.

Mal A is very similar to *B. occipitalis* and occurs in Malaysia only. This species was examined by us some years ago and aspects of the results were mentioned in a brief report (Kitching 1986). These specimens were field collected in Malaysia and were incorrectly reported as being *Dacus occipitalis*. This species is now regarded (Drew, unpublished) as taxonomically distinct from *B. occipitalis* but his study will be reported in due course. We have been unable to obtain authentic *B. occipitalis* for analysis.

A more recent examination of this Mal A confirms the results obtained on earlier specimens, except for the absence of methyl eugenol metabolites that were detected in the earlier study. (Methyl eugenol is the lure used for trapping, but the trap design now used prevents feeding on the attractant). Temperature programmed gas chromatography (SE 54 columns) of the acetone extract showed the presence of one major (~70%; 5 μg/fly) and several minor components. This major component exhibited apparent M = 158 (2.4%) and (M-18) at m/z = 140 (5%), suggesting an alcohol. Additional ions at m/z 71 (75%) and 115 (16%) indicated that 6-oxo-1-nonanol ($C_9H_{18}O_2$) (10) was a likely structure and this was supported by the McLafferty ion at m/z = 86 (37%). Synthesis of the previously unreported 6-oxo-1-nonanol (10) was conducted as outlined in the Experimental Section, and identity with the natural product was established by mass spectral and gas chromatographic comparisons. A minor compound (*ca* 4%) eluting slightly after

6-oxo-1-nonanol, showed highest m/z = 117 (14%) with other ions at m/z 99 (34%) (117-18), and m/z = 81 (64%). This information coupled with the chromatographic data, suggested 1,6-nonanediol (11) was present and this was confirmed by comparisons with an authentic sample acquired by reduction of the synthesised 6-oxo-1-nonanol. The EI mass spectrum of the diol lacks a molecular ion (M^+ = 160), but exhibits a prominent ion at m/z = 117 corresponding to $HOCH(CH_2)_5OH$. $(M-C_3H_7)$. The chirality of this diol would be of some interest, but this has not yet been determined. N-(3-methylbutyl)acetamide (6%) (7) and ethyl 3-methyl-2-hydroxy butanoate (12) (~5%) (0.97 match with library spectrum) were also identified. The spiroacetal, 2-ethyl-8-methyl-1,7-dioxaspiro-[5.5]undecane, (5) and pyrazine (13) were very minor components, with the structure (13) being confirmed by mass spectral and gas chromatographic comparisons (retention time, co-elution) with an authentic sample. Analysis of pentane extracts provided the same chemical profile. The compounds are displayed in Figure 3.

The analysis of the second species from Malaysia (Mal B) provided a vastly different result. The major components were the C_{16},C_{18} saturated and unsaturated acids, together with high molecular weight hydrocarbons. In the volatile region, very low levels of trimethyl pyrazine (14), spiroacetals (5) and (8) and N-(3-methylbutyl)acetamide (7) were present in various analyses. This species has not been examined previously, but it is taxonomically very close to *B. dorsalis* itself (discussed above), and both are sparse in terms of volatile glandular components. Fatty acids are the major components in each species, and both secrete low levels of spiroacetal (5), trimethylpyrazine and amide (7). There were differences however, including the absence of the C_{12} ethyl ester and the appearance of spiroacetal (8) in (Mal B).

The analysis of *Phil B* revealed a similarity to the dorsalis type, with a low level of volatile compounds, with fatty acids again being dominant. However, in comparison with Mal B, there was the presence of large amounts of C_{12} and C_{14} (saturated) and C_{16} (saturated and unsaturated) fatty acid ethyl esters. Small amounts of spiroacetal (5), amide (7) and trimethyl pyrazine were observed but not spiroacetal (8). Thus the analysis of *Phil B* is most similar to that of *B. dorsalis* in which spiroacetal (5) was absent but the C_{12} fatty acid ethyl ester was present.

These results indicate that in Malaysia, MAL A and MAL B are two very closely related but distinct sibling species of the *dorsalis* complex. Though taxonomically very similar (being difficult to differentiate by normal morphological examination) these two species show vast differences in the chemistry of their rectal gland extracts. Mal A, in fact, has a glandular chemistry which is most distinct from that of any other species examined, whereas Mal B, Phil B and *B. dorsalis* have similar glandular components. Minor, consistent differences were found however between Mal B, Phil B and *B. dorsalis*. These results have important application in the taxonomic studies of this most destructive fruit-fly complex and assist in defining the species. They also add to our knowledge of the general chemistry of fruit-flies.

ACKNOWLEDGEMENT: The authors are grateful to Dr Sabine Krohn for an authentic sample of pyrazine (13).

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Legends for Figures, Schemes

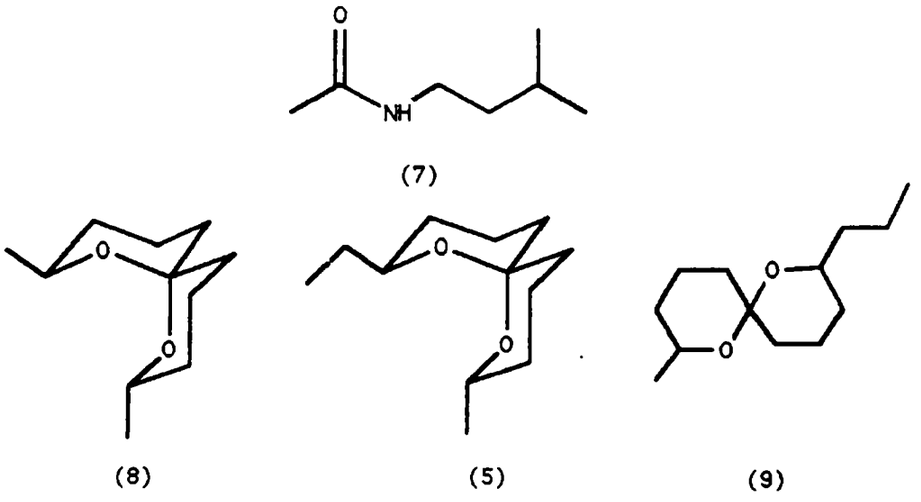
Legend for Figure 1: Compounds observed by solvent extraction of adult male *Dacus dorsalis* (Hendel).

Legend for Figure 2: Compounds observed in the volatiles of female *Dacus dorsalis* (Hendel) (Baker, 1985).

Legend for Figure 3: Compounds observed by solvent extraction of male Mal A.

Scheme 1: Synthesis of 6-oxo-1-nonanol and 1,6-nonandiol.

Scheme 2: Synthesis of 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane.



(7)

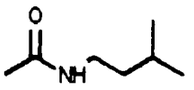
(8) (5) (9)

FATTY ACIDS: Ethyl Esters of C_{12}, C_{14}, C_{16} (Saturated)

C_{16} (Mono-unsaturated)

FIGURE 2.

Major Components



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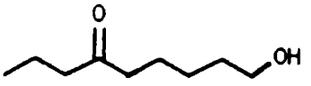
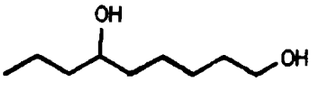
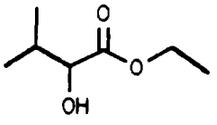


(10)

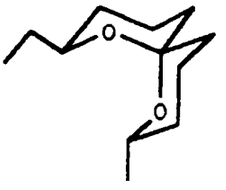


(11)

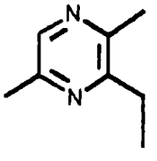
Others



(12)



(5)



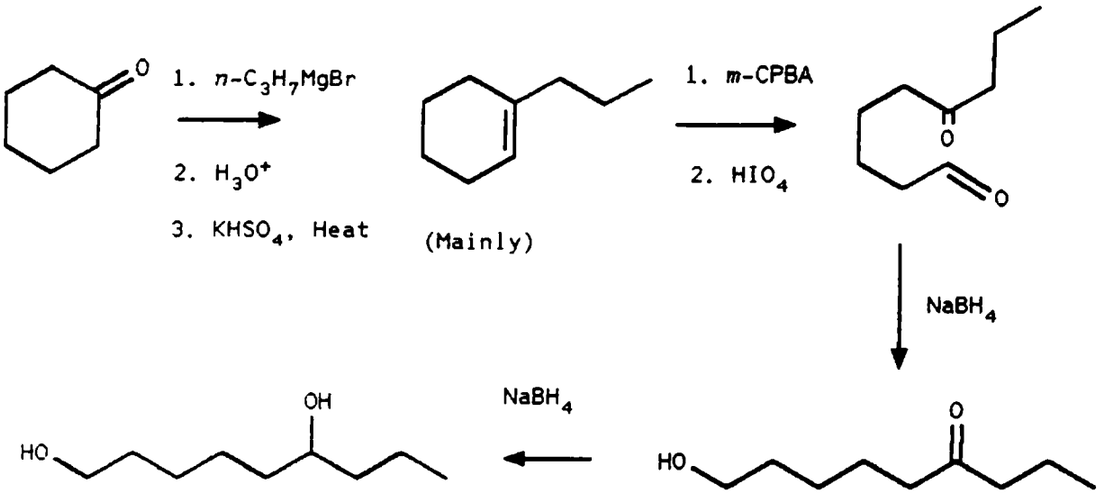
(13)

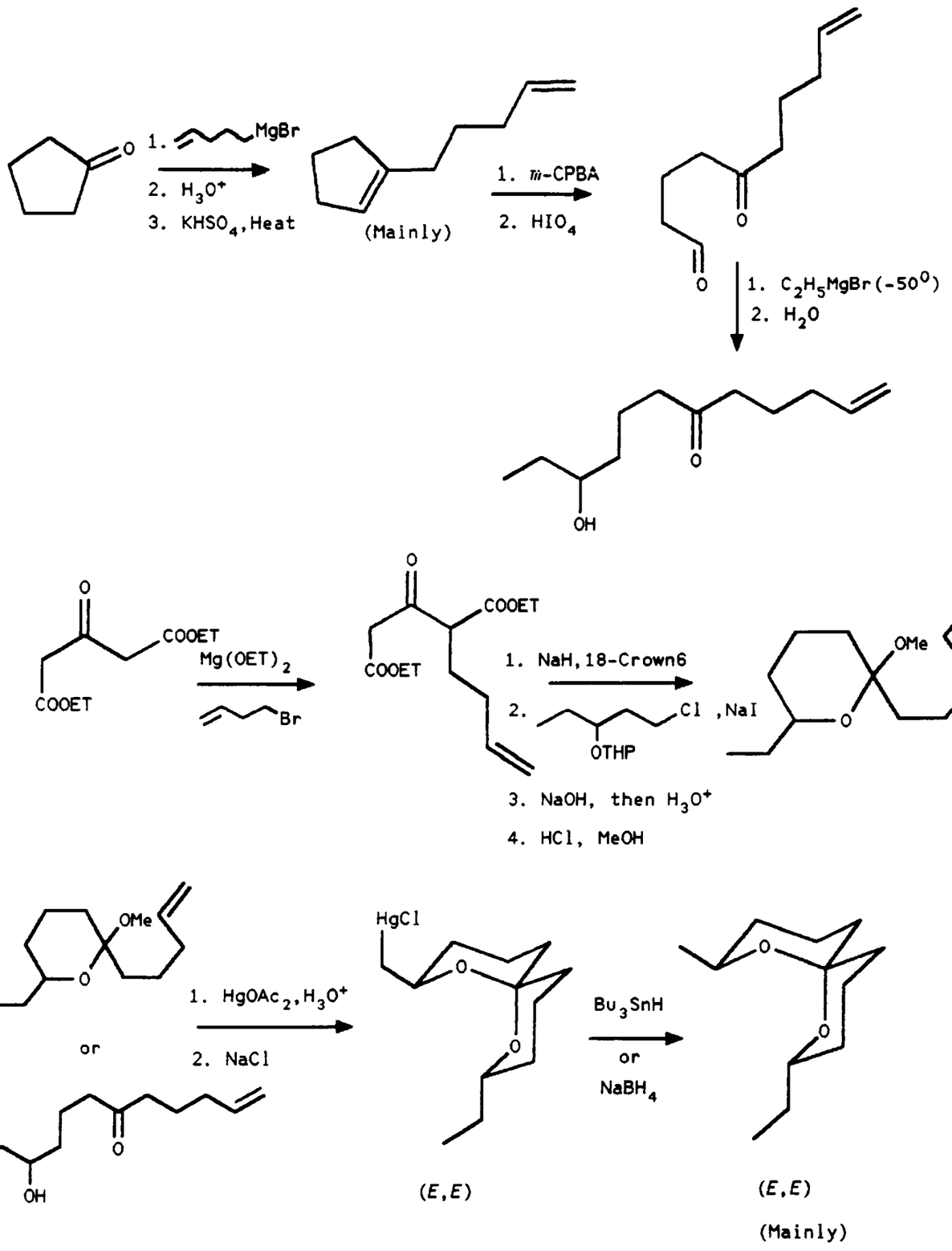
FATTY ACIDS: C_{16}, C_{18} (Saturated)

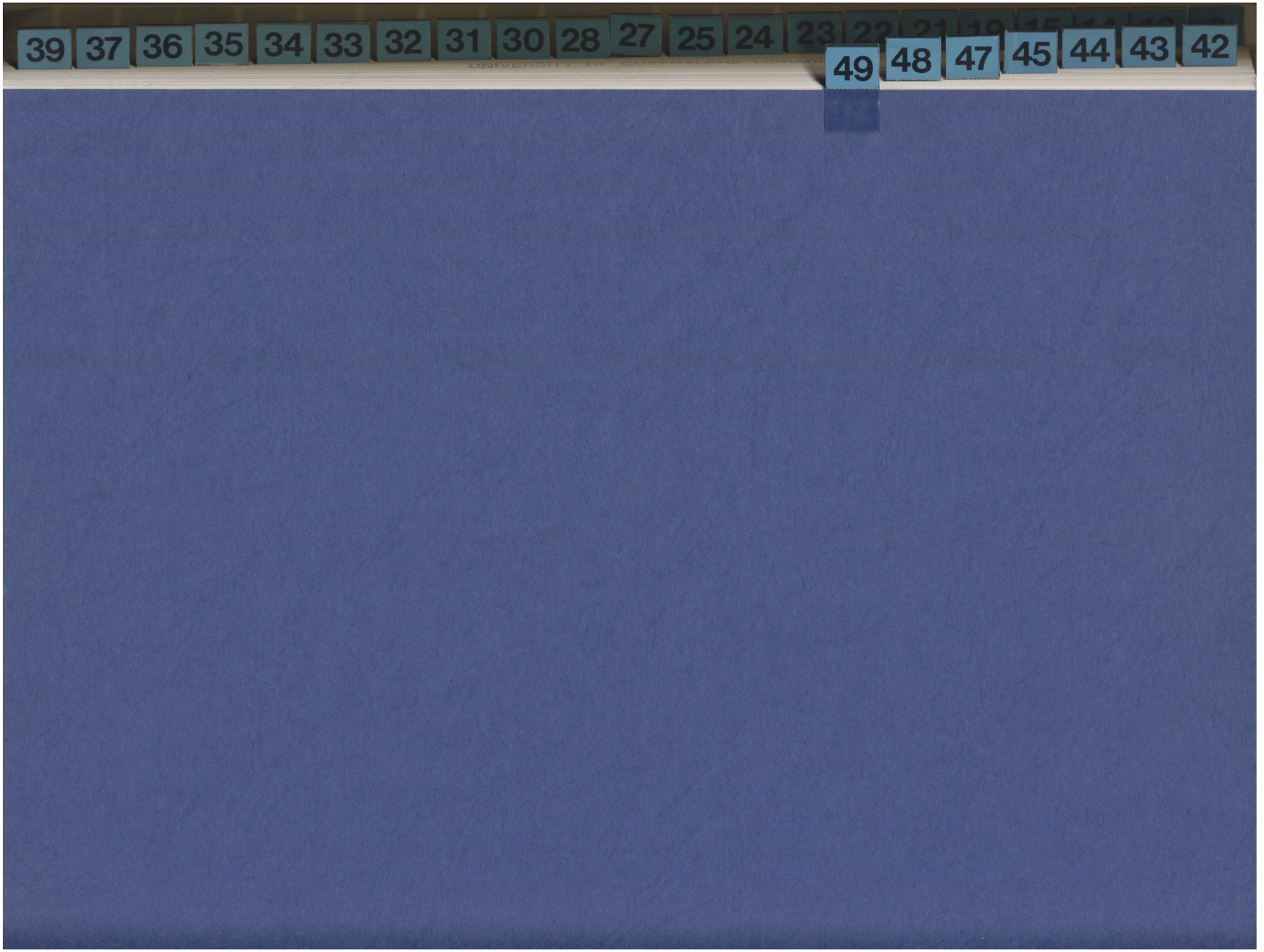
C_{16}, C_{18} (Mono-unsaturated)

C_{18} (Di-unsaturated)

FIGURE 3.


O
1. n-C3H7MgBr
2. H3O+
3. KHSO4, Heat
(Mainly)
1. m-CPBA
2. HIO4
O
O
NaBH4
O
HO
NaBH4
OH
HO


1. MgBr
2. H_3O^+
3. $KHSO_4$, Heat
(Mainly)
1. m-CPBA
2. HIO_4
1. $C_2H_5MgBr(-50^0)$
2. H_2O
COOET
$Mg(OET)_2$
Br
1. NaH, 18-Crown6
2.
Cl , NaI
OTHP
OMe
3. NaOH, then H_3O^+
4. HCl, MeOH
OMe
or
1. $HgOAc_2$, H_3O^+
2. NaCl
HgCl
Bu_3SnH
or
$NaBH_4$
(E,E)
(E,E)
(Mainly)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An (S)-(+)-Lactic Acid Route to (2S,6R,8S)-2,8-Dimethyl-1,7-dioxaspiro[5.5]undecane and (2S,6R,8S)-2-Ethyl-8-Methyl-1,7-dioxaspiro[5.5]undecane and Demonstration of their Presence in the Rectal Glandular Secretion of *Bactrocera nigrotibialis* (Perkins)

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ABSTRACT: The chiral iodide resulting from reduction and iodination of the tetrahydropyranyl ether of ethyl (S)-(+)-lactate has been engaged in a free-radical addition to acrylonitrile. The resulting protected hydroxy nitrile, on reaction with 4-pentenylmagnesium bromide afforded (S)-2-tetrahydropyranyloxy- 6-oxo-undec-10-ene. Oxymercuration of this hydroxy enone, under reversible conditions, employing aqueous acid - tetrahydrofuran, effected simultaneous deprotection and cyclisation, and in-situ biphasic demercuration with sodium borohydride, provided essentially stereochemically pure (2S,6R,8S)-2,8- dimethyl-1,7-dioxaspiro[5.5]undecane

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(i.e. the (E,E)-diastereomer only). Epoxidation of the protected hydroxy enone, followed by dimethylcuprate ring-opening and cyclisation, provided a mixture of the (E,E) and the two possible (E,Z)-diastereomers of 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane with the former being the (2S,6R,8S) stereoisomer. Separation of the (E,E) from the two (E,Z) isomers was achieved by preparative gas chromatography. Gas-chromatographic analysis of these samples and of the rectal glandular secretion of male *Bactrocera nigrotibialis*, using a cyclodextrin based phase, demonstrated that the (2S,6R,8S)-stereoisomers of the 2,8-dimethyl- and 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecanes were the natural products, with no detectable level of the antipodes.

INTRODUCTION:

The spiroacetal unit is found in an expanding variety of naturally occurring compounds, many of which exhibit important physiological activity.[1,2] As a result, a large number of methods for generating the spiroacetal sub-structure have been developed.[3] Following Francke's demonstration[4] that 2-ethyl-1,6-dioxaspiro[4.4]-nonane was the principal aggregation pheromone of the bark beetle *Pityogenes chalcographus*, relatively simple spiroacetals of various ring systems have been identified in insect species located in the orders Coleoptera, Hymenoptera and Diptera, and these spiroacetals exhibit a wide range of behaviour as chemical messengers.[5,6] With respect to Tephritid fruit-fly species, principally derived from the genus Dacus‡, an impressive variety of alkyl and hydroxy-substituted spiroacetals have been identified, both in extracts of the rectal gland and from aerial trapping of emitted volatiles.[5,7,8,9] With a few exceptions, most insect derived spiroacetals contain nine, eleven or thirteen carbon atoms in an unbranched arrangement and may have a close relation with other fatty acid derived pheromones.[10] Although these spiroacetals presumably play an important role in the life-cycle of the fruit-fly species, only in the case of the olive fly, *Dacus oleae*, has careful biological testing established this for the female-generated 1,7-dioxaspiro[5.5]undecane, and here the enantiomers elicit sex-specific responses under the proper conditions.[11] This emphasises the necessity to establish the chirality of any spiroacetals that may be behaviour-influencing within a species and this in turn requires enantiospecific syntheses[6] and very sensitive methods for chirality determinations.[12] With respect

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‡ Bactrocera is the new genus name applied in the general taxonomical revision (Dr R.A. Drew, unpublished results) to a large number of fruit-fly species previously located in the Dacus genus.

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to insect-derived spiroacetals, little is known regarding chirality, and we were particularly interested in this aspect for the unusual *even-carbon numbered* spiroacetals, and in this category, (E,E)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]-undecane has been identified ás a low level component in a number of species.[9,13,14] In this paper we report efficient syntheses of both (2S,6R,8S)-2,8-dimethyl-1,7- dioxaspiro[5.5]undecane and (2S,6R,8S)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]- undecane from ethyl (S)-(+)-lactate, and demonstrate their presence in the rectal gland secretion of *Bactrocera*‡ *nigrotibialis* (Perkins).[15]

RESULTS AND DISCUSSION:

Synthesis of the enantiomers of (E,E)-2,8-dimethyl-1,7-dioxaspiro[5.5]-undecane, (1) and (2), was originally reported by Mori,[16] who utilised iodides (3) and (4) (derived from ethyl (S)-(+)-3-hydroxybutanoate (5)), to alkylate anions derived from methylacetoacetate. Ethyl (R)-(-)-3-hydroxybutanoate was unavailable at that time (1981), and antipodal iodide (4) was acquired[16] by a sequence including a Walden inversion at C-3 (Mitsunobu reaction) (Scheme 1).

INSERT SCHEME 1

Rotations for (1) and (2) were reported as $[\alpha]_D^{23} = -51.6^\circ$ (c = 1.72, pentane) and $+51.7^\circ$, respectively, and the optical purity of chemically pure (1) could be calculated as 99.8%, if the chiral centre of (5) (92% optically pure) survived without any appreciable racemisation. Subsequently, Isaksson[17] described the separation of (1) and (2) (and also of the enantiomers of the (E,Z)-diastereomer) by liquid chromatography utilising microcrystalline triacetylcellulose, and considered their (1) and (2) to be >98% optically pure, with $[\alpha]_D^{24} = -44.3^\circ$ for (1) and $+44.6^\circ$ for (2). The discrepancy in the reported optical rotations was investigated in detail by Mori[18] who utilised the now readily available ethyl (R)-(-)-3-hydroxybutanoate (~100% ee) for direct access to key iodide (4) and

hence (2). In addition a new synthesis, starting with (S)-malic acid was reported by Mori,[18] and in this sequence the optical purity of the penultimate compound was established as 100% ee (nmr of derived diastereomeric esters). As a result, it is established that optically pure (1) has $[\alpha]_D^{23} = -59$ to $-60°$. In the "double alkylation" approach[16] to (1) and (2), two units of the same chiral iodide are required to generate the protected keto-diol equivalent of the spiroacetal.

Our approach to the (2S,6R,8S) enantiomer of the thermodynamically more stable (E,E)-diastereomer (1), utilises one unit of the chiral iodide derived from ethyl (S)-(+)-lactate (6) combined with reversible, cyclising reactions which ensure very heavy predominance of the (E,E) diastereomer through the virtue of the anomeric effect.[19] In addition, the alkene moiety present in (10) below in Scheme 2, permits elaboration to other systems, such as the ethyl and hydroxy-methyl[18,20] derivatives. This chemistry is summarised in Scheme 2.

INSERT SCHEME 2

Protection of ethyl (S)-(+)-lactate as the tetrahydropyranyl ether[21] and reduction with $LiAlH_4$ provided protected diol (7) which was very efficiently (~85%) converted to iodide (8) using triphenylphosphine/iodine in the presence of imidazole.[22] This iodide (8) was then engaged in a free radical addition to acrylonitrile[23] to afford the protected hydroxy nitrile (9) in moderate yield (~36% isolated after chromatography). Acquisition of key enone (S)-(10), resulted from addition of 4-pentenylmagnesium bromide to nitrile (9), followed by careful hydrolysis of the imino intermediate. (S)-(10) was then available for a number of transformations. Markovnikov hydration of the double bond, with concomitant deprotection of the installed hydroxy function (in (10)) and spiroacetalisation to provide essentially exclusively the (E,E) diastereomeric arrangement was envisaged to result from oxymercuration under aqueous acidic conditions, such that both oxymercuration and spiroacetalisation were reversible.[9] This proved to be the case, and subsequent demercuration with $NaBH_4$ under biphasic conditions provided diastereomerically pure (E,E)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane,

necessarily as the (2S,6R,8S) enantiomer (1) (Scheme 3). Chemically pure (1) acquired by preparative gas chromatography, exhibited $[\alpha]_D^{23} = -58.7^\circ$ (c = 1.6, pentane) and examination by chiral gas chromatography on a cyclodextrin based phase (see Fig. 1) indicated an ee of 98%. These measurements are in agreement with the results of Mori.[18]

INSERT SCHEME 3

Acquisition of stereoisomers (12), (13) and (14) of 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane was approached by peracid epoxidation of alkene (S)-(10) followed by epoxide ring opening with dimethylcuprate[24] and cyclisation. The stereochemical deficiency in this route, *viz.* that epoxidation of (S)-(10) generates a new (racemic) chiral centre at the secondary epoxide carbon and consequently a diastereomeric mixture of the desired 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane in which the (E,E) cannot exceed 50%, was considered to be a minor drawback considering the route's directness and the anticipated ease of separation of the (E,E) diastereomer (12) from the two possible (E,Z) isomers, (13) and (14). Thus epoxidation of (S)-(10) was conducted using *m*-CPBA in CH_2Cl_2, in the standard way and the resulting unprotected keto-epoxide (11) was ring opened with dimethylcuprate as shown in Scheme 4.

INSERT SCHEME 4

Preparative gas chromatography permitted acquisition of the diastereomerically pure (2S,6R,8S) isomer (12), with (E,Z)-(13) and (Z,E)-(14) being obtained as a pure (50:50) mixture. (12) exhibited $[\alpha]_D^{24} = -72.9^\circ$ (c, 0.38 in pentane), a somewhat higher value than for (1) discussed above. Examination by chiral gas chromatography using a per-n-hexyl-α-cyclodextrin phase, provided an ee of 98% (Fig. 1). Completely assigned ^1H and ^{13}C nmr have been obtained for (±)-(12), and the data for the "methyl-bearing ring" show close similarity with those for (1).[25] (13) and (14) would be expected to possess very similar chromatographic properties and are not easily separable. These have been characterised as a mixture.

Chirality of (E,E)-2,8-Dimethyl- and 2-Ethyl-8-methyl-1,7-dioxaspiro[5.5]-undecanes in *Bactrocera nigrotibialis*

The three diastereomers of 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane have been demonstrated to be present in the rectal glandular secretion of certain species of fruit-flies,[9] and some aeration studies[13,26] have shown that these spiroacetals may be released into the atmosphere at mating time. Previously we reported[9] that the (E,E)-diastereomer was the major glandular component in the cucumber fly, *D. cucumis*, and that this was highly enantiomerically pure, possessing the (2S,6R,8S) configuration (1). Although odd carbon-numbered spiroacetals greatly predominate amongst the relatively simple spiroacetals identified from insect sources,[19] some low-level *even* carbon number spiroacetals have also been characterised. Thus, the 2-methyl,[26] 2-ethyl-8-methyl-[8,9] and 2-n-butyl-8-methyl[8] derivatives of the 1,7-dioxaspiro[5.5]undecane system have been characterised, but normally at quite a low-level (1-3%) and are clearly disfavoured biosynthetically. Thus it was of some interest to establish the chirality of one of these more unusual systems relative to the more abundant (E,E)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane. This comparison required a species in which an adequate level was present so that determination by chiral gas chromatography could be conducted. *D. nigrotibialis* is located throughout Malaysia, Thailand and Laos but this species has not been cultured, and our specimens were trapped (with Cue-Lure) in the Gombok rainforest, Malaysia. The male rectal glandular secretion contains *ca* 85% (E,E)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane and *ca* 3% of 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane shown to be the (E,E) diastereomer by chromatographic comparisons with an authentic sample.[15]

Examination of a mixture of racemic (E,E)-2,8-dimethyl- and racemic (E,E)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecanes on a per-n-hexyl-α-cyclodextrin phase demonstrated that the enantiomeric pairs were nicely resolved

(Fig. 1). Similar examination of our synthesised (2S,6R,8S) enantiomers of each of the above (E,E) diastereomers confirmed their high optical purity, with ee = 98% in each case (Figure 1). Under the same conditions, the extract of *D. nigrotibialis* showed only the (2S,6R,8S) enantiomers of each of the (E,E) diastereomers, and if the (2R,6S,8R) enantiomer of 2,8-dimethyl-1,7-dioxaspiro[5.5]undecane was present at all, the level is certainly less than 1%. However for the less abundant 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane the accuracy of the result is necessarily lower, although no peak corresponding to the (2R,6S,8R) enantiomer could be seen. These results are shown in Figure 2.

INSERT FIGURES 1,2

The chirality of (E,E)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane from three insect sources has now been determined to be (2S,6R,8S) in each case.[9,27] Although generalisation may be difficult, it is likely that the (2S,6R,8S) configuration will also characterise the 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane from insect sources, as found for *D. nigrotibialis*. It would be of some interest to establish the situation for 2-n-butyl-8-methyl-1,7-dioxaspiro[5.5]undecane, but the level of this *even* carbon spiroacetal in *D. latifrons*[8] is very low. Efforts in these areas are continuing.

EXPERIMENTAL SECTION

^{1}H nmr spectra were recorded at 400 MHz (FT mode) using a JEOL JNM-GX400 spectrometer. Deuterochloroform was employed as solvent and chemical shifts are relative to internal tetramethylsilane (0.0 ppm) or residual chloroform (7.24 ppm). ^{13}C nmr spectra were recorded at 100 MHz, utilising $CDCl_3$ as solvent and chemical shifts are relative to the central component of the $CDCl_3$ triplet at 77.00 ppm. High resolution mass spectra were recorded on a Kratos MS-25RFA spectrometer and chemical ionisation spectra refer to ammonia as ionising gas. Gas

chromatographic analyses were performed using a Hewlett-Packard 5710A gas chromatograph using OV1 or BP5 capillary columns, or a Varian Model 3700 gas chromatograph using an OV101 capillary column. Combined gas chromatography mass spectrometry was performed on a Hewlett-Packard 5970B mass selective detector. Preparative gas chromatography was performed using a Shimadzu gas chromatograph Model GC-9A equipped with OV101 and C-20M columns. Ir spectra were recorded on a Perkin-Elmer Model 397 spectrometer. Optical rotations were measured using a Perkin-Elmer 141 MC or 241 MC polarimeter.

Ethyl (S)-(-)-2-Tetrahydropyranyloxypropionte (6):

Pyridinium *p*-toluenesulphonate (~100 mg) was added to a stirred solution of ethyl (S)-lactate (15.0 g, 0.127 mol) and dihydropyran (15.0 g, 0.178 mol) in dry dichloromethane (200 ml) contained in a flask fitted with a reflux condenser and drying tube. After three hours at room temperature the mixture was washed with saturated aqueous $NaHCO_3$, dried ($MgSO_4$) and the solvent removed under reduced pressure. The resulting oil was distilled (76-78° C/0.25 mm) to yield ethyl 2-tetrahydropyranyloxypropionate (23.9 g, 93%) as a mixture of two diastereomers.

Mass Spectrum: (CI) m/z 203 (M^+ +1, 29.1%), 103 (12.0), 102 (100), 101 (47.6), 86 (52.0), 84 (30.3). HRMS calcd. for $C_{10}H_{19}O_4$ (M^+ +1) 203.1283, found 203.1272.

NMR: ^{13}C δ ppm ($CDCl_3$) 13.87, 13.94, 17.75, 18.46, 18.86, 18.90, 25.07, 25.15, 30.12, 30.22, 60.38, 60.46, 61.96, 62.09, 69.72, 72.27, 97.27, 98.00, 172.94, 173.02.

^1H δ ppm ($CDCl_3$) 1.145 (t, J = 7.1 Hz, 3H, CH_2-CH_3), 1.15 (t, J = 7.1 Hz, 3H, CH_2-CH_3 (overlaps with other methyl)), 1.25 (d, J = 6.8 Hz, 3H, O-C-CH_3), 1.31 (d, J = 6.8 Hz, 3H, O-C-CH_3), 1.35-1.8 (m, 12H), 3.29-3.40 (m, 2H), 3.67-3.83 (2H), 4.0-4.1 (m, 5H), 4.27 (q, J = 7.1 Hz, 2H, one $-O-CH_2-CH_3$), 4.55-4.60 (m, 2H).

$[\alpha]_D^{23}$ -45.5° (c, 2.5 $CHCl_3$). (Lit.[21] $[\alpha]_D^{23}$ = -41.1°, c, 2.1 $CHCl_3$).

(S)-(+)-2-Tetrahydropyranyloxypropan-1-ol (7):

To an ice cooled solution of $LiAlH_4$ (8.25 g, 0.218 mol) in dry ether (200 ml) under a nitrogen atmosphere, the ester (6) (20.0 g, 0.99 mol) in ether (100 ml), was added dropwise over 1.5 hours. The reaction was stirred for a further hour and then saturated aqueous NH_4Cl (50 ml) added. Precipitated salts were removed by filtration and well extracted with ether and the combined organic phases were separated, dried ($MgSo_4$) and the solvent removed under reduced pressure to yield a oil. Distillation (74°C/0.25 mm) provided the alcohol (7) (14.0 g, 88.5%) as a mixture of two diastereomers.

Mass Spectrum: (EI) m/z 160 (M^+, 0%), 129 (24), 101 (20), 87 (20), 86 (33), 85 (67), 84 (32), 83 (20), 74 (13), 67 (48), 59 (58), 58 (39), 57 (100), 56 (73), 55 (97). HRMS calcd. for $C_8H_{17}O_3$ (M^+ +1) 161.1178, found 161.1172.

NMR: ^{13}C δ ppm ($CDCl_3$) 16.85, 17.57, 19.76, 20.55, 24.91, 25.16, 30.82, 31.30, 62.76, 64.09, 65.87, 66.86, 74.50, 76.96, 98.78, 99.34.

^1H δ ppm ($CDCl_3$) 1.01 (d, J = 6.3 Hz, 3H, $-CH_3$), 1.09 (d, J = 6.3 Hz, 3H, $-CH_3$), 1.37-1.50 (m, 8H), 1.58-1.75 (m, 5H), 2.73 (br s, 1H, one $-OH$?), 3.33-3.45 (m, 6H), 3.65-3.90 (m, 4H), 4.44 (dd, J = 5.6, 1.9 Hz, 1H, O-C*H*-O), 4.62 (dd, J = 5.1, 2.8 Hz, 1H, O-C*H*-O).

$[\alpha]_D^{23}$ +3.66 (c, 3.9 $CHCl_3$) (Lit.[21] $[\alpha]_D^{23}$ = +17.0, c, 2.3 $CHCl_3$).

(S)-(+)-1-iodo-2-tetrahydropyranyloxypropane (8):

A mixture of alcohol (2) (11.0 g, 0.069 mol), triphenylphosphite (54.17 g, 0.206 mol), imidazole (14.0 g, 0.206 mol) and iodine (34.9 g, 0.137 mol) in toluene (500 ml) were stirred at reflux with a bath temperature of 120°C for 1.5 hours. To the cooled, stirred mixture, saturated aqueous $NaHCO_3$ (500 ml) was added, followed by iodine (I_2) (in portions) until the iodine colour persisted in the toluene phase. The sclution was stirred for a further 10 min, after which time, aqueous

sodium thiosulphate was added to discharge the iodine colour. The toluene layer was separated, washed with water (150 ml), dried ($MgSO_4$) and the toluene removed under reduced pressure. The residue (consisting of triphenylphosphine oxide and the product) was triturated with hexane (200 ml) and the insoluble triphenylphosphine oxide removed by filtration. Evaporation of the hexane yielded the iodide (8), (15.8 g, 85%).

Mass Spectrum: (EI) m/z 270 (M^+, 0%), 269 (27.3), 228 (33.1), 170 (12.3), 169 (87.3), 168 (14.4), 143 (11.8), 142 (10.2), 141 (13.6), 129 (28.7), 128 (11.3), 127 (24.6), 103 (41.3), 102 (13.2), 101 (87.8), 87 (54.0), 86 (24.2), 85 (100), 84 (23.8), 83 (15.2), 73 (12.5), 71 (16.8), 67 (44.2). HRMS calcd. for $C_8H_{14}O_2I$ (M^+ -1) 269.0038, found 269.0039.

NMR: ^{13}C δ ppm ($CDCl_3$) 11.43, 12.36, 19.27, 19.49, 19.75, 21.63, 25.30, 25.34, 30.61, 30.84, 62.46, 62.52, 71.60, 71.80, 96.93, 97.88.

^1H δ ppm ($CDCl_3$) 1.21 (d, J = 6.2 Hz, 3H, $-CH_3$), 1.27 (d, J = 6.3 Hz, 3H, $-CH_3$), 1.43-1.85 (m, 12H), 3.15-3.21 (m, 3H), 3.28-3.32 (m, 1H), 3.41-3.47 (m, 2H), 3.68-3.74 (m, 2H), 3.79-3.85 (m, 1H), 3.90-3.96 (m, 1H), 4.65-4.68 (m, 2H, O-C*H*-O).

$[\alpha]_D^{22}$ +2.7° (*c*, 2.5 $CHCl_3$).

(S)-(+)-5-Tetrahydropyranyloxyhexane nitrile (9):

Tri-*n*-butyltin hydride (9.5 g, 32.6 mmol) and AIBN (~50 mg) in dry benzene (100 ml) was added dropwise over one hour to a stirred solution of the iodide (8) (8.0 g, 29.6 mmol), acrylonitrile (15.7 g, 296 mmol) and AIBN (~ 20 mg) in benzene (100 ml) at reflux under a nitrogen atmosphere. The reaction was heated for a further 10 min and then cooled, followed by removal of the benzene under reduced pressure. An aqueous solution of NaF (10 g, in 50 ml) was added to the residue and the mixture stirred for 30 min after which dichloromethane (200 ml) was added, and the mixture filtered. The organic layer was separated, washed with dilute

ammonia (50 ml), dried ($MgSO_4$) and evaporated to give an oil. The crude product was subjected to flash chromatography (Kieselgel 60, 230-400: Ethyl acetate: Hexane, 20:80) to give the nitrile (9). (Two isomers in the ratio 59:41). (2.1 g, 36%).

Mass Spectrum (CI): m/z 198 (M^++1, 13.8), 114 (12.9), 102 (24.0), 101 (11.8), 85 (100), 66 (16.7). HRMS calcd. for $C_{11}H_{20}O_2$(M^++1) 198.1494, found 198.1489.

NMR: ^{13}C δ ppm ($CDCl_3$) 16.78, 17.07, 19.08, 19.78, 19.93, 21.28, 21.30, 21.60, 25.25 (2 peaks superimposed), 30.98, 31.07, 35.18, 35.80, 62.66, 62.92, 69.86, 73.15, 96.01, 98.83, 119.48, 119.69.

^1H δ ppm ($CDCl_3$) 1.05 (d, J= 6.3 Hz, 3H, -C*H*$_3$ (major isomer)), 1.17 (d, J= 6.3 Hz, 3H, -C*H*$_3$ (minor isomer)), 1.40-1.83 (m, 20H), 2.27-2.38 (m, 4H), 3.37-3.44 (m, 2H), 3.64-3.86 (m, 4H), 4.52-4.57 (m, 2H, 2 x O-C*H*-O).

Infrared Spectrum: 2245.0 cm^{-1}(w), ν C≡N.

$[\alpha]_D^{22}$ +27.3 ^{o} (*c*. 3.3 $CHCl_3$ (Two isomers 59: 41))

(*S*)-2-Tetrahydropyranyloxy-6-oxo-10-undecene (10)

4-Pentenylmagnesium bromide was prepared from 4-pentenyl bromide (2.04 g, 13.7 mmol) and magnesium (0.34 g, 14.0 mmol) in ether in the normal way. To this refluxing solution was added dropwise the nitrile (9) (1.8 g, 9.13 mmol) in ether (10 ml). After addition was complete, the reaction was refluxed for a further 5 hours and then water (50 ml) was carefully added. The reaction mixture was stirred for a few minutes until the white solid dissolved. The layers were separated and the aqueous layer extracted with ether (2 x 50 ml) and the combined ether extracts were dried ($MgSO_4$) and evaporated to give an oil which was subjected to chromatography (Kieselgel 60, mesh 70-230) CH_2Cl_2 : ETOAc (80: 20) to give the enone (10) as an oil (1.8 g, 73.5 %) (as a mixture of two isomers in the ratio 53: 47)

Mass Spectrum: EI: m/z 268 (M^+, 0 %), 184 (4.8), 183 (3.6), 167 (41.3),

112 (11.5), 97 (20.7), 85 (100)

CI m/z 269 (M^++1, 17.2), 185 (49.4), 168 (14.4), 167 (100).

NMR: ^{13}C δ ppm ($CDCl_3$) 18.95, 19.62, 19.69, 19.92, 20.01, 21.41, 22.66 (2 superimposed peaks), 25.36, 25.39, 31.05, 31.09, 35.97 (2 superimposed peaks), 35.88, 36.72, 41.69, 41.72, 42.62, 42.66, 62.45, 62.68, 70.58, 73.68, 95.61, 98.70, 115.00, 115.03, 137.83, 137.87, 210.66, 210.87.

^1H δ ppm ($CDCl_3$) 1.025 (d, J= 6.1 Hz, 3H, $-CH_3$ (major isomer)), 1.14 (d, J= 6.1 Hz, 3H, $-CH_3$ (minor isomer)), 1.30-1.80 (m, 24H), 1.97 (br q, J= 6.8 Hz, 4H, 2 x $-CH_2-C=C$), 2.30-2.37 (m, 8H, 2 x $CH_2-C=O-CH_2$), 3.36-3.43 (m, 2H), 3.59-3.87 (m, 4H), 4.54 (dd, J= ~4, ~3 Hz, 1H, $-CH-O$), 4.60 (br t, J= ~3.5 Hz, 1H, $-CH-O$), 4.85-4.96 (m, 4H, $CH_2=C$), 5.68 (dddd, J= 17.1, 10.2, 6.8, 6,8 Hz, 2H, 2 x $-CH=CH_2$).

(2*S*, 6*R*, 8*S*)-2,8-dimethyl-1,7-dioxaspiro[5.5]undecane (1)

The enone (10) (0.3 g, 1.12 mmol) and $Hg(OAc)_2$ (0.43 g, 1.34 mmol) were stirred in a mixture of THF and aqueous 1% $HClO_4$ (1 : 1, 30 ml) for 18 h. The reaction was then treated sequentially with NaOH (30 ml, 10 %), dichloromethane (30 ml), benzyltriethyl ammonium chloride (~1.0 g) and finally $NaBH_4$ (0.06 g, 1.6 mmol), after which it was stirred for 40 min. The metallic mercury was removed by filtration through supercell and the organic layer extracted with ether (3 x 50 ml). The combined organic layers were dried ($MgSO_4$) and evaporated to yield (predominantly by GC analysis) the spiroacetal (1) (0.20 g, 90%). Pure (1) was obtained by preparative gas chromatography. Found C, 71.29; H, 11.26; $C_{11}H_{20}O_2$ requires C, 71.69; H, 10.93.

GC/MS: m/z 184 (M^+, 8.8%), 169 (2.2), 140 (14.0), 115 (97.3), 114 (44.0), 112 (100), 97 (60.9), 84 (12.6), 83 (23.7), 73 (18.0), 71 (15.3), 70 (16.2), 69 (48.3), 58 (19.7), 55 (58.5), 43 (74.8), 42 (36.2), 41 (53.0).

NMR: ^{13}C δ ppm (C_6D_6) 19.35 (C4/C10), 22.22 (C12/C13), 33.23 (C3/C9), 35.66 (C5/C11), 65.15 (C2/C8), 96.07 (C6).

^{1}H δ ppm (C_6D_6) 1.11 (tdd, J= 13.1, 11.23, 3.9 Hz, 2H, $H3_{ax}/H9_{ax}$), 1.15 (d, J= 6.35 Hz, 6H, Me12/Me13), 1.30 (td, J= 13.1, 4.5 Hz, 2H, $H5_{ax}/H11_{ax}$), 1.39 (ddddd, J= 13.1, 4.3, 2.2, 1.5$^{\#}$, ? ($J_{3eq/9eq,4eq/10eq}$ cannot be measured as signals $H3_{eq}/H9_{eq}$ and $H4_{eq}/H10_{eq}$ are almost coincident) Hz, 2H, $H3_{eq}/H9_{eq}$), 1.40 (ddddd, J= 13.1, 4.5, 3.9, 2.4, ? (see above comment) Hz, 2H, $H4_{eq}/H10_{eq}$), 1.63 (dddd, J= 13.1, 4.3, 2.5, 1.5$^{\#}$ Hz, 2H, $H5_{eq}/H11_{eq}$), 2.04 (qt, J= 13.1, 4.3 Hz, 2H, $H4_{ax}/10_{ax}$), 3.74 (dqd, J= 11.23, 6.35, 2.2 Hz, 2H, $H2_{ax}/H8_{ax}$) ($^{\#}$ Signifies a W coupling).

Optical Rotation: $[\alpha]_D^{23}$ -58.7^{o} (*c*, 1.6 Pentane) (Lit, $[\alpha]_D^{23}$ -58.8^{o}, *c*, 1.27)[18] (NB. Chiral GC analysis using a per-*n*-hexyl-α-cyclodextrin stationary phase gave an e.e. = 98 %)

1,2-Epoxy-6-oxo-10-(tetrahydropyranyloxy)-undecane (11)

The enone (10) (1.0 g, 3.73 mmol) and *m*-chloroperbenzoic acid (1.14 g, 85 %, 5.6 mmol) were stirred in dichloromethane (50 ml) for 5 hours. The reaction was then treated sequentially with saturated aqueous $NaHCO_3$ (20 ml), saturated aqueous $NaHSO_3$ (from sodium metabisulphite in water) (20 ml) and finally saturated aqueous $NaHCO_3$ (20 ml). The organic layer was dried ($MgSO_4$) and evaporated to give the epoxide (11) (0.9 g, 85 %) as a mixture of two isomers.

Mass Spectrum : m/z 284 (M^+, 0.6 %), 183 (28.8), 115 (23.1), 85 (100), 67 (13.9), 43 (19.3), 42 (19.3). HRMS Calcd. for $C_{16}H_{28}O_4$ (M^+) 284.1988, found 284.1983).

NMR: ^{13}C δ ppm ($CDCl_3$) 18.91, 19.54, 19.68, 19.87, 19.94, 20.03 (two superimposed peaks), 21.37, 25.32, 25.35, 31.02, 31.06, 31.62, 31.64, 35.83, 36.66, 41.87, 41.89, 42.55, 42.60, 46.57, 46.59, 51.82 (two superimposed peaks), 62.47, 62.66, 70.57, 73.63, 95.62, 98.65, 210.26, 210.46.

^1H δ ppm ($CDCl_3$) 1.01 (d, J= 6.1 Hz, 3H, one $-CH_3$), 1.13 (d, J= 6.1 Hz, 3H, one $-CH_3$), 1.25-1.80 (m, 28H), 2.25-2.42 (m, 10H), 2.65 (br t, J= 4.5 Hz, 2H), 2.78-2.83 (m, 2H), 3.35-3.43 (m, 2H), 3.60-3.86 (m, 4H), 4.51-4.63 (m, 2H).

2-Ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (12,13,14):

Dimethyl cuprate (2.3 mmol) was prepared[24] by the dropwise addition of methyl lithium (3.3 ml, 1.4 M, 4.6 mmol) to a slurry of CuI (0.44 g, 2.3 mmol) in dry ether (20 ml) at 0 ^oC. On addition of one equivalent of MeLi a bright yellow suspension was seen to form, but by completion of the addition the solution was clear. The mixture was stirred for 15 minutes and then cooled to -46 ^oC (dry ice cyclohexanone). The epoxide (11) (0.2 g, 0.70 mmol) in ether (5 ml) was added dropwise over 10 minutes and the reaction stirred for a further 45 minutes after which saturated aqueous NH_4Cl (10 ml) was added at -46 ^oC and the solution warmed to room temperature. The reaction mixture was diluted with ether and the aqueous layer extracted with ether (2 x 30 ml). The combined organic layers were dried ($MgSO_4$) and evaporated to give an oil (0.3 g), which was dissolved in a mixture of HOAc:THF:H_2O (4:2:1, 3 ml) and stirred at room temperature for 2 days. The mixture was then treated with saturated aqueous $NaHCO_2$, followed by solid Na_2CO_3 until it was basic. The solution was extracted with ether (3 x 50 ml), dried ($MgSO_4$) and evaporated to give an oil (crude 0.21 g). This oil was purified by preparative gas chromatography to give pure

/2*S*,6*R*,8*S*)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (12) (0.02 g, 14.3 %)

Mass Spectrum: m/z 198 (M^+, 31.9 %), 140 (23.0) 129 (55.4), 128 (18.4), 126 (39.7), 115 (100), 114 (21.0), 112 (71.6), 111 (25.3), 99 (14.0), 97 (34.3), 84 (13.2), 71 (17.2), 68 (28.5), 44 (20.7), 42 (28.5). HRMS Calcd. for $C_{12}H_{22}O_2$ (M^+)198.1620, found 198.1612.

NMR: ^{13}C δ ppm (C_6D_6) 10.51 (C13), 19.30 & 19.43 (C4 & C10), 22.20 (C14), 29.76 (C12), 31.32 (C3), 33.28 (C9), 35.75 & 35.98 (C4 & C10), 65.17 (C8), 70.30

(C2), 95.87 (C6).

^{1}H δ ppm (C_6D_6) 1.0 (t, J= 7.4 Hz, 3H, Me13), 1.11 (dtd, J= 13.1, 11.2, 3.9 Hz, 2H, $H3_{ax}$ & $H9_{ax}$ superimposed), 1.17 (d, J= 6.1 Hz, 3H, Me14), 1.31 (td, J= 13.1, 4.4 Hz, 1H, $H5_{ax}$ or $H11_{ax}$), 1.32 (td, J= 13.1, 4.4 Hz, 1H, $H5_{ax}$ or $H11_{ax}$), 1.36–1.46 (m, 4H, overlapping $H3_{eq}$, $H4_{eq}$, $H9_{eq}$ and $H10_{eq}$ – each d of m), 1.5–1.59 (m, 2H, 2 H on C12 (2nd order)), 1.61–1.68 (m, 2H, $H5_{eq}$ & $H11_{eq}$ overlapping), 2.03 (qt, J= 13.4, 4.2 Hz, 1H, $H4_{ax}$ or $H10_{ax}$), 2.05 (qt, J= 13.4, 4.2, 1H, $H4_{ax}$ or $H10_{ax}$), 3.51 (dddd, J= 11.2, 8.3, 4.6, 2.2 Hz, 1H, $H2_{ax}$), 3.78 (dqd, J= 11.2, 6.1, 2.2 Hz, 1H, $H8_{ax}$).

Optical Rotation: $[\alpha]_D^{24}$ −72.9 ^{o} (*c*, 0.38 Pentane). The sample was analysed by chiral gas chromatography using a per-*n*-hexyl-α-cyclodextrin stationary phase and an e.e. of 98 % was found.

Also obtained was (2*R*,6*S*,8*S*) (13) and (2*R*,6*R*,8*S*)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane (14) as a pure mixture (0.013 g, 9.5 %).

Mass Spectrum : m/z 198 (M^+, 22.6), 169 (18.9), 129 (72.3), 128 (19.7), 126 (16.2), 115 (100), 114 (18.6), 112 (28.6), 111 (38.5), 99 (12.9), 97 (37.0), 73 (12.6), 71 (14.9), 68 (17.5). HMRS Calcd. for $C_{12}H_{22}O_2$ (M^+) 198.1620, found 198.1616.

NMR: ^{13}C δ ppm (C_6D_6) 10.09, 10.68, 18.93, 18.97, 19.23, 20.13, 22.24, 22.42, 28.93, 29.81 (2 superimposed peaks), 30.71, 31.06, 31.19, 32.52, 33.58, 36.50, 36.78, 65.98, 68.51, 70.90, 73.84, 97.01, 97.25.

^{1}H δ ppm (C_6D_6) 0.94 (t, J= 7.4 Hz, 3H, *EZ* or *ZE* CH_2-CH_3), 0.97 (t, J= 7.4 Hz, 3H, *EZ* or *ZE* CH_2-CH_2), 1.0–1.8 (m, 32H (including 1.16 (d, J= 6.35 Hz, 3H, *ZE* Me14 (collapses to singlet on irradiation of 4.34), 1.18 (d, J= 6.1 Hz, 3H, *EZ* Me14 (collapses to singlet on irradiation of 3.44)), 1.95 (dm, J= ~13 Hz, 1H, *EZ* $H5_{eq}$ or *ZE* $H11_{eq}$), 1.97 (dm, J= ~13 Hz, *EZ* $H5_{eq}$ or *ZE* $H11_{eq}$), 3.07 (dddd, J= 9.8, 7.3, 4.7, 2.9 Hz, 1H, *ZE* $H2_{ax}$), 3.44 (dqd, J= 9.3, 6.1, 3.0 Hz, 1H, *EZ* $H8_{ax}$), 4.07

(dddd, J= 12.0, 6.5, 6.4, 2.2 Hz, *EZ* $H2_{ax}$), 4.34 (dqd, J= 11.2, 6.3, 2.3 Hz, 1H, *ZE* $H8_{ax}$).

Optical Rotation: $[\alpha]_D^{23}$ +15.8 ^{o} (*c*, 0.31 Pentane (*EZ* and *ZE* 50: 50)).

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CAPTION TO FIGURE 1.

FIGURE 1: (a) Enantiomer analysis of synthesised samples of (*EE*)-2,8-dimethyl and 2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane showing ~98% ee of the (2*S*, 6*R*, 8*S*) configurations.

(b) Sample as in (a) mixed with corresponding (*E*,*E*)-racemates.

Conditions: 35 m glass capillary column with per-*n*-hexyl-α-cyclodextrin. Column temperature 75 ^{o}C, carrier gas 0.95 bar H_2. Retention times as indicated (Conditions vary slightly from (a) to (b)).

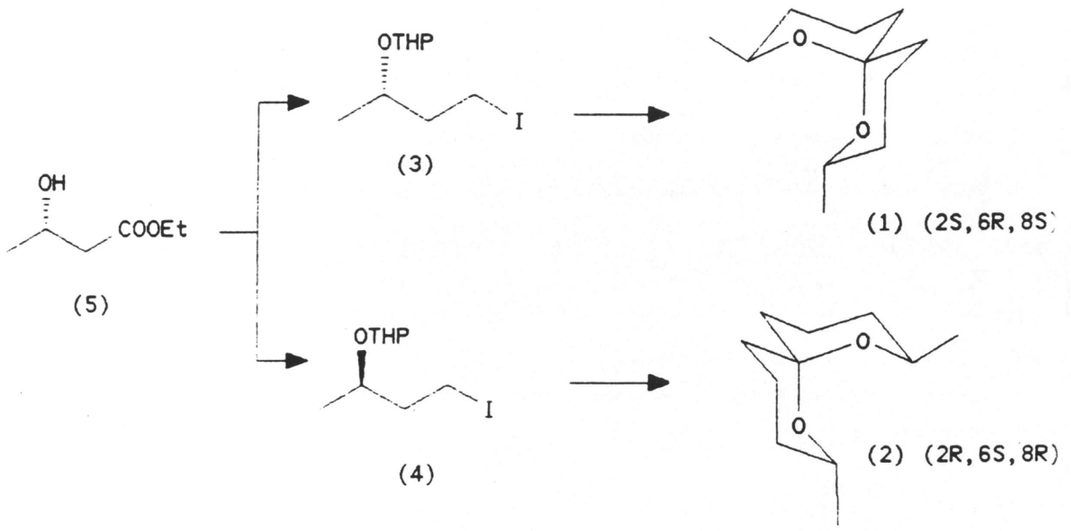
CAPTION TO FIGURE 2.

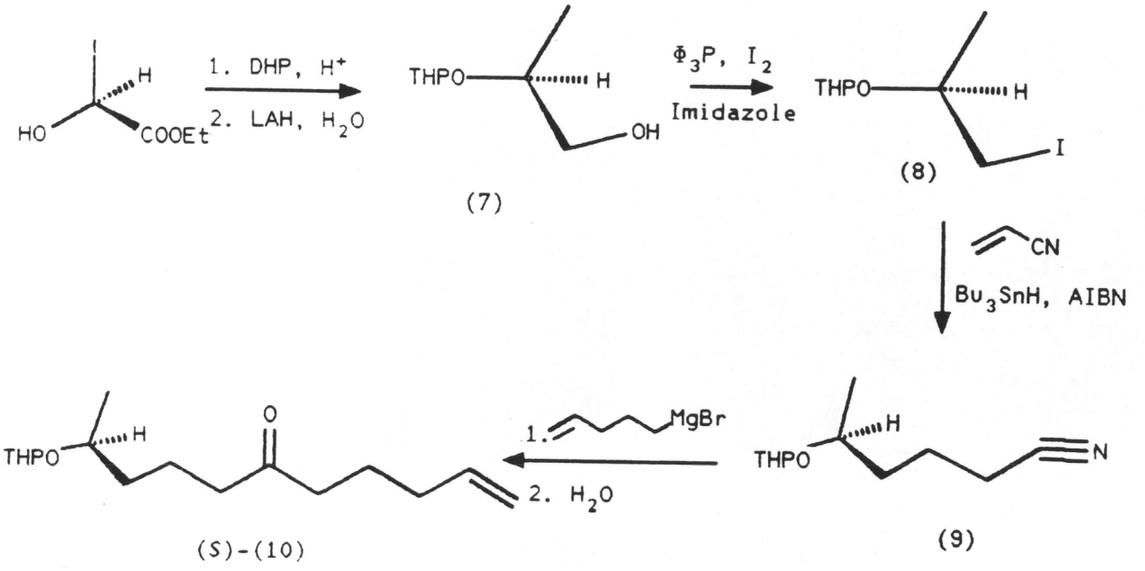
FIGURE 2: (a) Enantiomer resolution of racemic (*E*,*E*)-2,8-dimethyl and (*E*,*E*)-2-ethyl-8-methyl-1,7-dioxaspiro[5.5]undecane.

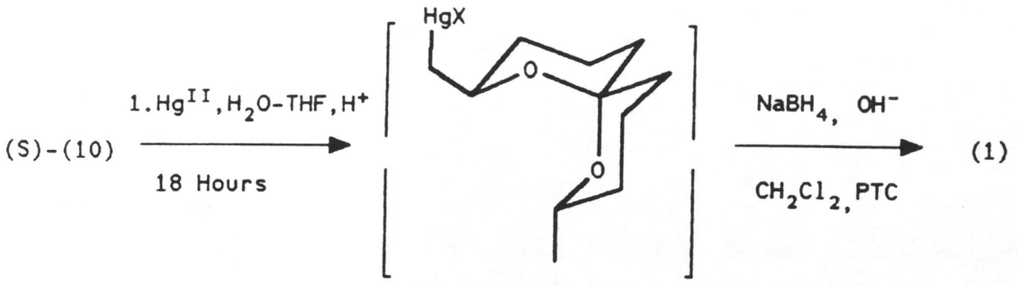
(b) Corresponding analysis for the rectal glandular extract (male) of *B. nigrotibialis*, showing one enantiomer only of each of the above (*E*,*E*) spiroacetals (1) and (12).

(c) Sample as in (b) admixed with the corresponding (*E*,*E*) racemates.

Conditions: As outlined for Figure 1.


OTHP
I
(3)
OH
COOEt
(5)
OTHP
I
(4)
O
O
(1) (2S, 6R, 8S)
O
O
(2) (2R, 6S, 8R)


H
HO
COOEt
1. DHP, H+
2. LAH, H2O
THPO
H
OH
(7)
Φ3P, I2
Imidazole
THPO
H
I
(8)
CN
Bu3SnH, AIBN
THPO
H
N
(9)
1.
MgBr
2. H2O
THPO
H
O
(S)-(10)


HgX
1. Hg^{II}, H_2O-THF, H^+
18 Hours
(S)-(10)
$NaBH_4$, OH^-
CH_2Cl_2, PTC
(1)

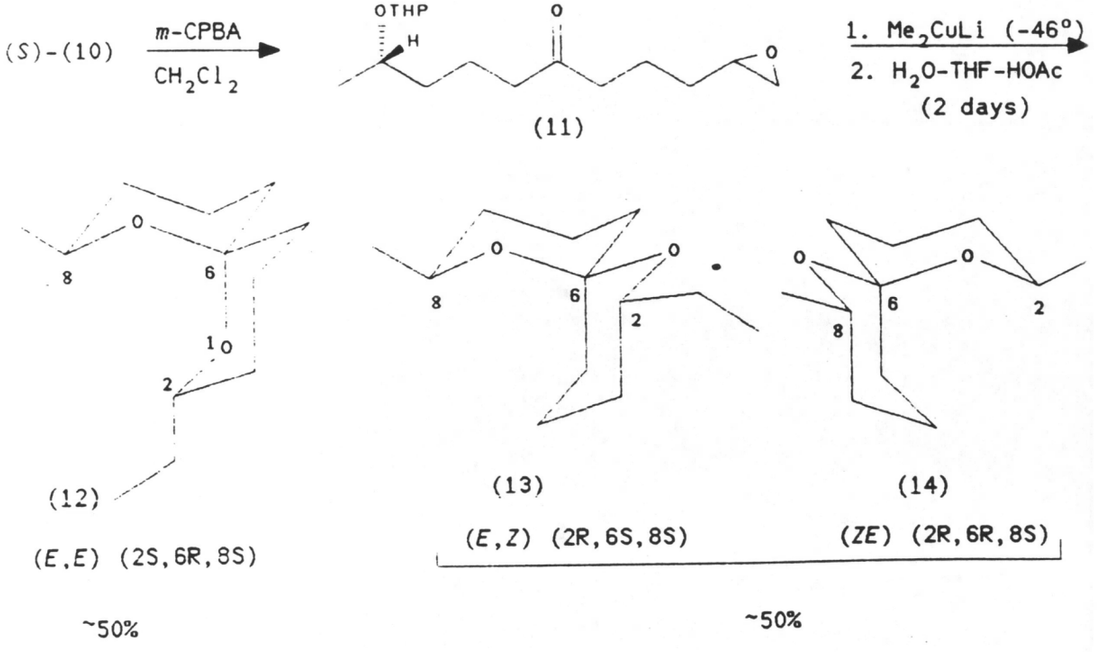

(S)-(10)
m-CPBA
CH_2Cl_2
OTHP
H
(11)
1. Me_2CuLi (-46°)
2. H_2O-THF-HOAc
(2 days)
(12)
(E,E) (2S,6R,8S)
~50%
(13)
(E,Z) (2R,6S,8S)
(14)
(ZE) (2R,6R,8S)
~50%

Figure 1

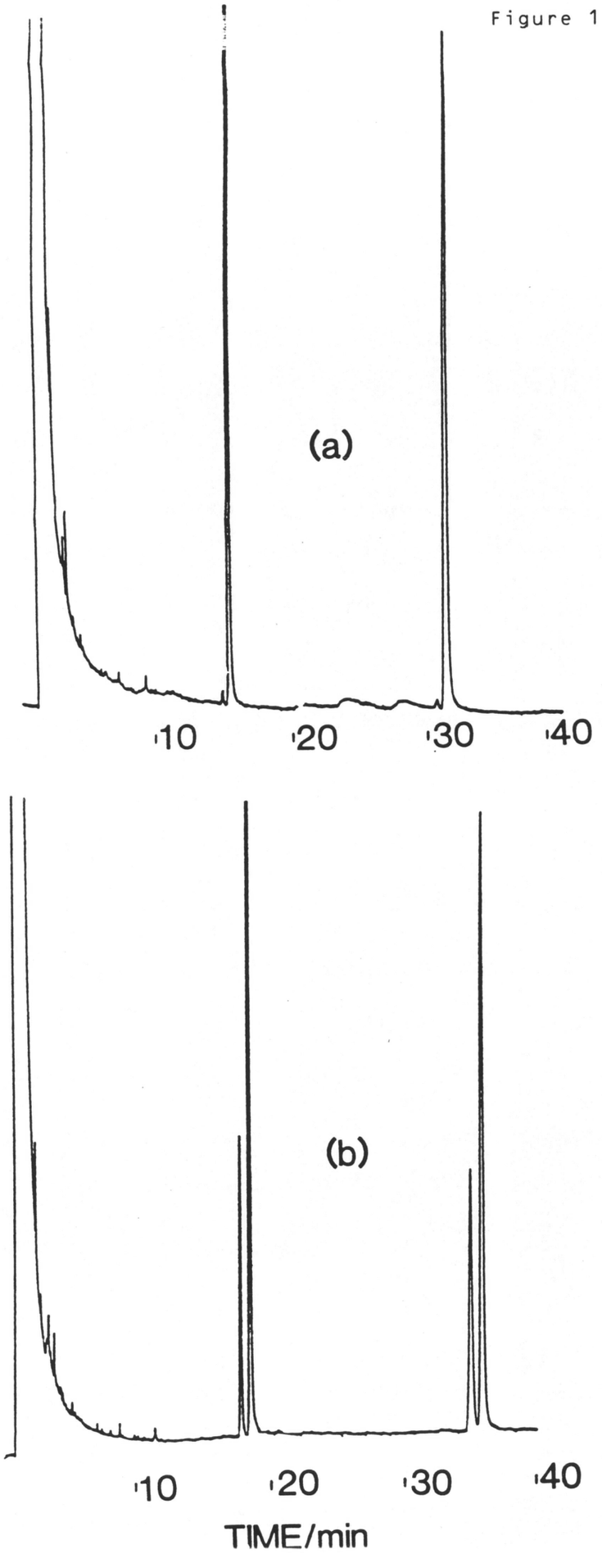
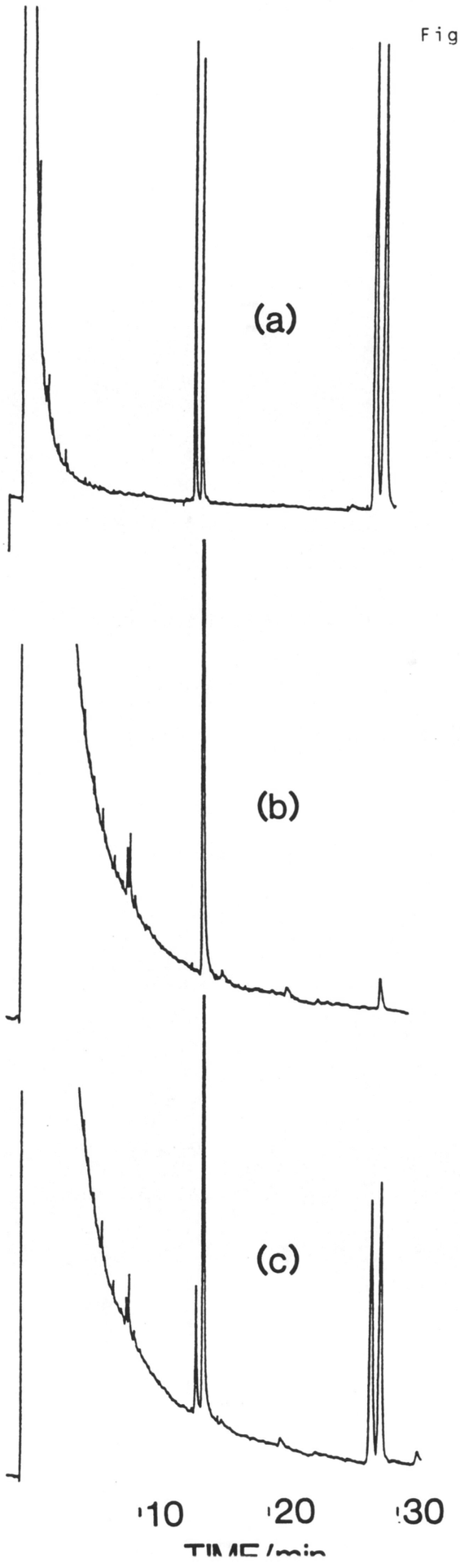


Figure 2







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(DIPTERA: TEPHRITIDAE: DACINAE)

Volume II - Taxonomy (Part A)

by

RICHARD ARTHUR IAN DREW

Publications submitted to the Faculty of Science,
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TWO NEW SPECIES OF DACINAE (DIPTERA: TRYPETIDAE) FROM NEW BRITAIN

By R. A. I. DREW*

[*Manuscript received September* 26, 1967]

Abstract

Two new species, *Asiadacus triangularis* and *Asiadacus nigrescens* are described and figured.

Asiadacus triangularis sp.n. (Fig. 1)

Types: NEW BRITAIN: *Holotype* male, 22 male *paratypes*, ex lure traps charged with methyl eugenol, December 1966. Collected by Sir Alan Mann. 2 male *paratypes* ex lure trap charged with 1-(p-hydroxyphenyl)-butan-3-one plus 1-(p-acetoxyphenyl)-butan-3-one, May 1967. Collected by D. F. O'Sullivan.

Holotype (Reg. No. T.6574) and 1 *paratype* (Reg. No. T.6575) in the Queensland Museum; 2 *paratypes* in the British Museum (Natural History); 2 *paratypes* in Australian National Insect Collection, C.S.I.R.O., Canberra; 2 *paratypes* in the Papua and New Guinea Public Museum and Art Gallery, Port Moresby; 2 *paratypes* in Dept of Agriculture, Stock and Fisheries, Konedobu, Papua; remaining 15 *paratypes* in Dept of Primary Industries, Brisbane, Queensland.

A medium sized species, generally fulvous in colour, with large facial spots, no post-sutural vittae but with a yellow triangle on mesonotum, first costal cell fulvous, second costal cell colourless, a narrow costal band, transverse infuscations, an anal streak and a black spot in the centre of fifth abdominal tergite.

Male.—

Length 5.4 mm; wing 5.3 mm.

Head.—Generally fulvous. Vertical length 1.4 mm. *Frons* of even width; length 1.5 times breadth; fulvous with no dark markings; bristles black: 1 *s.or.*, 2 *i.or.*; ocellar triangle black. *Face* with large circular spots reaching epistoma; length 0.65 mm; diameter of spot (0.23 mm) greater than width of third antennal segment. *Genae* fulvous, sub-ocular spot absent, bristle black. *Occiput* fulvous; occipital row weak, with 8-12 pale bristles each side. *Antennae* fulvous; arista with basal 1/3 fulvous (remainder dark brown); length of segments: 0.15 mm; 0.25 mm; 0.71 mm.

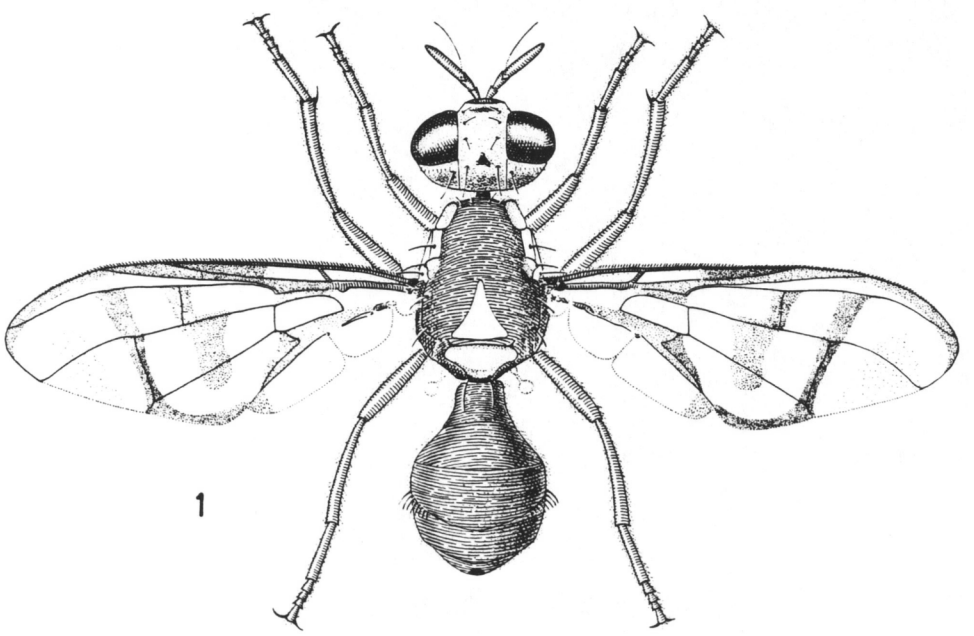
Thorax.—Fulvous, often with variable dark markings dorsally, which correspond with areas of attachment of flight muscles and vary with maturation of specimen. Yellow markings as follows: posterior 1/3 humeral calli; anterior 1/2 notopleural calli; band connecting humeral and notopleural calli; triangular mesopleural stripe reaching humeral callus above and continuing onto sternopleuron below as a transverse spot; upper 3/4 lower hypopleural calli (remainder of lower and the upper hypopleural calli fulvous); broad triangle on dorsal surface of mesonotum with base of triangle along posterior margin. *Postnotum* fulvous. *Scutellum* fulvous with yellow dorsally almost to posterior margin. *Bristles: sc.* 2, *prsc.* wanting, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; bristles black, except upper *p.sa.* fulvous. *Legs* fulvous; middle tibiae each with an apical black spur. *Wings:* first costal cell fulvous, second costal cell colourless; sparse microtrichia in outer portion of second costal cell only; remainder of wing colourless, except for the following fuscous markings—narrow costal band widening slightly after crossing R_{2+3} and ending midway between extremities of R_{4+5} and M_{1-2}; broad anal streak terminating at extremity of anal cell extension; transverse infuscation from R_{4+5}, enclosing outer median cross vein, the distal extremity of M_{3+4} and continuing along the wing margin to $Cu_1 + 1A$; infuscation enclosing r-m cross vein and widening into an irregular shape across veins M_{1+2} and M_{3+4}; a very pale area around extremity of M_{1+2}. The second costal cell shorter than stigma in the proportion 0.6: 1. r-m dividing M_{1+2} above discoidal cell in proportion of 1.5: 1. Proportion of anal cell extension to $Cu_1 + 1A$, 2.6: 1. A strong supernumerary lobe and a dense aggregation of microtrichia at the extremity of $Cu_1 + 1A$.

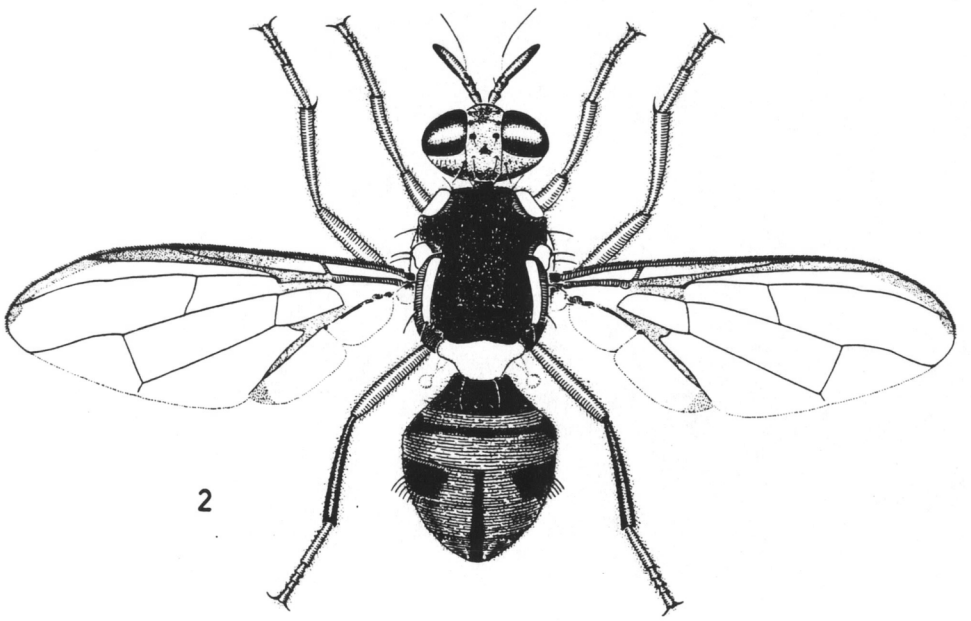
Abdomen.—Rounded; tergites free; colour fulvous with a black spot in the centre of fifth tergite; pecten present on third tergite.

*Entomology Laboratory, Department of Primary Industries, Indooroopilly, Queensland.

Comments

This species has been placed in the genus *Asiadacus* as defined by May (1963). It is similar in size and general body shape to *Asiadacus strigifinis* (Walker, 1861), but differs in shape of the yellow triangle on the mesonotum, larger facial spots, pattern of wing infuscation, absence of lateral post-sutural yellow vittae, and abdominal colouration. *A. triangularis* differs from *Asiadacus curvifer* (Walker) and *Asiadacus seguyi* (Hering) in size, body colouration and pattern of wing infuscation and from *Asiadacus emarginatus* (Perkins) and *Asiadacus pepisalae* (Froggatt) in





FIGS. 1, 2.—(1) *Asiadacus triangularis* sp.n. (x 10); (2) *Asiadacus nigrescens* sp.n. (x 9.5).

the presence of yellow triangle on mesonotum, pattern of wing infuscation and body colouration. *A. emarginatus* (Perkins) has smaller facial spots.

The *a.sa.* bristle is absent in three paratypes. The upper *p.sa.* bristle is weak.

Vestiges of an outer crossvein between R_{4+5} and M_{1+2} are present in three paratypes. Figure 3 is a drawing of the wing venation of one of these specimens.

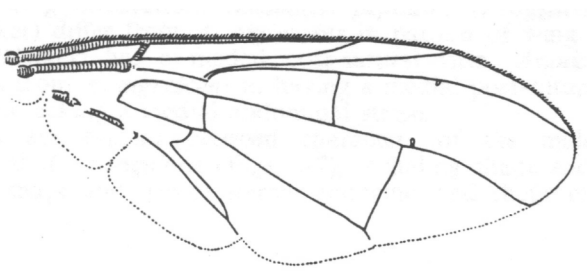


FIG. 3.—Wing venation of 3 paratypes of *Asiadacus triangularis* sp.n. showing vestiges of an outer cross vein between R_{4+5} and M_{1+2}

Asiadacus nigrescens sp.n. (Fig. 2)

Types: NEW BRITAIN: *Holotype* male, 2 male *paratypes*, ex lure traps charged with methyl eugenol, December 1966. Collected by Sir Alan Mann.

Holotype (Reg. No. T.6576) in Queensland Museum; 1 *paratype* in British Museum (Natural History); 1 *paratype* in Dept of Primary Industries, Brisbane, Queensland.

A dark coloured, medium sized species. facial spots trapezoidal, thorax black with lateral post-sutural vittae, mesopleural stripe narrow, wing with a narrow costal band and an anal streak. costal cells colourless, distinct medial black stripe on last three abdominal tergites.

Male.—

Length 6.6 mm; wing 5.8 mm.

Head.—Generally fulvous. Vertical length 1.6 mm. Bristles black. *Frons* of even width; Length 1.57 times breadth; fulvous except fuscous around orbital bristles and tending fuscous on central raised hump; latter covered with short black setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; ocellar triangle black. *Face*, length 0.7 mm; with trapezoidal facial spots slightly drawn out to a point anteriorly; width of spot (0.18 mm) less than width of third antennal segment; colour fulvous; lunule darkened. *Genae* fulvous; medium sized, brown, sub-ocular spots present; bristle black. *Occiput* fulvous, yellow along eye margin; occipital row strong, 6 bristles each side. *Antennae* fulvous, with fuscous on the apex and outer surface of the third segment; a strong black bristle on the second segment; arista fulvous proximally (remainder black); length of segments: 0.25 mm; 0.33 mm; 0.78 mm.

Thorax.—Black, with brown below humeral calli and lateral to post-sutural vittae; yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, slightly broader than notopleural callus above and continuing onto sternopleuron below as a transverse spot; upper hypopleural callus (posterior apex black); 5/8 lower hypopleural callus (remainder black); two moderately broad, lateral post-sutural vittae ending at the upper *p.sa.* bristle. *Postnotum* black. *Scutellum* pale yellow, except for narrow black basal band. *Bristles: sc.* 2, *prsc.* wanting, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs* fulvous except for middle and hind coxae and hind tibiae fuscous, and front coxae red-brown; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, with microtrichia in outer portion of second costal cell only; remainder of wings colourless except narrow fuscous costal band widening slightly after crossing R_{2+3} and ending midway between

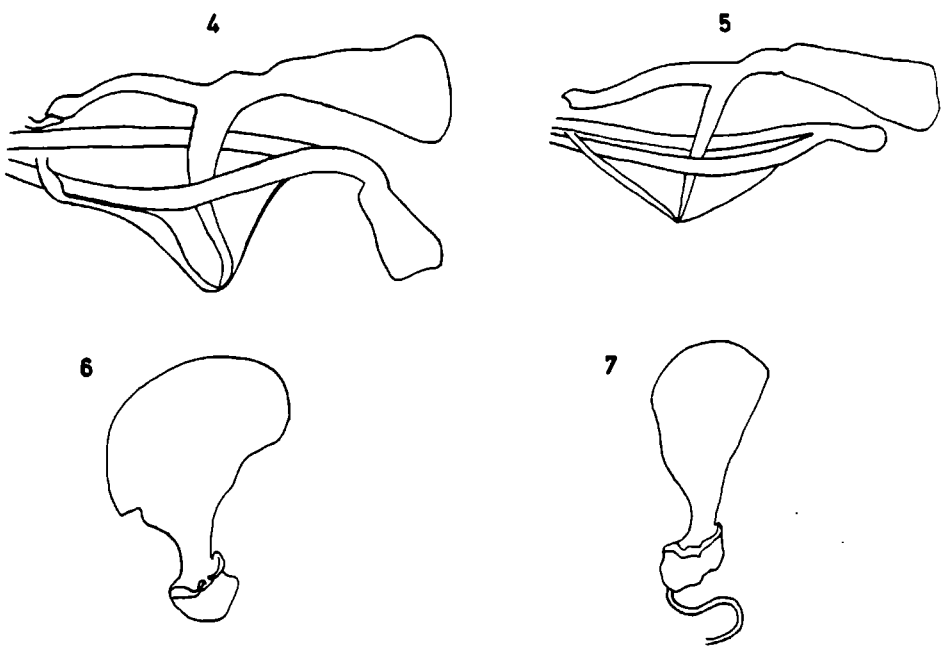
extremities of R_{4+5} and M_{1-2}, and a narrow fuscous anal streak ending at extremity of anal cell extension. A dense aggregation of microtrichia around extremity of vein $Cu_1 + 1A$. A strong supernumerary lobe. The second costal cell shorter than stigma in the proportion 0.8 : 1. r-m dividing M_{1+2} above discoidal cell in proportion of 1.4 : 1. Proportion of anal cell extension to $Cu_1 + 1A$, 2.2 : 1.

Abdomen.—Oval; tergites free; pecten present on third abdominal tergite. First tergite black; second tergite fulvous with a dark brown or black transverse line expanding into black areas laterally; third and fourth tergites reddish-brown with black laterally; fifth tergite dark amber with fuscous laterally; a prominent, medial, longitudinal, black band on last three tergites; a pair of shining spots on fifth tergite.

Comments

This species has been placed in the genus *Asiadacus* as defined by May (1963). It differs from *Asiadacus seguyi* (Hering) and *Asiadacus curvifer* (Walker) in size and in pattern of wing infuscation. *Asiadacus pepisalae* (Froggatt) and *Asiadacus strigifinis* (Walker) differ from *A. nigrescens* in pattern of wing infuscation, and *A. strigifinis* (Walker) has a medial post-sutural vitta. *Asiadacus emarginatus* (Perkins) differs from *A. nigrescens* in having a medial post-sutural vitta, a broad costal band, and lacking a medial abdominal stripe.

Differences are evident between characters of the male terminalia of *A. nigrescens* and *A. triangularis* (Figs. 4-7), including shape and size of fultella, width of vane, shape and size of sternal apodeme, and shape of the ejaculatory apodeme.



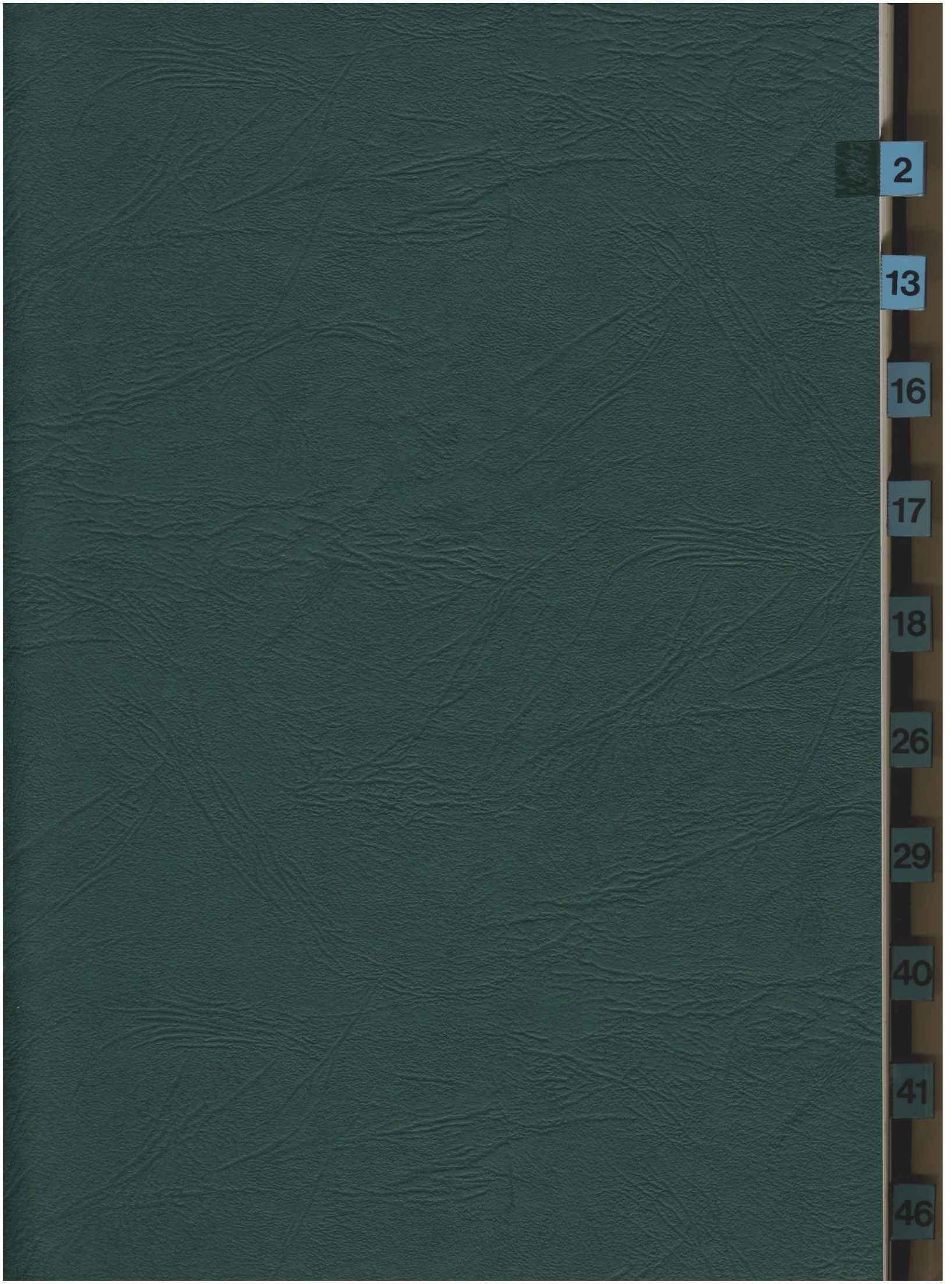
FIGS. 4-7.—Male terminalia: (4-5) lateral view of fultella and genital ring—(4) *Asiadacus nigrescens* sp.n., (5) *Asiadacus triangularis* sp.n.; (6-7) ejaculatory apodeme—(6) *A. nigrescens*, (7) *A. triangularis*.

ACKNOWLEDGEMENT

Mr. W. W. Manley, Dept of Primary Industries, Queensland, prepared the illustrations.

REFERENCE

MAY, A. W. S. (1963).—An investigation of fruit flies (Fam. Trypetidae) in Queensland 1. Introduction, species, pest status and distribution. *Qd J. agric. Sci.* **20**: 1-82.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TWO NEW SPECIES OF DACINAE (DIPTERA: TRYPETIDAE) FROM NEW GUINEA

By R. A. I. DREW*

[*Manuscript received June* 13, 1968]

Abstract

Two new species, *Strumeta brevistriata* and *Strumeta nigella* are described and figured.

Strumeta brevistriata sp.n. (Fig. 1)

Types: NEW GUINEA: *Holotype* male, 2 male *paratypes*, ex lure trap charged with 1-p-h at Wau, April, 1965. Collected by Dr. E. N. Marks.

Holotype (Reg. No. T.6611) in Queensland Museum; 1 *paratype* in British Museum (Natural History); 1 *paratype* in Department of Primary Industries, Brisbane, Queensland.

A medium sized species, facial spots absent or very faint and small, thorax black with narrow mesopleural stripes and lateral post-sutural vittae, costal cells colourless, narrow costal band and an anal streak, legs fulvous, abdomen fulvous with a very narrow medial abdominal stripe on fifth tergite. Chaetotaxy as for genus *Strumeta*.

Male.—

Length: *holotype* 6.8 mm, range for type series 5.9 to 6.8 mm; wing: *holotype* 6.3 mm, range for type series 6.1 to 6.3 mm.

Head.—Generally fulvous. Vertical length: holotype 1.5 mm, range for type series 1.45 to 1.53 mm. *Frons* of even width; length 1.5 times breadth; fulvous with fuscous markings at bases of orbital bristles; bristles black: 1 *s.or.*, 2 *i.or.*; ocellar triangle black; antero-medial hump with fuscous markings and covered with short dark setae; lunule fulvous except fuscous lateral to antennae. *Face*, length 0.45 mm; spots lacking, except very pale and small in one paratype; colour fulvous; *Genae* fulvous; small, brown sub-ocular spots present; bristle black. *Occiput* fulvous, with yellow along eye margin; occipital row with 4 to 6 strong black bristles each side. *Antennae* fulvous, with fuscous on apex and outer surface of third segment; arista fulvous proximally (remainder black); length of segments: 0.2 mm; 0.33 mm; 0.78 mm.

Thorax.—Black with brown along transverse suture of mesonotum, below and behind humeral callus and around *p.sa.* bristles. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes 1½ times the width of the notopleural callus above and continuing on to sternopleuron below as a transverse spot; upper hypopleural callus (posterior apex black); ⅛ lower hypopleural callus (remainder, including ventral margin, black); two lateral post-sutural vittae of medium width and narrowing posteriorly to end well before upper *p.sa.* bristle. *Postnotum* black. *Scutellum* yellow, except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black except *sc.* bristles dark brown basally. *Legs* fulvous; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, with microtrichia in outer portion of second costal cell only; remainder of wings colourless except narrow fuscous costal band bounded below by vein R_{2+3} and narrowing to end midway between veins R_{4+5} and M_{1+2}, and a wide fuscous anal streak ending along $Cu_1 + 1A$ before wing margin. A dense aggregation of microtrichia around extremity of vein $Cu_1 + 1A$. A weak supernumerary lobe. The second costal cell shorter than stigma in the proportion 0.66 : 1 in *holotype*, 0.66 : 1 to 0.71 : 1 range for type series. r-m dividing M_{1+2} above discoidal cell in the following proportions: *holotype* 1.65 : 1, range for type series 1.62 : 1 to 1.71 : 1. Proportion of anal cell extension to $Cu_1 + 1A$, 2.5 : 1.

Abdomen.—Oval; tergites free; fulvous pecten present on third abdominal tergite; first tergite fuscous, with posterior margin fulvous; second, third, fourth and fifth tergites light red-brown; a very narrow, median dark brown band on fifth tergite. A pair of shining spots on fifth tergite.

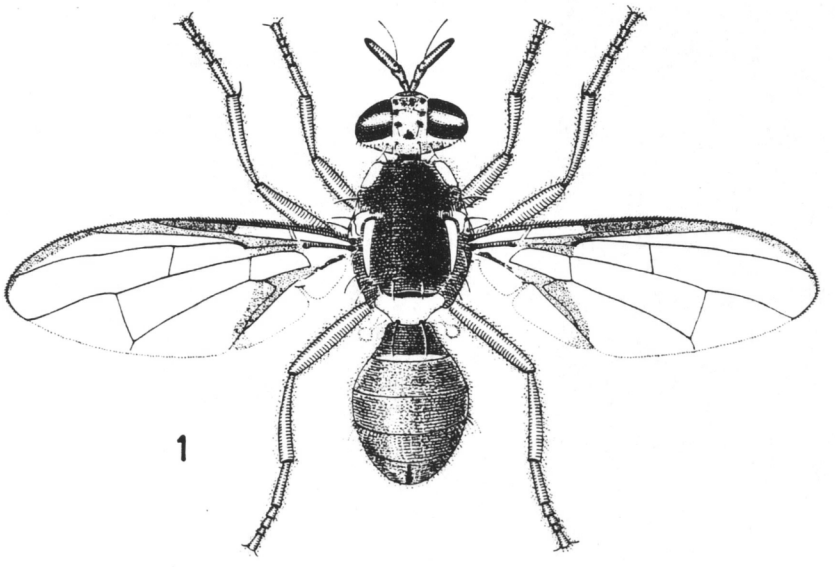
Comments

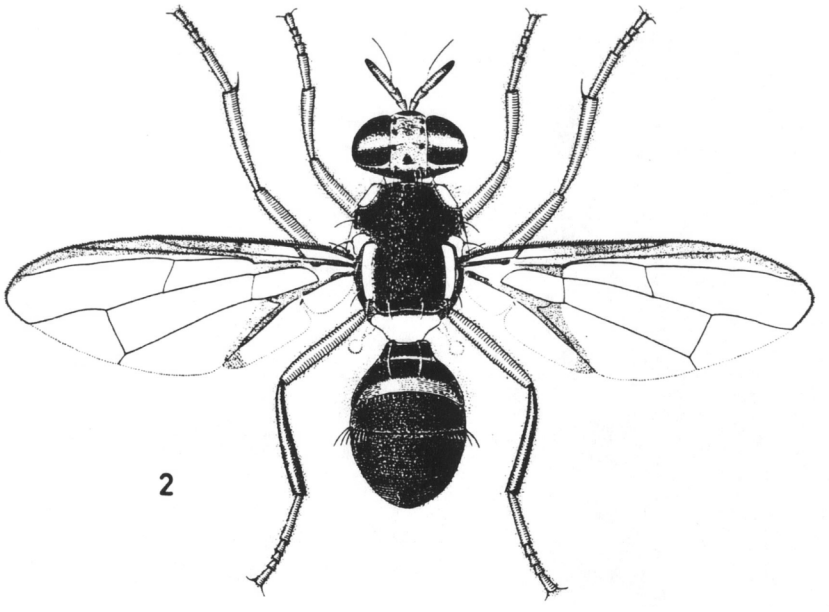
Strumeta brevistriata is similar to *Strumeta musae* (Tryon) and *Strumeta dorsalis* (Hendel) in general body colour, but the two latter species differ in the presence of distinct facial spots and in having hind tibiae dark brown. *S. musae* differs in possessing parallel sided post-sutural vittae which reach the upper *p.sa.*

*Entomology Laboratory, Department of Primary Industries, Indooroopilly, Queensland.

bristle, and in usually lacking a medial abdominal stripe. *S. dorsalis* differs in the presence of a distinct black medial abdominal stripe over the last three tergites and a black band along the anterior margin of third abdominal tergite.

Strumeta incertus (Malloch) and *Strumeta passiflorae* (Froggatt) resemble *S. brevistriata* in lacking facial spots. *S. incertus* differs in lacking post-sutural vittae, in having mesopleural stripe broad and reaching humeral callus above, thorax brownish-yellow, and possessing a medial abdominal stripe and a black band along anterior margin of third tergite. *S. passiflorae* differs in lacking post-sutural vittae, and in possessing black humeral calli and a black abdomen.





FIGS. 1, 2.—(1) *Strumeta brevistriata* sp.n. (x 7.5): (2) *Strumeta nigella* sp.n. (x 6.4).

Strumeta nigella sp.n. (Fig. 2)

Types: NEW GUINEA: *Holotype* male, 2 male *paratypes*, ex lure trap charged with methyl eugenol at Wau, April, 1965. Collected by Dr. E. N. Marks.

Holotype (Reg. No. T. 6612) in the Queensland Museum; 1 *paratype* in British Museum (Natural History); 1 *paratype* in Department of Primary Industries, Brisbane, Queensland.

A medium sized species, generally black in colour, facial spots small, thorax black with lateral post-sutural vittae, narrow mesopleural stripe, wing with a narrow costal band and an anal streak, first costal cell colourless, second costal cell with fulvous colouration around margins, chaetotaxy as for genus *Strumeta*, abdomen black.

Male.—

Length 6.6 mm; wing 6.1 mm.

Head.—Generally fulvous. Vertical length 1.5 mm. *Frons* of even width; length 1.4 times breadth; dark fulvous in colour, with brown markings at bases of bristles; bristles black: 1 *s.or.*, 2 *i.or.*; brown coloured antero-medial hump, covered with small dark coloured setae; ocellar triangle black; lunule darkened. *Face* fulvous with small, black, triangular spots, not reaching epistoma; width of spot (0.09 mm) less than width of third antennal segment; length 0.53 mm. *Genae* fulvous; medium sized brown sub-ocular spots present; bristle black. *Occiput* fuscous, except for yellow band along eye margin; occipital row with 8 strong black bristles each side. *Antennae* fulvous, except for fuscous on the apex and outer surface of third segment; arista black except basal ⅓ fulvous; length of segments: 0.23 mm; 0.28 mm; 0.83 mm.

Thorax.—Black, with a brown spot below the postero-ventral corner of humeral callus and dark brown lateral to post-sutural vittae. Yellow markings as follows: humeral callus (ventral margin dark brown and anterior margin brown); notopleural calli; narrow mesopleural stripe, slightly broader than notopleural callus above and continuing on to sternopleuron below as a small transverse spot; upper hypopleural callus (posterior apex black); ⅓ lower hypopleural callus (remainder, including ventral margin, black); two lateral post-sutural vittae of medium width, narrowing slightly posteriorly and ending broadly at or slightly before the upper *p.sa.* bristle. *Postnotum* black. *Scutellum* yellow, except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl* 2, *scp.* 4; all bristles well developed and dark brown. *Legs:* coxae and trochanters fuscous, femora fulvous, fore tibiae fulvous and darkened basally, middle tibiae fulvous, hind tibiae dark brown, tarsi fulvous; middle tibiae each with an apical black spur. *Wings:* first costal cell colourless, second costal cell colourless with fulvous distally and along subcostal vein, microtrichia in outer portion of second costal cell only; remainder of wings colourless except narrow fuscous costal band extending below R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending midway along vein $Cu_1 + 1A$. A dense aggregation of microtrichia around extremity of vein $Cu_1 + 1A$. A weak supernumerary lobe. The second costal cell shorter than stigma in the proportion 0.7 : 1. r-m dividing M_{1+2} above discoidal cell in proportion of 1.4 : 1. Proportion of anal cell extension to $Cu_1 + 1A$, 2.0 : 1.

Abdomen.—Elongate-oval; tergites free; pecten present on third abdominal tergite; first tergite black with a narrow fulvous band medially along the posterior margin; second tergite black with a wide fulvous band along the posterior margin, but ending before the lateral margins; third, fourth and fifth tergites black; a pair of shining spots on fifth tergite.

Comments

There are many species of *Strumeta*, found in the South Pacific, that are generally black in colour. *S. perfuscus* (Aubertin) and *S. passiflorae* (Froggatt) differ from *S. nigella* in the absence of facial spots. *S. perfuscus* differs in possessing a black scutellum and in leg colouration. *S. passiflorae* differs in possessing black humeral calli, lacking post-sutural vittae and in leg colouration.

S. atra (Malloch), *S. carbonarius* Hendel and *S. kirki* (Froggatt) all differ from *S. nigella* in possessing a black scutellum. In addition, *S. atra* lacks a definite costal band and post-sutural vittae, *S. carbonarius* has brown humeral calli, and *S. kirki* lacks post-sutural vittae and differs in abdominal colouration.

S. atramentata Hering differs from *S. nigella* in colour of scutellum (yellow with black medial band) and in possessing black humeral calli. *S. lineata* Perkins differs in possessing short, narrow post-sutural vittae, black humeral calli and in leg and abdominal colouration. *S. exspoliata* Hering differs in lacking post-sutural vittae, and *S. obscurus* (Malloch) differs in abdominal colouration.

ACKNOWLEDGEMENT

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ECONOMIC FRUIT FLIES OF THE SOUTH PACIFIC REGION

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(1) PREPARATION OF MATERIAL FOR TAXONOMIC STUDIES

ADULTS—Previously, damage has been caused to valuable adult fruit fly specimens in collections through incorrect pinning methods. Many important taxonomic characters exist on the thorax and these are destroyed by placing large pins through this area.

The best method of setting adult specimens for holding in permanent collections is to place a stainless steel micropin dorsoventrally through the thorax (in the mesonotal area), and then stage the steel on a piece of polyporus pith about 1.2 cm long. The pith can then be supported in collection drawers (or storage boxes) by stainless steel insect pins. This method results in a minimum of damage to the specimen.

Equipment necessary for pinning adult specimens may be obtained in Australia from—Australian Entomological Supplies, 35 Kiwong Place, Yowie Bay, New South Wales, 2228.

The equipment mentioned is as follows:—
"Minuten" stainless steel pins (micropins),
Polyporus pith (about 3 mm square),
"Asta" stainless steel pins (No. 5, 3.7 cm).

LARVAE—Identification of larval specimens to species is extremely difficult and not yet possible in most cases. For this reason, when larvae are collected in fruit it is generally best to rear them through to the adult stage for identification, as described in Section IV (5).

If collected larvae must be killed, they should be placed in hot Dietrich's fixative solution (60 parts water, 30 parts 95 per cent ethanol, 10 parts formalin, 1 part glacial acetic acid) for 2 hours and then transferred to 80 per cent ethanol.

Also it should be noted that for the few species that can be identified as larvae the identification is based on characters of mature or final stage larvae.

GENITALIA AND ABDOMINAL STERNITE PREPARATION—In the male, the shape of abdominal sternites I and V and certain structures on abdominal segment IX (the genital segment) have been found valuable at the generic level (Drew, 1972a) and parts of the ovipositor have provided useful characters at the species level (Hardy, 1973; 1974).

In addition, measurements of some male endoskeletal structures in the genital segment have been found useful in assessing the physiological age of specimens (Drew, 1969).

Some of the characters on the male genital segment and abdominal sternites can be studied *in situ*. If additional microscope examination is required, the methods of preparation described below should be found suitable. Methods of preparation necessary for studying the ovipositor and the male endoskeletal structures are also described.

Male endoskeletal structures:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes, allow to soak in this solution for 12-24 hours;
(b) cut abdomen open and clean out;
(c) wash abdomen in 10 ml water containing a few drops of 10 per cent acetic acid;
(d) wash abdomen in three different sets of distilled water;
(e) stain in mercurochrome stain for 10 minutes (a 1 per cent solution of stain powder mixed in water);
(f) place in absolute alcohol for 2-3 minutes;
(g) place in clove oil for 15 minutes;
(h) dissect the structures from the abdomen and mount in canada balsam—the flat section of the genitalia (the fultella) should be mounted on a flat glass microscope slide; the three-dimensional sections of the genitalia should be mounted in a glass cavity microscope slide (in the cavity they can be moved into a suitable position before they set firm, in order to facilitate subsequent examination).

If mounts of the fultella are required for measuring for age studies, staining in chlorazol black E stain was found to be better than mercurochrome.

Male abdominal sternites:

(a) to (d) as for male endoskeletal structures;
(e) stain in chlorazol black E stain for 5 minutes (a 0.5 per cent solution of stain dissolved in 70 per cent ethanol);
(f) place in absolute alcohol for 2-3 minutes;
(g) place in clove oil for 15 minutes;
(h) mount sternites on a flat glass microscope slide in canada balsam; the sternites are small and surrounded by membrane, thus allowing the entire ventral area (including all sternites) to be removed from the abdomen in one layer for mounting on a slide.

Ovipositor:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes;
(b) wash thoroughly in water;
(c) place in chloralphenol or phenol until cleared enough to allow suitable differentiation of characters under the microscope (chloralphenol is a mixture of equal parts of chloral hydrate and phenol); this process usually takes about 15 minutes;
(d) mount in euparal on a flat glass microscope slide.

Male genital segment:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes, allow to soak in this solution for 12-24 hours;

either

(b) treat as for (b) and (c) in ovipositor technique,

or

(c) stain with mercurochrome stain as for male endoskeletal structures (b) to (g);

(d) dissect the genital segment from the remainder of the abdomen and mount in a glass cavity microscope slide, either as for (d) in the ovipositor technique or (h) in the male endoskeleton technique; this three-dimensional structure can be moved around in the cavity before setting until the required area of view is visible.

(2) STUDY OF MATERIAL

Some characters important in identification, namely, male and female genitalia, thoracic bristles and microtrichia in the costal cells require clear, high power, stereo microscopy. For example, often the bristles are broken off and so high power examination is required to see if they were present or always absent. It is, therefore, impossible to identify most fruit fly species without the aid of a good quality stereo microscope.

Thoracic colours are often difficult to see under the microscope due to the reflection of light off minute hairs on the mesonotum. This problem can be overcome by turning the specimen with the head pointing away from the light source and wetting the mesonotum with absolute alcohol using a fine hair brush.

Important characters occur on the head, thorax, abdomen, wings and legs. For this reason, specimens should be maintained in the best possible condition and particular care should be taken during transportation of collected material from the survey areas to the laboratory.

(3) MORPHOLOGY

This section is devoted to an explanation of the morphological characters of adult fruit flies, with particular reference to the taxonomic characters.

HEAD (Figures 1, 2)

Frons—that area on the anterior surface of the head, bounded by the eyes laterally and between the black ocellar triangle (which is on the dorsal margin of the head) and the antennae.

Antero-medial hump—a small hump in the centre of the frons.

Superior fronto-orbital bristles (s.or.)—the most dorsal pair of bristles on the frons—there is always only one pair in the subfamily Dacinae (tropical fruit flies).

Inferior fronto-orbital bristles (i.or.)—the two or three pairs of bristles that occur on the frons below the *s.or.* bristles.

Lunule or frontal lunule—a small raised area between the antennal bases and the frons.

Vertex—the dorsal area of the head between the eyes, frons and occiput.

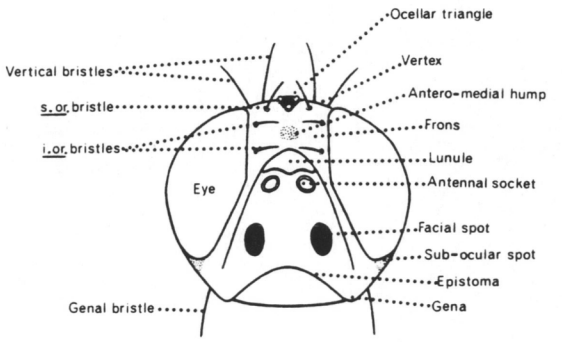

Figure 1—Head of fruit fly (Tephritidae: Dacinae)—anterior view

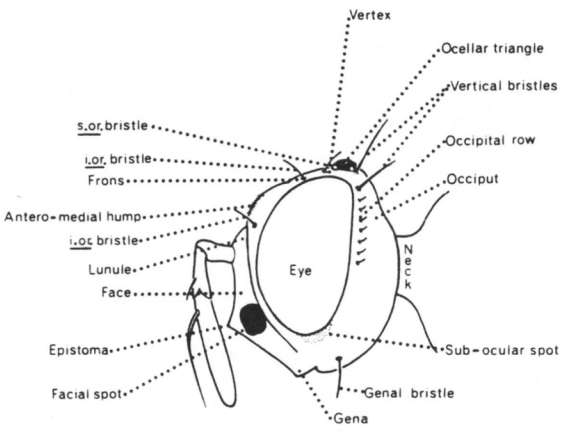

Figure 2—Head of fruit fly (Tephritidae: Dacinae)—lateral view

Face—an inverted V-shaped area on the anterior surface between the antennae and the ventral margin of the head (epistoma).

Facial spots—two dark spots are often present, one on each ventrolateral corner of the face. The presence or absence of these spots is a valuable species character. In some species the face is entirely black.

Epistoma—the ventral margin of the face.

Genae—the area of the head on each side below the eyes.

Sub-ocular spots—a dark spot on each gena adjacent to the eye margin.

Occiput—the whole posterior area of the head below and behind the eyes.

Occipital rows—a row of bristles on the occiput along the posterior margin of each eye.

Antennae—the antennae are 3-segmented and possess an arista (elongate bristle) on the dorsal surface of each apical segment (segment III). The ratio of the combined lengths of the three antennal segments to the vertical length of the head is an important generic character.

THORAX (Figures 3, 4, 5)

Humeral calli—rectangular protuberances on the anterolateral corners of the dorsal surface of the thorax. These are part of the mesothorax.

Notopleural calli—raised triangular protuberances on the notopleura, between the humeral callus and the base of the wing. There is one notopleural callus on each side of the thorax. The colour of the humeral and notopleural calli is an important taxonomic character.

Hypopleural calli—two rounded raised protuberances on each side of the thorax posteroventral to the wing base.

Postnotum—the plate on the posterior end of the thorax below the scutellum and between the hypopleural calli.

Sternopleura—the region below the mesopleuron and pteropleuron and above the fore and mid coxae on each side of the thorax.

Scutellum—a triangular section cut off by an impressed line from the posterior margin of the mesonotum.

Bristles—*sc.* = 2 or 4 bristles on the scutellum.

prsc. = prescutellar bristles—2 bristles on the posterior margin of the mesonotum just anterior to the scutellum—these bristles may be present or absent.

p.sa. = posterior supra-alar bristles—a pair of bristles above the base of each wing, on the posterolateral corners of the mesonotum; in lateral view, one bristle is dorsal to the other and in line with the lateral post-sutural vitta.

a.sa. = anterior supra-alar bristles—a bristle directly above the base of each wing on the lateral margin of the mesonotum; these bristles may be present or absent.

mpl. = mesopleural bristles—a bristle on the mesopleuron below each notopleural callus.

npl. = notopleural bristles—a pair of bristles on each notopleural area—the posterior notopleural bristle is on the apex of the triangular notopleural callus and the anterior notopleural bristle is midway between the humeral and notopleural calli.

scp. = scapular bristles—four bristles along the anterior margin of the mesonotum.

The number of *sc.* bristles and the presence or absence of *prsc.* and *a.sa.* bristles are valuable taxonomic characters at the subgeneric level.

Mesopleural stripes—a yellow band on each lateral surface of the thorax which covers the posterior margin of the mesopleuron, the anterior margin of the pteropleuron and usually continues onto the upper margin of the

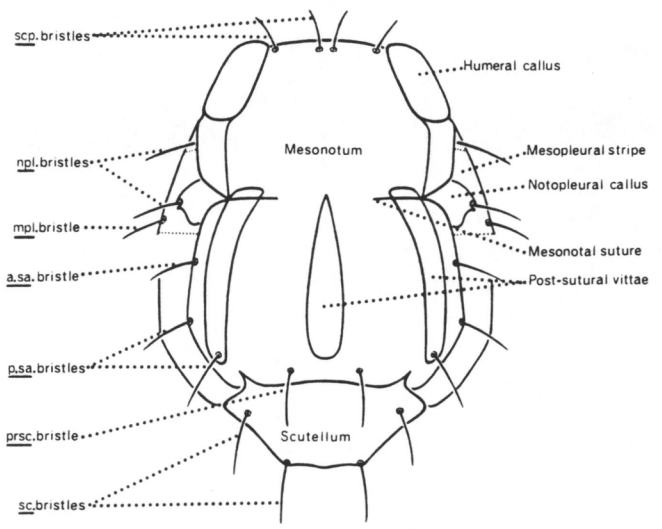

Figure 3—Thorax of fruit fly (Tephritidae: Dacinae)—dorsal view

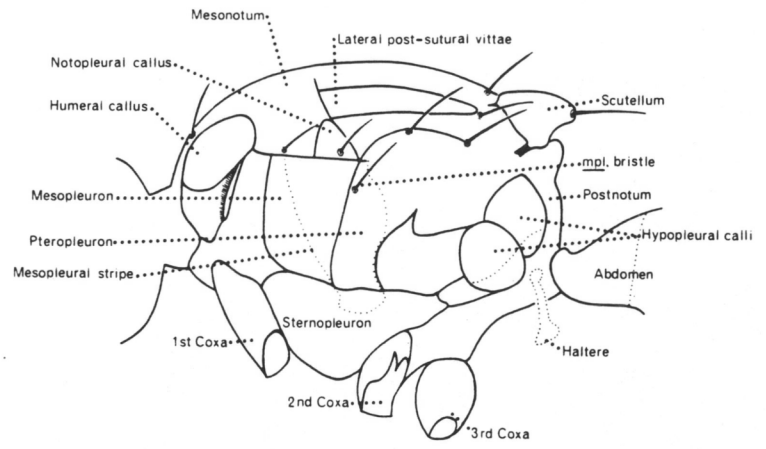

Figure 4—Thorax of fruit fly (Tephritidae: Dacinae)—lateral view

sternopleuron. The shape and size of these stripes are important species characters, especially their width in relation to the humeral calli.

Lateral post-sutural vitta—a yellow band (or stripe) along each lateral margin of the mesonotum; these stripes vary in shape and size, may begin at or anterior to the mesonotal suture and end before, at or posterior to the upper *p.sa.* bristle. Also a lateral yellow band often connects the humeral and notopleural calli.

Medial post-sutural vitta—a single median yellow band running along the mid line of the mesonotum.

The presence or absence of these post-sutural vittae, their shape, size and length in relation to the upper *p.sa.* bristles are valuable taxonomic characters.

Mesonotal suture—an impressed line on the mesonotum, running from the inner margin of each notopleural callus towards the centre of the mesonotum. A triangular yellow band may run from each notopleural callus along the mesonotal suture.

Legs—the shape of the major leg segments (coxa, femur, tibia and tarsus) does not vary between species; the colour of these segments however, does often vary and is a valuable taxonomic character. In one species, *Callantra petioliforma* May, there is a row of spines along the ventral margin of the fore femora (Figure 52).

Wings—veins: the wing venation is reduced as a result of fusion of some veins. An explanation of the venation is best gained from studying Figure 5. Veins R_2 and R_3 are fused to give vein R_{2+3}, R_4 and R_5 fused to R_{4+5}, M_1 and M_2 fused to M_{1+2}, M_3 and M_4 fused to M_{3+4}, and CuA and 1A are fused at their extremities to give CuA+1A. There is usually a dense mass of microtrichia at the extremity of CuA+1A in males, but this is absent in females.

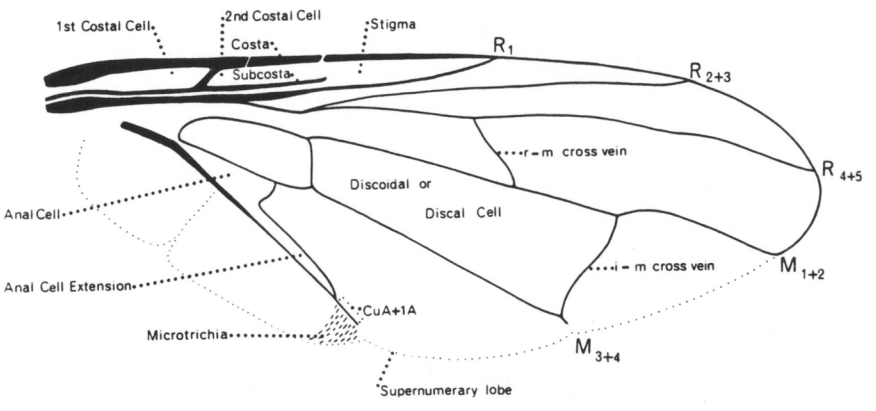

Figure 5—Wing of fruit fly (Tephritidae: Dacinae)

Important characteristics of the family Tephritidae are—(a) two breaks in the costal vein on the anterior margin of the wing above the second costal cell; and (b) the short, fine sub-costal vein in the second costal cell.

cells: the cells in the wing and the supernumerary lobe are illustrated in Figure 5. Within the costal cells there is often a mass of small microtrichia and the presence or absence of these is a specific character. The supernumerary lobe is reduced in size in the males of some species and in the females of all species. The presence or absence of colour in the costal cells is an important species character.

colour patterns: there are important taxonomic characters in the variations of colour patterns in the wing. These patterns are often termed infuscations because of their fuscous colouration. Within the subfamily Dacinae, there is almost always a fuscous costal band running around the costal margin from the wing base to the apex of the wing and a fuscous anal streak which runs through the anal cell and above the anal cell extension and vein CuA + 1A to the wing margin (Figure 51). There is considerable variation between species in the width of the costal band and in the numerous colour patterns that occur across the wing in addition to the costal band and anal streak. The costal band is classed as narrow if it is confluent with or overlaps vein R_{2+3} but does not reach vein R_{4+5}. It is broad if it is confluent with or overlaps vein R_{4+5}.

ABDOMEN (Figures 6, 7)

The general abdominal shape in dorsal view can be—(a) petiolate and clavate (club-shaped); (b) elongate-oval; or (c) oval. In the male there are five well developed abdominal segments, segments VI to VIII are absent, while segment IX exists as a reduced genital segment (Drew, 1969). Characters on segment IX and abdominal sternite V of the male are valuable at the generic

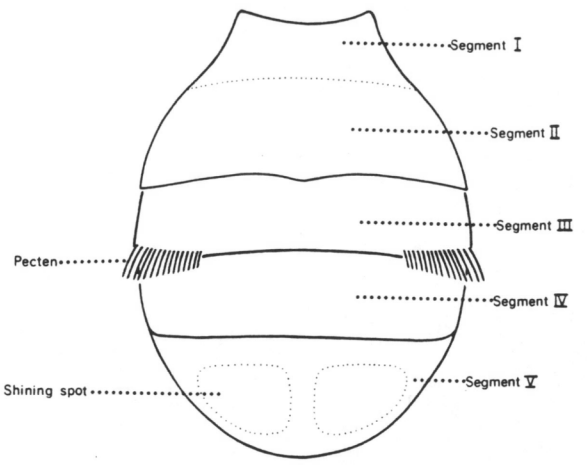

Figure 6—Abdomen of fruit fly (Tephritidae: Dacinae)—dorsal view

level. In the female, abdominal segments I to V are well developed, segment VI is absent while segments VII to IX are modified to form the ovipositor (Drew, 1969). Abdominal tergites I to V are usually free but in a few species they are fused.

In the male of most species there is a pecten (or comb) of cilia on the posterolateral corners of tergite III, and a pair of large oval shining spots on tergite V.

Abdominal shape, fusion or non-fusion of abdominal tergites, presence or absence of cilia on tergite III and variation in abdominal colour patterns, are all valuable taxonomic characters.

Hardy (1973, 1974) has demonstrated that characters on the apical segment of the female ovipositor (abdominal segment IX) are also good for species differentiation.

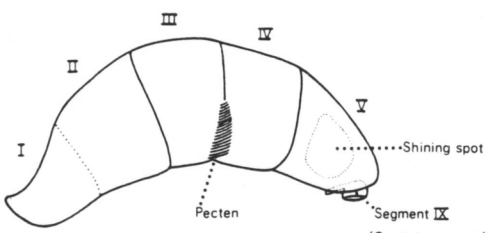

Figure 7—Abdomen of fruit fly (Tephritidae: Dacinae)—lateral view

COLOUR PATTERNS

Thoracic and abdominal colour patterns are depended upon for separation of fruit fly species and this causes many difficulties in identification of specimens. Within a species it is common to find extremely large variations in colour patterns (see Drew, 1974b: pp. 65, 71, 90) and this has been a cause of mis-identification by some workers. Such intra-specific variation must be understood and this can only be done by studying large series of specimens. Once such studies have been undertaken colour patterns become quite valuable taxonomic characters.

The main colours referred to in species keys are fuscous (a plain mixture of black and red), fulvous (tawny or brownish-yellow), black (dull or glossy), yellow, orange-brown, red-brown, brown.

(4) FRUIT FLY SPECIES OF ECONOMIC IMPORTANCE

In this section, all species of economic or potential economic importance in the South Pacific region are discussed. It is important to realise that many of these species have the potential to become serious economic pests either in the regions where they presently occur (if horticulture is developed in these regions in future years) or in countries with already well developed horticulture (if such species are introduced to these countries).

It is hoped that information provided in this section will assist entomologists to identify readily the fruit fly species which present a serious threat to fruit and vegetable industries in the South Pacific area. The quick and accurate identification of these species is of vital importance to the application of control, suppression or eradication techniques. These techniques vary with each species and must be applied as soon as possible after the detection of a new introduction or outbreak.

Extensive fruit fly monitoring programmes in northern and eastern Australia have provided considerable data on the distribution of species. As a result, it is possible to give updated distribution records for most species. For species either new to Australia or with a wide distribution range, maps are presented.

In this section, subgenus *Dacus (Bactrocera)* Macquart is used instead of *Dacus (Strumeta)* Walker because *Strumeta* is a junior synonym of *Bactrocera* (Hardy, 1976). *Strumeta* has been used consistently as a subgenus of *Dacus* by most taxonomists involved with the subfamily Dacinae. However, the status of *Bactrocera* is now clear and this subgenus must be used for all species formerly placed in *Strumeta*.

Hardy (1951) showed that the species name *bilineatus* (Perkins and May) is preoccupied in the genus *Dacus* by *D. bilineatus* Walker. Hardy (1959) also showed that *D. bilineatus* Walker belongs to the genus *Dimeringophrys* Enderlein within the subfamily Trypetinae. Because *bilineatus* is a pre-occupied name, Hardy (1951) established a new name for the species described by Perkins and May. He named it *Dacus mayi* Hardy. In subsequent literature on Australian Tephritidae (May, 1953; 1957; 1963) the name *mayi* was overlooked and *bilineatus* used incorrectly. This has caused some confusion for later workers and this explanation is given for the use of *mayi* Hardy in the following section.

The known commercial hosts are also given for each species.

(A) Species within Australia—Some species in this section also occur in countries outside Australia.

Callantra aequalis (Coquillett)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Ayr (northern Queensland).

A large wasp-like species; facial spots large and elongate; thorax red-brown to fuscous; lateral post-sutural vittae absent; mesopleural stripes narrow; triangular yellow markings along anterior margin of mesonotal suture; humeral calli fuscous; notopleural calli yellow; scutellum yellow to fulvous; wing with a very broad fuscous costal band confluent with M_{1+2}; costal cells fuscous with microtrichia covering all of both cells; abdomen generally fuscous with a large oval red-brown spot on centre of tergite V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except large fuscous spots around orbital bristles and on antero-medial hump; latter covered with pale setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule red-brown to fuscous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with large, elongate black spots almost reaching to epistoma. *Genae* fulvous; large, dark fuscous sub-ocular spots present; bristles fuscous. *Occiput* red-brown, yellow along eye margin; occipital rows with 4-7 well developed fuscous bristles each side. *Antennae* red-brown; a strong red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura fuscous, tending red-brown below humeral calli. Mesonotum red-brown to fuscous with no dark markings. Yellow markings as follows: notopleural calli; narrow triangles running along anterior margin of mesonotal suture, with bases at notopleural calli and apices at inner margins of mesonotal suture; very narrow mesopleural stripes, each less than width of notopleural callus above, extending onto sternopleuron below as a small yellow spot, anterior margin straight; anterior corners of upper hypopleural calli (remainder fuscous); a broad band across centre of lower hypopleural calli (remainder fuscous). Humeral calli fuscous. Lateral post-sutural vittae absent. *Postnotum* red-brown to fuscous. *Scutellum* yellow to fulvous except for a broad triangular fuscous basal band. *Bristles: sc.* 2, *prsc.* absent, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; bristles generally weak and red-brown to fuscous. *Legs:* coxae and femora fuscous to dark fuscous, tibiae fuscous, tarsal segments fulvous; middle tibiae each with an apical black spur. *Wings:* costal cells fuscous, microtrichia covering all of both costal cells; reminder of wings tinged with extremely pale fuscous except fuscous stigma, very broad costal band confluent with M_{1+2} for its entire length, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A in male. Supernumerary lobe weak in both sexes.

Abdomen—Elongate, clavate and slightly petiolate; tergites fused; pecten present on tergite III of male. Tergite I fuscous, tending towards red-brown along intersegmental line between tergites I and II. Tergite II fulvous except for a very large oval fuscous spot over the anterior 2/3 of the tergite but not reaching lateral margins. Tergites III to V fuscous except for a large oval red-brown spot on centre of tergite V and a very narrow pale fuscous medial longitudinal band on tergite V. In some specimens the red-brown spot and the medial longitudinal band extend onto tergite IV. Often the medial longitudinal band is absent or reduced to small narrow lines. Ovipositor strongly developed with the visible portion of oviscape red-brown, large, oval in transverse cross section and tapering sharply posteriorly in dorsal view.

Comments—There is little evidence that *C. aequalis* is capable of breeding in any commercial fruits. The only commercial host record is from the type specimens which were reported as being bred from orange at Gosford, New South Wales (Froggatt, 1909: p. 91). The absence of subsequent commercial host records for this species throws some doubt on the authenticity of the host record for the type specimens. Consequently, this species is included in this paper for discussion but it is not regarded as an economic pest.

Dacus (Afrodacus) jarvisi (Tryon)

(Figure 8)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Innisfail (northern Queensland).

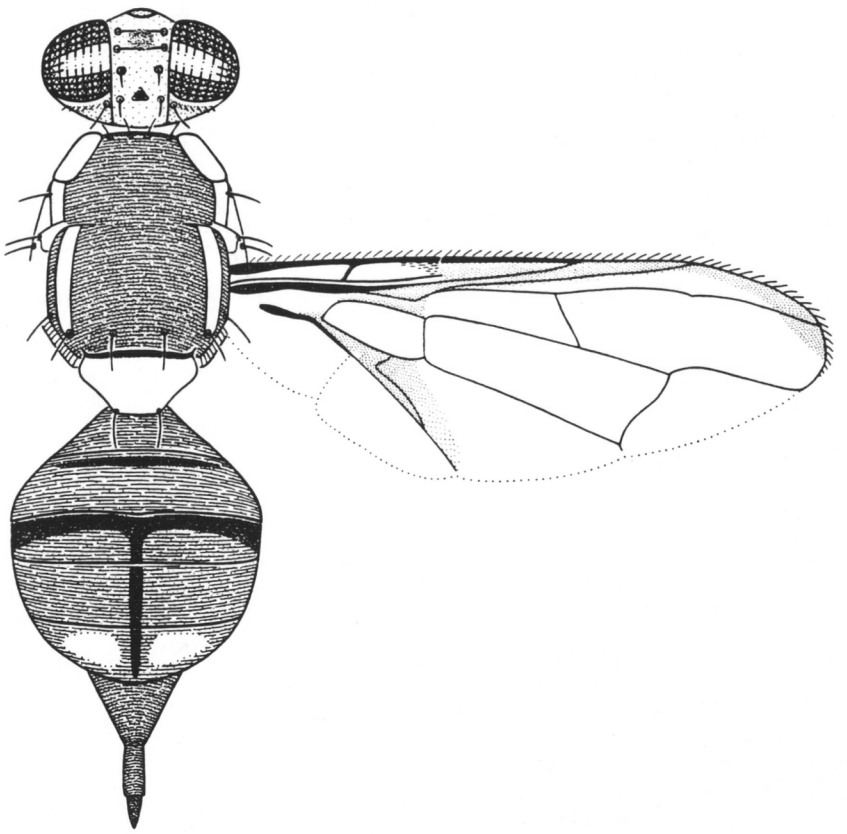

Figure 8—*Dacus (Afrodacus) jarvisi* (Tryon) (X14)

A medium sized pale species; facial spots small and oval; thorax red-brown with no dark markings; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow and joined by a lateral yellow band; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless with microtrichia in outer portion of second costal cell only; abdomen with tergites III to V orange-brown except for a narrow transverse black band along anterior margin of tergite III and a narrow medial longitudinal fuscous to black band over all three tergites.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with at most pale fuscous around *s.or.* bristles and on antero-medial hump; latter covered with short pale setae; bristles fulvous to dark fulvous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small, oval black spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 3-5 well developed fulvous bristles and a large number of small pale bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; pale fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; lateral bands connecting humeral and notopleural calli; medium sized mesopleural stripes, each ending at anterior *npl.* bristle above, continuing onto sternopleuron below, anterior margin convex; upper hypopleural calli (posterior apices red-brown or fuscous); anterior $\frac{1}{3}$ lower hypopleural calli (remainder red-brown or fuscous); two moderately broad, parallel sided, lateral post-sutural vittae ending behind upper *p.sa.* bristles. *Postnotum* red-brown. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band just overlapping R_{2+3} and expanding at apex of wing to end midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I fulvous; tergite II fulvous except some specimens with a narrow transverse pale fuscous band along anterior margin but not reaching lateral margins; tergites III to V orange-brown except for a narrow transverse fuscous to black band along anterior margin of tergite III (not reaching lateral margins in some specimens) and a narrow medial longitudinal fuscous to black band on tergites III to V (this band varies in colour and continuity and it often exists only as a spot on tergites IV and V). A pair of shining spots on tergite V.

Comments—D. jarvisi occurs across northern Australia from Broome in Western Australia to Cape York in Queensland, along the entire eastern coast of Queensland and south to the Sydney area in New South Wales (Figure 9). In Queensland, this species is a pest of deciduous fruits, mangoes, persimmons and guavas. May (1963) classified this species as one of major importance and

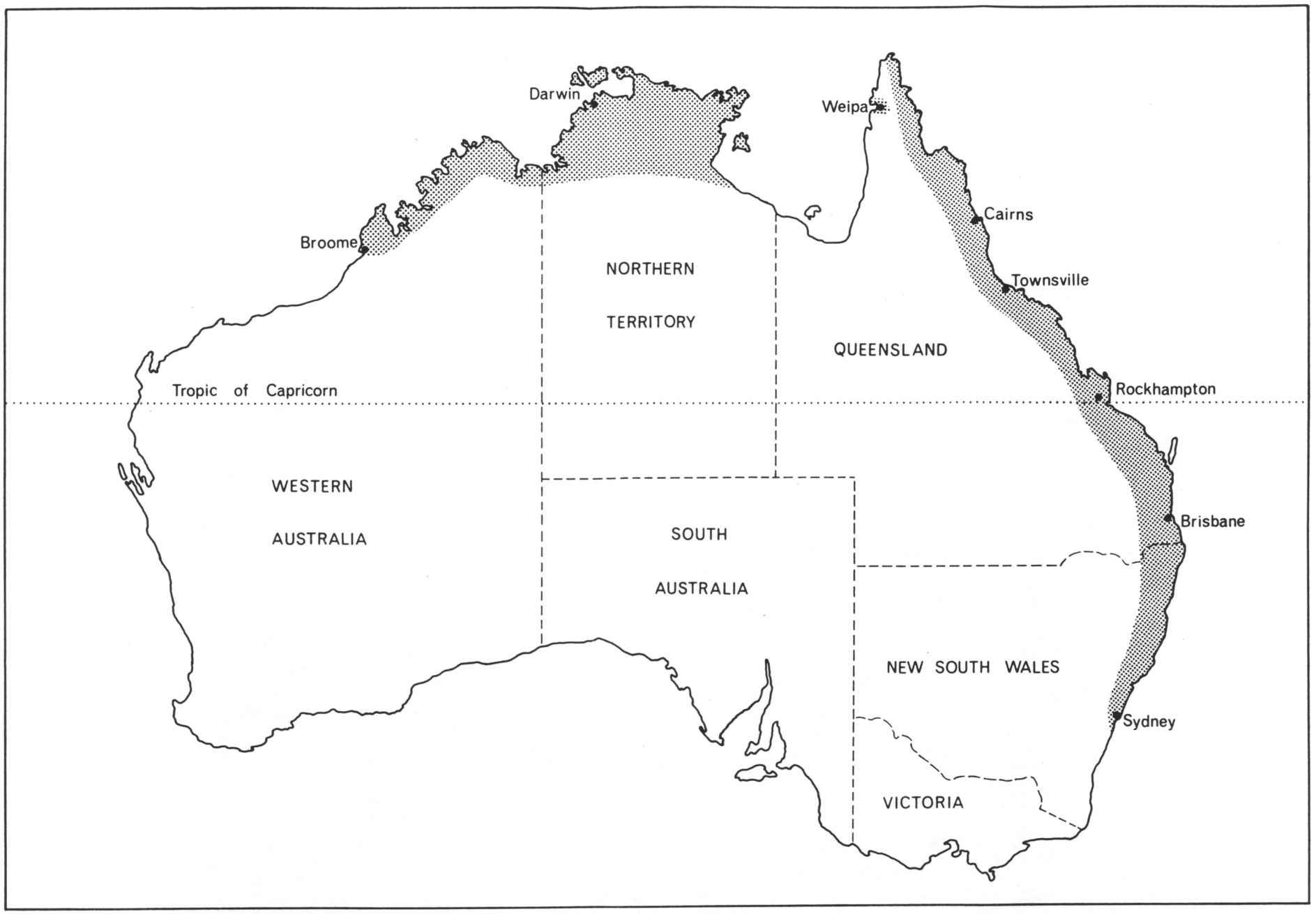

Figure 9—Map of Australia showing distribution of *D. iarvisi*

stated that, throughout its range, it is supported from season to season by commercial hosts.

It is more prevalent and more abundant in the northern areas of Queensland than in the southern part of its distribution. Because it does not respond to male lures, it is difficult to monitor and so its exact distribution is presently unknown.

Dacus (Austrodacus) cucumis French

(Figure 10)

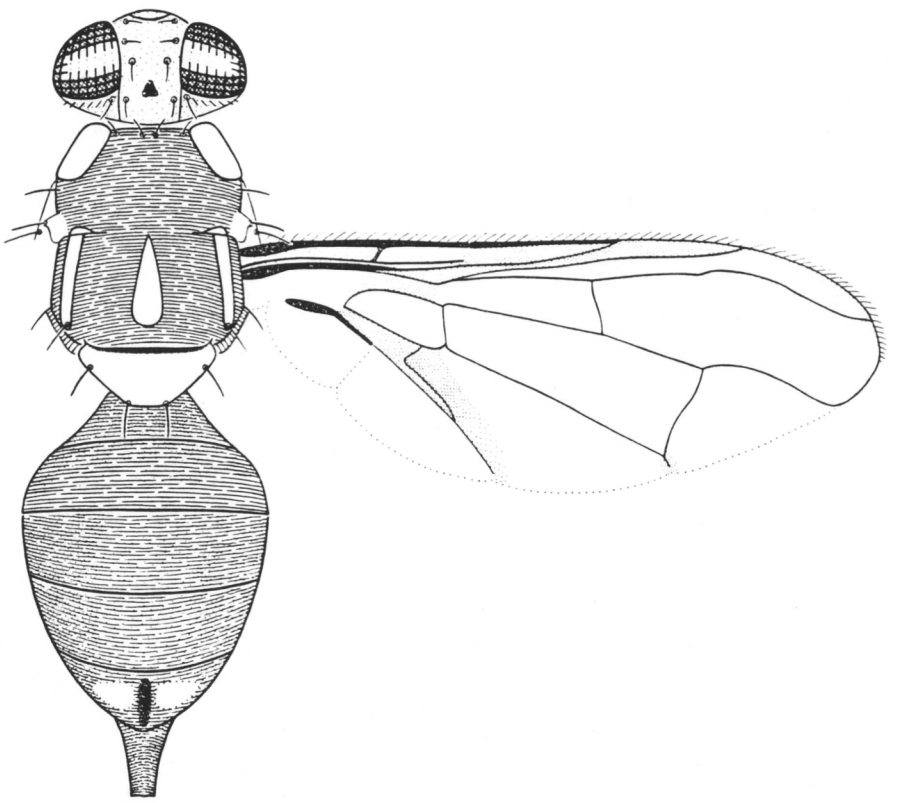

Figure 10—*Dacus (Austrodacus) cucumis* French (X13)

Material studied: A series of specimens collected at localities from Gatton (south-eastern Queensland) to Cairns (northern Queensland).

A medium sized pale species; facial spots small and oval; thorax orange-brown; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells pale fulvous with microtrichia in outer portion of second costal cell only; abdomen fulvous with broad lateral longitudinal orange-brown bands over tergites III to V and a narrow medial longitudinal orange-brown to fuscous band on tergite V (this may be of varying length over tergites III to V).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump covered with short pale setae; bristles fuscous: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small, circular fuscous or black spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-6 well developed fulvous or fuscous bristles each side. *Antennae* fulvous; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Orange-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a large yellow spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{3}{4}$ lower hypopleural calli (remainder red-brown); two moderately broad parallel sided lateral post-sutural vittae, beginning anterior of mesonotal suture and ending behind upper *p.sa.* bristles; a broad medial post-sutural vitta beginning at level of mesonotal suture and ending just before line of upper *p.sa.* bristles. *Postnotum* red-brown. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 4, *prsc.* absent, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous to black except the second pair of *sc.* bristles which are sometimes smaller in size and the *mpl.* bristle which is often fulvous. *Legs:* fulvous except basal $\frac{1}{3}$ of all femora pale fulvous; middle tibiae each with an apical dark fulvous spur. *Wings:* costal cells pale fulvous (second costal cell paler than first), microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe very weak.

Abdomen—Oval; tergites free; pecten absent on tergite III. Tergite I orange-brown; tergite II orange-brown except for a brown fulvous band over posterior $\frac{1}{3}$ to $\frac{1}{2}$ of tergite and narrowing to end at posterolateral corners; tergites III to V fulvous except for two broad lateral longitudinal orange-brown bands over all three tergites and sometimes meeting along anterior margin of tergite III, a narrow medial longitudinal band which is orange-brown on tergite III and orange-brown to dark fuscous on tergites IV and V

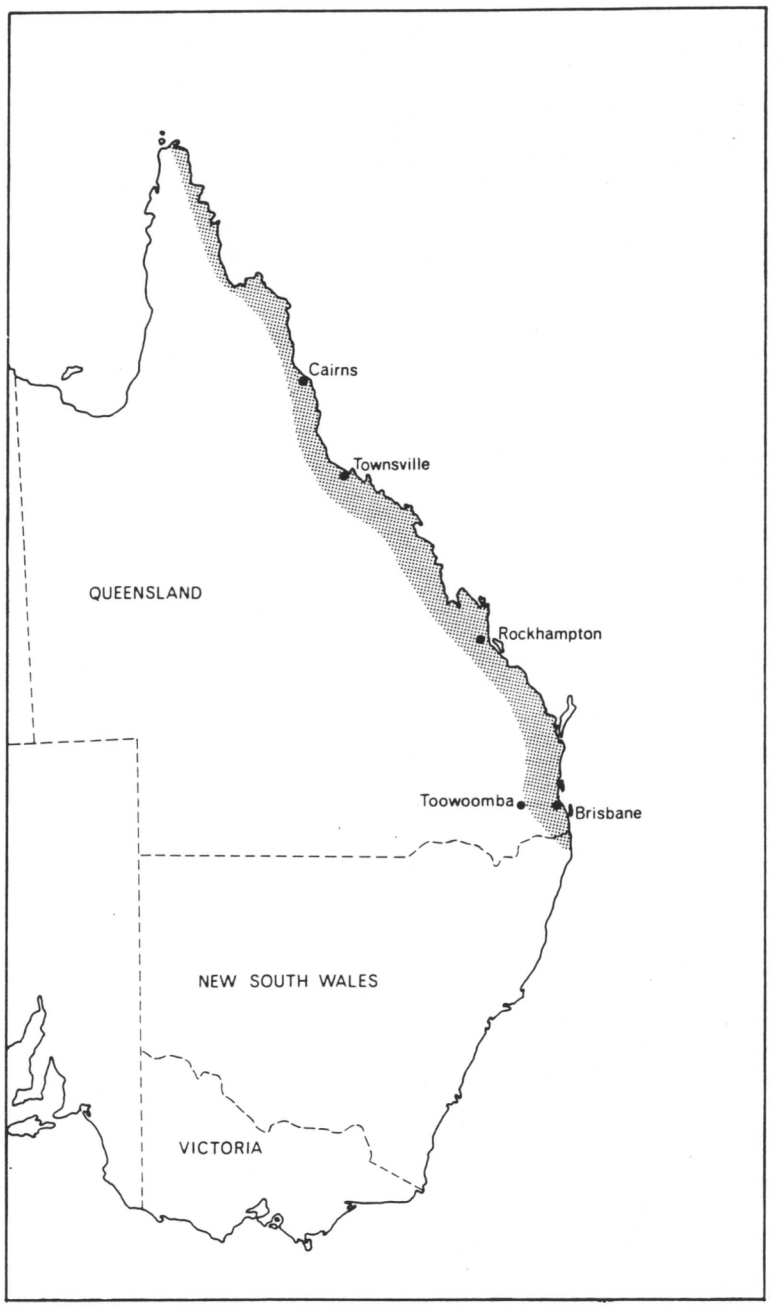

Figure 11—Map of eastern Australia showing distribution of *D. cucumis*

(this band is broader on tergite V). In the female, the medial longitudinal fuscous band is limited to tergite V. A pair of shining spots on tergite V.

Comments—D. cucumis is a serious pest of all cucurbits, tomatoes and papayas. It causes serious crop losses before harvest and is responsible for restrictions against the marketing of these crops on markets outside of its known distribution. May (1963) considered this species as one of major importance and stated that its populations were larger in the northern areas of Queensland than in the southern areas.

D. cucumis is distributed along the eastern coast of Australia from Cape York in the north to the Queensland-New South Wales border district in the south (Figure 11). Because this species does not respond to any of the male lures it is difficult to monitor and so its geographic distribution is not fully defined.

Dacus (Bactrocera) breviaculeus Hardy

(Figure 12)

Material studied: A series of specimens collected at localities from Ayr to Atherton in northern Queensland.

A medium sized species; facial spots oval; thorax generally red-brown; a pair of longitudinal fuscous bands on mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells extremely pale fulvous with microtrichia in outer portion of second costal cell only; abdomen with broad lateral longitudinal fuscous to black bands and a narrow medial longitudinal pale fuscous band on tergites III to V.

Head—Generally fulvous. *Frons* of medium width; fulvous except fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with medium sized oval black spots not reaching epistoma. *Genae* fulvous; medium sized brown sub-ocular spots present; bristles red-brown. *Occiput* red-brown, yellow along eye margin; occipital rows with 3-6 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleural areas fuscous except red-brown below humeral callus. Mesonotum red-brown except for a large circular fuscous spot between humeral callus and notopleural suture and a large oval fuscous spot on the inner margin of each lateral post-sutural vitta (these fuscous patterns vary from extremely pale fuscous to dark fuscous, and occasionally the posterior markings are absent). Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto

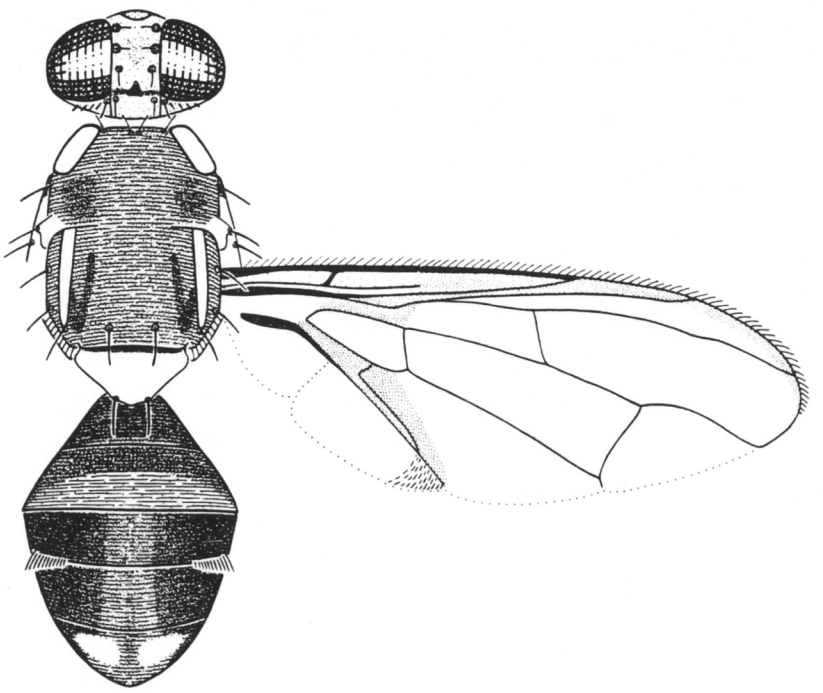

Figure 12—*Dacus (Bactrocera) breviaculeus* Hardy (X13)

sternopleuron below as a yellow spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown to fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two lateral post-sutural vittae of medium width, parallel sided or tapering slightly posteriorly and ending at upper *p.sa.* bristles. *Postnotum* red-brown to fuscous. *Scutellum* yellow except for narrow red-brown basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae and hind tibiae pale fuscous; middle tibiae each with an apical red-brown spur. *Wings:* costal cells extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and ending beyond extremity of R_{4+5}, a broad fuscous anal streak ending at wing margin. A dense aggreation of microtrichia around CuA+1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III of males. Tergite I fuscous except for a narrow transverse red-brown band along posterior margin but not reaching lateral margins. Tergite II fulvous except

for a broad transverse fuscous band across anterior ½ of tergite and expanding over lateral margins. Tergites III to V orange-brown except for a pair of broad lateral longitudinal bands and a very narrow medial longitudinal band over all three tergites. In most specimens the lateral longitudinal bands are fuscous, however, in a few specimens they are black and are joined along anterior margin of tergite III. Generally, the medial longitudinal band is pale fuscous and most distinct on tergite IV and anterior ½ of tergite V (occasionally this medial longitudinal band is absent). A pair of shining spots on tergite V.

Comments—D. breviaculeus occurs in the eastern coastal areas of Queensland north from Rockhampton. It has been bred from guava in this area. Presently, it can be regarded as being only of minor economic importance.

Dacus (Bactrocera) bryoniae (Tryon)

(Figure 13)

Material studied—A series of specimens collected at localities throughout eastern Queensland.

A large species; facial spots medium sized and pointed anteriorly; mesonotum dull black; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow; wing with a broad fuscous costal band and anal streak; costal cells fulvous with microtrichia in outer ½ of second cell only; abdominal tergites III to V orange-brown with a broad transverse dark fuscous to black band on tergite III and a medial longitudinal dark fuscous band over all three tergites, anterolateral corners of abdominal tergites IV and V fuscous.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except small fuscous markings around orbital bristles and on antero-medial hump; latter covered with a large number of short dark setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule fuscous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with irregularly circular facial spots drawn out to a point anteriorly but not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present; bristles fuscous. *Occiput* fulvous (tinged with fuscous in a few specimens), yellow along eye margin; occipital rows well developed with 4-11 strong fuscous to black bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; a strong fuscous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dull black with brown markings as follows: below humeral calli; above mid coxae; below and behind lateral post-sutural vittae; along mesonotal suture; above notopleural calli; above notopleural suture between humeral and notopleural calli; on mesonotum adjacent to humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, each slightly broader than notopleural callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing posteriorly to end at upper *p.sa.* bristles (in a small number of

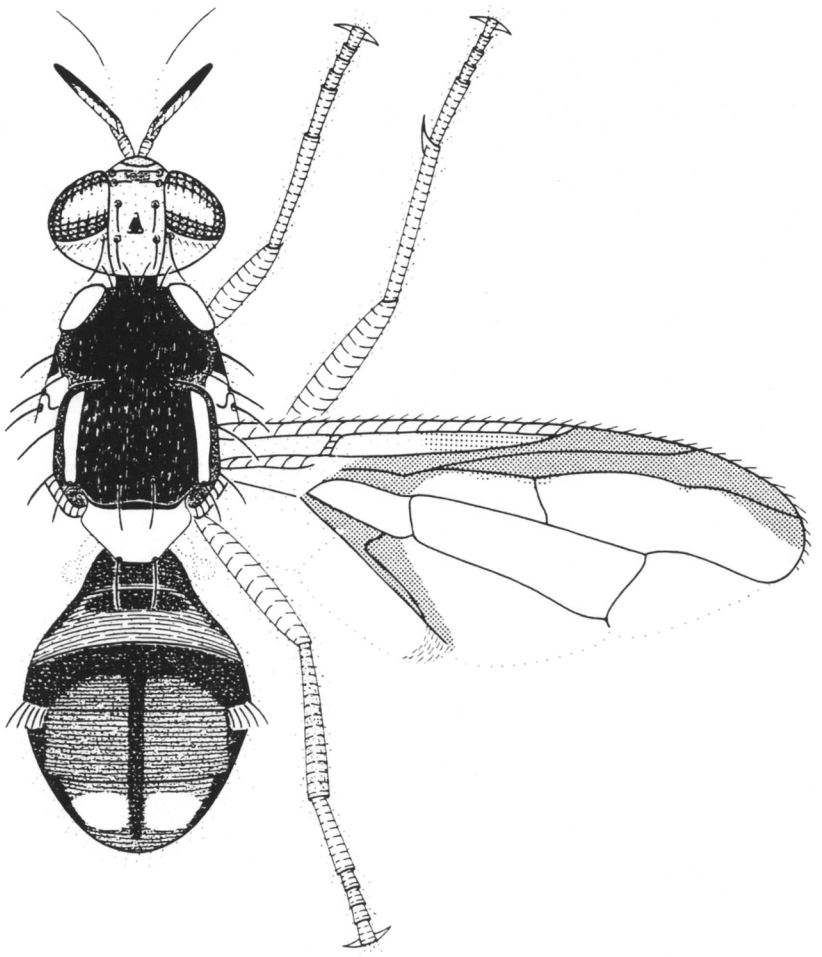

Figure 13—*Dacus (Bactrocera) bryoniae* (Tryon) (X12)

specimens the lateral post-sutural vittae appear to end before the upper *p.sa.* bristles due to an increase in the area of brown colouration). *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs*: all coxae fuscous; remainder of legs fulvous except hind tibiae dark fulvous (in some specimens the mid tibiae tend dark fulvous basally and hind femora are correspondingly fuscous); rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings

colourless except dark fulvous stigma, a broad fuscous costal band slightly overlapping R_{4+5} along its entire length and ending between extremities of R_{4+5} and M_{1+2}, a narrow area of infuscation along anterior $\frac{1}{2}$ of r-m cross vein, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA+1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I fuscous with narrow orange-brown band along posterior margin (in some specimens the dark area is dark fuscous to black); tergite II orange-brown with anterolateral corners fuscous and with a transverse dark fuscous to black band which becomes narrower and paler laterally (generally this band is at most equal to $\frac{1}{2}$ the width of the tergite); tergites III to V orange-brown with a broad transverse dark fuscous to black band of varying width across anterior margin of tergite III and widening to cover lateral margins, anterolateral corners of tergites IV and V fuscous, the pair of shining spots on tergite V brown, a medium sized medial longitudinal dark fuscous band running from transverse band on anterior margin of tergite III to end just before posterior margin of tergite V.

Comments—D. bryoniae is a pest of capsicum, mangoes and passionfruit in Queensland. It is considered to be a pest species in the Northern Territory. In Papua New Guinea it is a very destructive pest of bananas (Dr. J. Stibick, personal communication). It occurs throughout eastern coastal areas of Queensland and as far south as Sydney in New South Wales, the northern coastal areas of Western Australia and the Northern Territory, Melville and Bathurst Islands. Outside Australia it is widespread through Papua New Guinea and associated islands and islands of the Bismarck Archipelago.

Dacus (Bactrocera) cacuminatus (Hering)

(Figure 14)

Material studied: A series of specimens collected at localities from Gatton (south-eastern Queensland) to Atherton Tableland (northern Queensland).

A medium sized species; facial spots medium sized and circular; thorax generally dark red-brown with a characteristic arrow shaped dark fuscous to black pattern on the mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless with microtrichia in outer portion of second costal cell only; abdominal tergites III to V orange-brown with dark fuscous to black along anterior margin of tergite III and with similarly coloured medial and lateral longitudinal bands.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without small pale fuscous markings around orbital bristles and on antero-medial hump; latter covered with short pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous or fuscous. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous with medium sized circular black spots not reaching epistoma. *Genae* fulvous; medium sized, brown sub-ocular spots present; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with

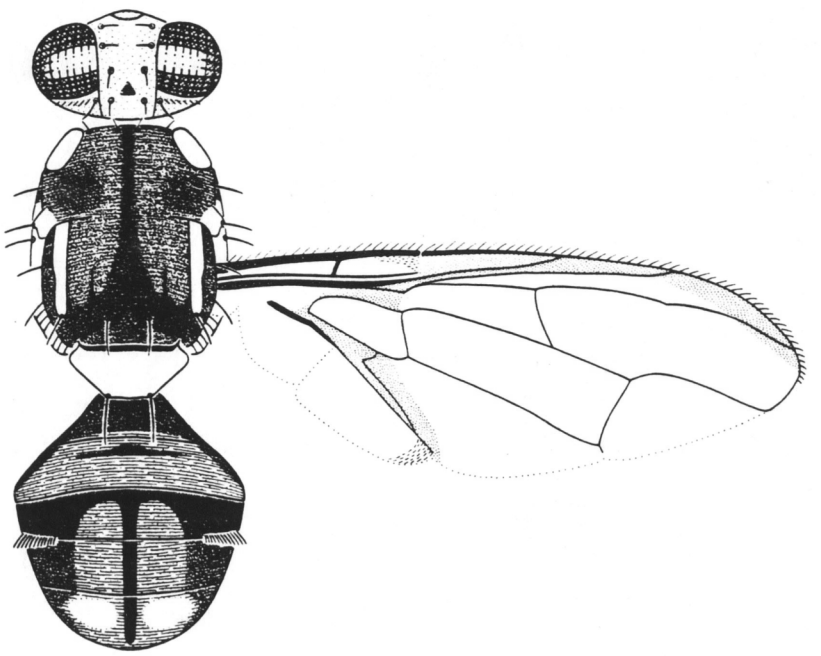

Figure 14—*Dacus (Bactrocera) cacuminatus* (Hering) (X12)

3-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on apex and outer surface of third segment; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dark red-brown with dark markings as follows: entire pleural areas dark fuscous to black except below humeral calli (generally dark fuscous below wings and black anterior to mesopleural stripes and on sternopleura); brown below lateral post-sutural vittae and on posterior margin of mesonotum; a characteristic dark fuscous to black pattern on the mesonotum, with base along posterior margin, with a medial longitudinal band narrowing to a point as it reaches anterior margin and with two shorter lateral bands also pointed anteriorly (this pattern is often reduced to a narrow dark fuscous outline, delineating the 3-pointed marking). Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a yellow spot, anterior margin convex; upper hypopleural calli (posterior apices black), anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two moderately broad lateral post-sutural vittae narrowing slightly posteriorly and ending at or just before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow except for narrow black

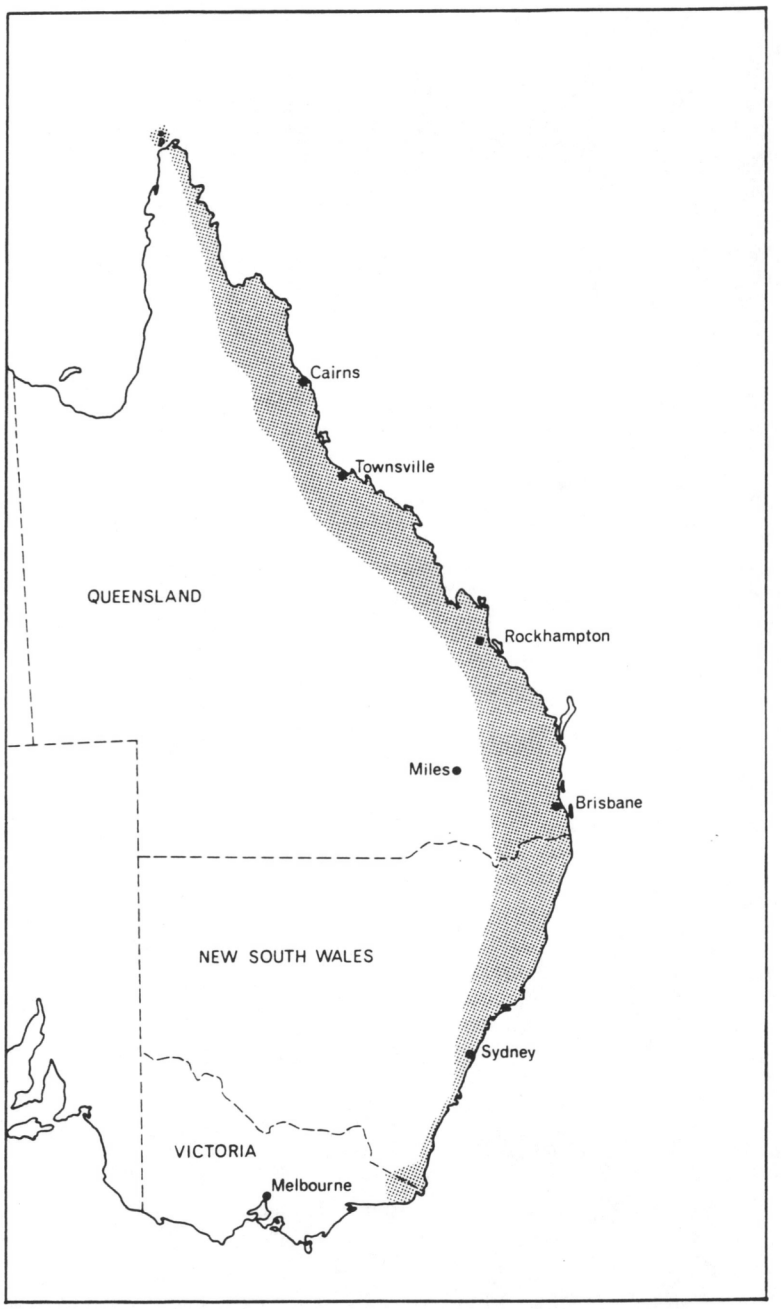

Figure 15—Map of eastern Australia showing distribution of *D. cacuminatus*

basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous except mid coxae, hind coxae and hind tibiae pale fuscous; middle tibiae each with an apical red-brown to fuscous spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only, remainder of wings colourless except fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and widening beyond extremity of this vein to end midway between R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I fuscous to black except for a narrow orange-brown transverse band along posterior margin not reaching lateral margins; tergite II orange-brown except for a narrow transverse fuscous band just behind anterior margin and not reaching the fuscous lateral margins; tergites III to V orange-brown except for dark fuscous to black along anterior margin of tergite III and dark fuscous to black medial and lateral longitudinal broad bands. A pair of shining spots on tergite V. (The dark colour patterns on the abdomen vary from fuscous to black and in some specimens the lateral longitudinal bands are reduced by the expansion of orange-brown colouration on tergite IV.)

Comments—D. cacuminatus is a minor pest of tomatoes and capsicum in Queensland. It occurs throughout eastern Australia from Cape York in the north to the East Gippsland district in the south (Figure 15).

Dacus (Bactrocera) dorsalis (Hendel)
(Figure 16)

Material studied: For this description, specimens collected from India, Thailand, Malaysia, Saipan and Hawaii have been studied. Material from north-western Australia, presently classified as *D. dorsalis*, has also been included in this study.

A medium sized dark coloured species; facial spots circular; mesonotum black; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scuttellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell only; abdomen with transverse black band on basal margin of tergite III and a medial longitudinal fuscous to black band on tergites III to V.

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles fuscous; 1 *s.or.*, 2 *i.or.*; lunule fulvous to fuscous. *Ocellar triangle* black. *Vertex* dark fulvous to fuscous. *Face* fulvous with medium sized, circular black spots not reaching epistoma. *Genae* fulvous; medium sized, brown sub-ocular spots present or absent; bristles fuscous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* fulvous except fuscous

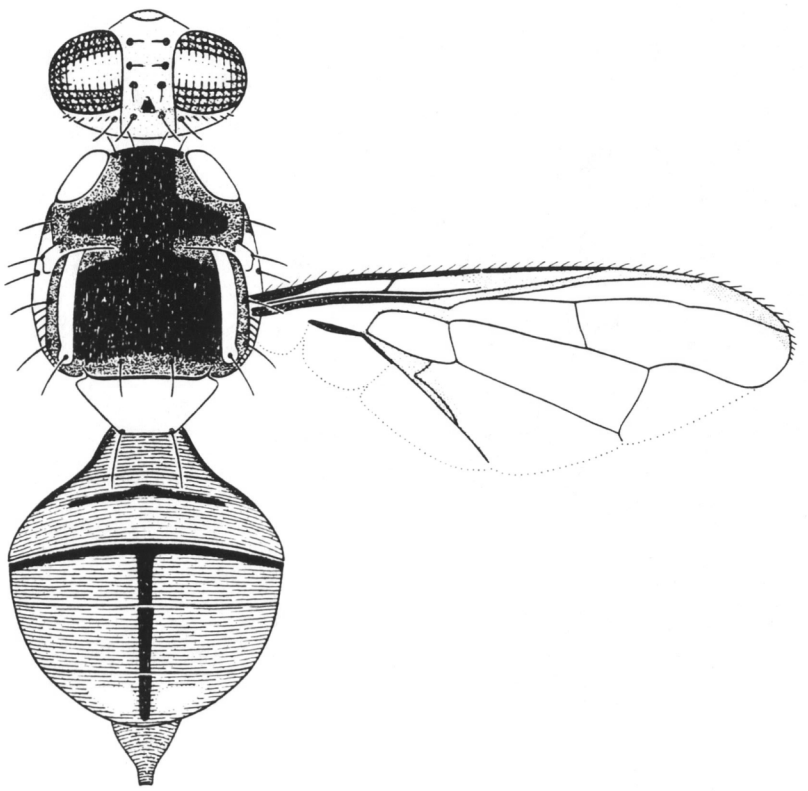

Figure 16—*Dacus (Bactrocera) dorsalis* (Hendel) (X12)

on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

Thorax—Black except brown markings as follows: below humeral calli; above mid coxae; below wings; below and behind lateral post-sutural vittae; along mesonotal suture; above notopleural calli; between humeral and notopleural calli dorsal to notopleural suture; around humeral calli and often along posterior margin of mesonotum. The brown patterns vary in size and shape in some specimens, particularly on the mesonotum where the expansion of these areas reduces the black colouration to a variety of irregular shapes. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a large yellow spot, anterior margin convex; (in some specimens the mesopleural stripe is narrow, approaching width of *npl.* callus and with

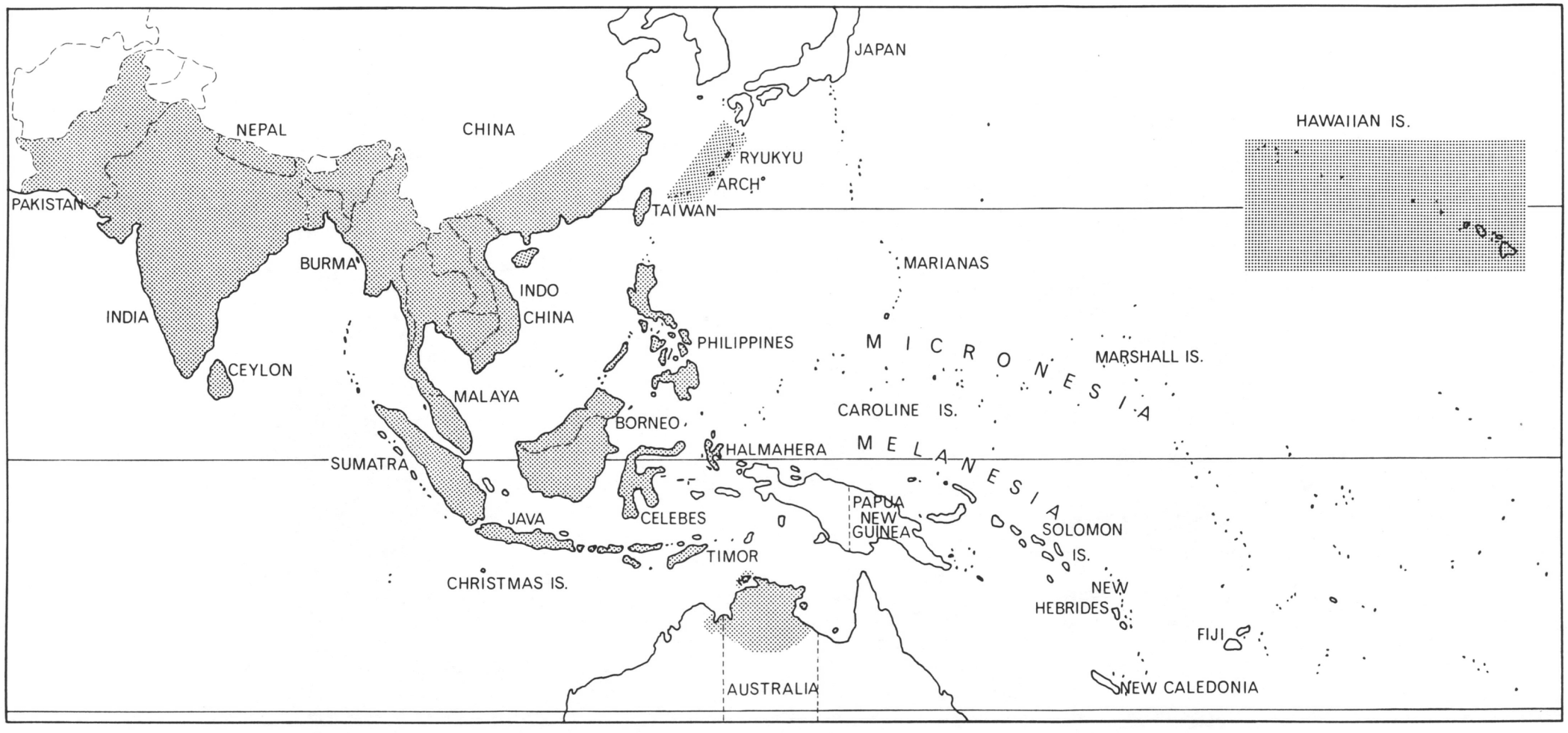

Figure 17—Map of Asian and Pacific regions showing distribution of *D. dorsalis*

anterior margin straight); upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); two broad, parallel sided, lateral post-sutural vittae, broadly rounded posteriorly and ending behind upper *p.sa.* bristles. *Postnotum* black, tending fuscous medially. *Scutellum* yellow except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous except fuscous on fore and hind tibiae of Thailand material, and only occasionally fuscous on hind tibiae of specimens from other areas; middle tibiae each with an apical red-brown spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band usually confluent with R_{2+3} (sometimes just overlapping this vein) and widening beyond extremity of this vein to end just beyond extremity of R_{4+5}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak. In Australian material the costal band overlaps R_{2+3} in all specimens.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I fulvous with narrow fuscous markings on lateral margins; tergite II fulvous with narrow fuscous to black markings on anterolateral margins and a narrow transverse fuscous to black band along anterior margin and ending before lateral margins (the dark markings on tergite II often become paler and may even be absent); tergites III to V fulvous with a transverse fuscous to black band along anterior margin of tergite III and a medial longitudinal fuscous to black band on tergites III to V, occasionally with fuscous to black markings on anterolateral corners of tergits IV and V (definitely without lateral longitudinal bands on tergites III to V). A pair of shining posts on tergite V. There is a large variation in the size of the fuscous to black markings on tergites III to V—the bands may be reduced to a series of elongate spots and the medial longitudinal band may even be absent; the naterolateral markings on tergites IV and V are often absent.

Female

See Hardy (1969) for female ovipositor characters as these are useful in separating closely related species within the *dorsalis* complex.

Comments—Hardy (1969) and Drew (1975) discussed the taxonomy and zoogeography of the *Dacus dorsalis* (Hendel) complex of species in South-East Asia and the South Pacific area. Presently, there are 18 described species which form this complex, 9 endemic to South-East Asia and 9 to the South Pacific. The existence of so many closely related species and the occurrence of a wide range of colour forms within each species makes identification extremely difficult. The 'Australian *dorsalis*' population has a considerably greater percentage of pale colour forms than does the species in other localities. It has been found that the pale forms are not due to tenerality and that the colour variation is probably genetically controlled. Studies are presently being carried out in order to determine whether or not this population is genetically differentiated from *D. dorsalis* which is known as a serious economic pest in South-East Asia and the northern Pacific islands.

Within Australia, *D. dorsalis* is most closely related to *Dacus (Bactrocera)*

endiandrae (Perkins and May) (Figure 48), *Dacus (Bactrocera) silvicola* (May) and *Dacus (Bactrocera) musae* (Tryon). *D. endiandrae* and *D. silvicola* differ from *D. dorsalis* in having lateral post-sutural stripes which narrow posteriorly and end before the upper *p.sa.* bristle and in possessing broad lateral fuscous to black margins on abdominal tergites III to V, while *D. musae* differs in possessing a broader costal band and in having the abdomen predominantly orange-brown without dark markings.

In South-East Asia, *D. dorsalis* is most closely related to *Dacus (Bactrocera) muiri* Hardy and Adachi, *Dacus (Bactrocera) occipitalis* (Bezzi) (Figure 49) and *Dacus (Bactrocera) pedestris* (Bezzi) (Figure 50). *D. muiri* and *D. pedestris* differ from *D. dorsalis* on characters of the ovipositor (see Hardy, 1969) while *D. occipitalis* has a wider costal band.

Within the *dorsalis* complex, only *D. cacuminatus*, *D. dorsalis*, *D. musae* and *D. pedestris* are known to be of economic pest status.

In Hawaii, *D. dorsalis* has been bred from 173 species of host plants covering 112 genera. Throughout its range, it is a "broad generalist" feeder and is assumed capable of breeding in almost all fleshy fruits. *D. dorsalis* is a most serious pest species and in Hawaii it is destructive to all marketable fruit crops except pineapple and strawberries. The latter two fruits, however, are recorded hosts of the fly.

D. dorsalis is distributed widely throughout most Asian and South-East Asian countries and most major northern Pacific islands (Figure 17). In this figure *D. dorsalis* is shown to occur in Australia. However, as indicated above, genetic studies are presently being undertaken on this population in order to assess its relationship to the South-East Asian *D. dorsalis*.

Dacus (Bactrocera) frauenfeldi Schiner

(Figure 18)

Material studied: A series of specimens collected at localities from Cape York to Papua New Guinea, islands of the Bismarck Archipelago and the Solomon Islands.

A medium sized dark coloured species; facial spots large and circular; mesonotum glossy black; lateral post-sutural vittae narrow and short; mesopleural stripes of medium width; humeral calli black; notopleural calli yellow; scutellum yellow with a glossy black triangular marking on dorsal surface; wing with a narrow and extremely pale fuscous costal band; a narrow transverse fuscous band across wing; costal cells pale fuscous; microtrichia in most of second costal cell only; abdominal tergites III to V orange-brown with one broad medial and two broad lateral longitudinal black bands over all three tergites.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with, at most, pale fuscous markings around orbital bristles; antero-medial hump covered with a small number of dark fulvous setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with large circular spots not reaching epistoma. *Genae* fulvous; brown

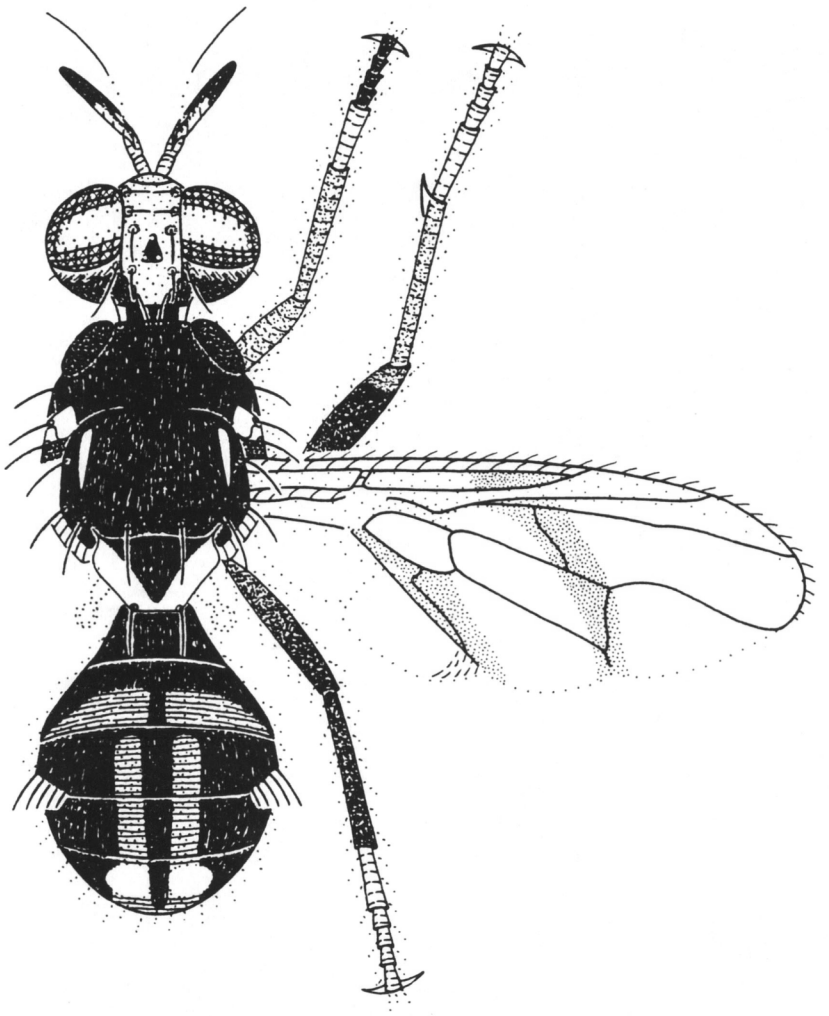

Figure 18—*Dacus (Bactrocera) frauenfeldi* Schiner (X15)

sub-ocular spots present; bristles black. *Occiput* black dorsally, fulvous ventrally, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* fulvous with fuscous on apex and outer

surface of third segment: a strong dark fuscous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight to slightly convex; upper hypopleural calli (posterior apices black); anterior $\frac{5}{8}$ lower hypopleural calli (remainder, including entire ventral margin black); two narrow short lateral post-sutural vittae tapering posteriorly to end just behind *a.sa.* bristles. Humeral calli black. *Postnotum* black. *Scutellum* yellow except for a black triangle on dorsal surface which varies in size from small (with apex at centre of scutellum) to large (with apex enveloping the two apical scutellar bristles). *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae fuscous, mid and hind coxae black; fore femora dark fulvous, basal $\frac{1}{3}$ and apex of mid femora and basal $\frac{1}{4}$ of hind femora dark fulvous (remainder dark fuscous to black); fore and mid tibiae dark fulvous, hind tibiae dark fuscous to black; tarsal segments fulvous except apical four segments of fore tarsi fuscous; rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells pale fuscous, microtrichia in most of second costal cell only; remainder of wings colourless except fuscous stigma, narrow extremely pale fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a narrow fuscous transverse band from costal band to hind margin and enveloping r-m and i-m cross veins, a broad fuscous anal streak ending at wing margin and including area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I black; tergite II orange-brown with a broad black transverse band across anterior margin which widens to cover lateral margins and a narrow medial longitudinal band running from transverse band to posterior margin; tergites III to V vary between two extremes as follows: (1) orange-brown with two broad lateral longitudinal black bands running from anterior margin of tergite III to posterior margin of abdomen, a broad medial longitudinal black band running from anterior margin of tergite III and narrowing posteriorly to end just before posterior margin of tergite V (the three longitudinal bands are usually connected along anterior margin of tergite III by a narrow transverse black band); (2) black with the posterior margin of tergite V and the pair of oval shining spots on tergite V dark brown.

Comments—D. frauenfeldi (the mango fly) has been bred from mango, breadfruit and guava. It is a very abundant species throughout its geographic range and almost certainly will become a serious pest when horticulture industries are developed in these areas. This species is distributed widely—in South-East Asia, northern Pacific islands, Papua New Guinea, islands of the Bismarck Archipelago, Bougainville Island, Solomon Islands and Australia (Melville Island, Northern Territory, northern Queensland and islands of Torres Strait). Its distribution within northern Queensland is shown on Figure 19.

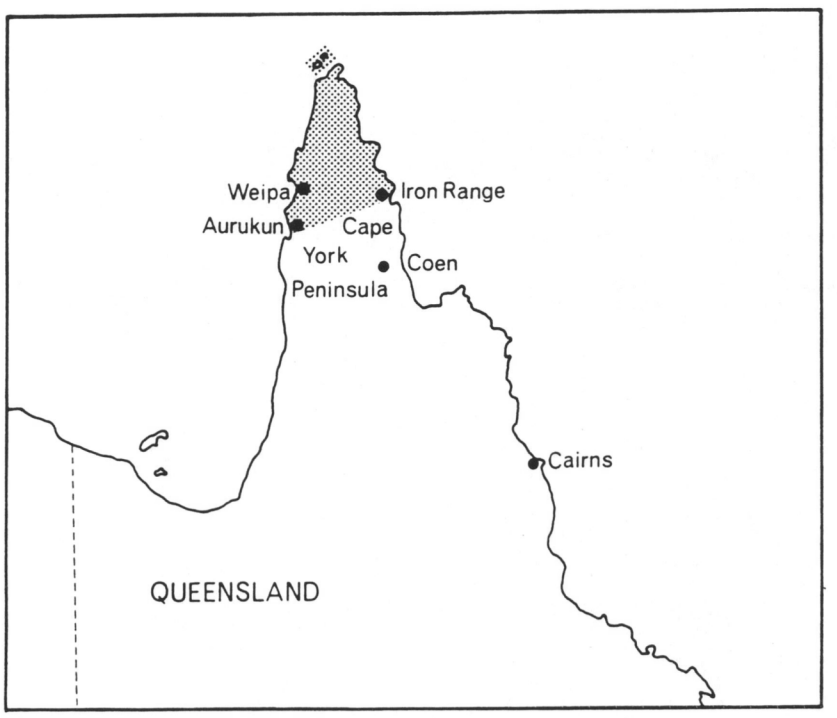

Figure 19—Map of Queensland showing distribution of *D. frauenfeldi*

Dacus (Bactrocera) halfordiae Tryon

(Figure 20)

Material studied: A series of specimens collected at localities from Brisbane to Toowoomba (south-east Queensland).

A medium sized pale coloured species: facial spots oval to pear shaped; thorax generally pale red-brown; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow with broad red-brown basal band; wing with a narrow fuscous costal band and anal streak; costal cells fulvous with microtrichia in outer portion of second costal cell only; abdomen generally orange-brown with at most fuscous markings on lateral margins of tergites III and IV and with the shining oval spots on tergite V dark brown to fuscous.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous to dark fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fuscous. *Ocellar triangle* black. *Vertex* fuscous to dark fuscous. *Face* fulvous with

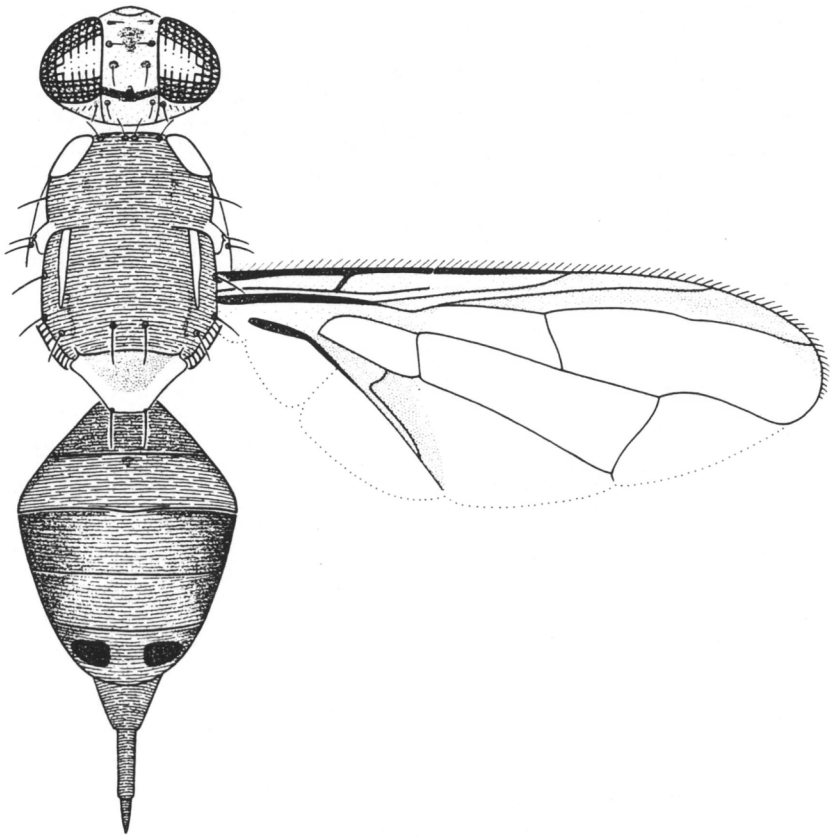

Figure 20—*Dacus (Bactrocera) halfordiae* Tryon (X11)

medium sized oval to pear shaped spots not reaching epistoma. *Genae* fulvous: large dark brown sub-ocular spots present; bristles fuscous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pale red-brown with dark markings as follows: fuscous anterior to mesopleural stripes, a small fuscous area along posterior margin of mesopleural stripes, fuscous to black above hind coxae, dark fuscous to black on sternopleura, a small fuscous spot posterocentrally of each humeral callus and occasionally a fuscous spot along inner posterior margin of lateral post-sutural vittae. Yellow markings as follows: humeral calli; notopleural calli;

narrow mesopleural stripes, each slightly wider than *npl.* callus above, continuing onto sternopleuron below as a yellow spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two narrow lateral post-sutural vittae narrowing posteriorly to end before the upper *p.sa.* bristles. *Postnotum* black centrally, red-brown laterally. *Scutellum* yellow except for broad red-brown basal band extending almost to centre of scutellum. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae fuscous and hind tibiae pale fuscous; middle tibiae each with an apical dark fuscous spur. *Wings*: costal cells fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless to extremely pale fulvous except for fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III in males. Tergite I fuscous except for a narrow orange-brown transverse band along posterior margin but not reaching lateral margins. Tergite II orange-brown with at most a small fuscous spot centrally just posterior of anterior margin. Tergites III to V orange-brown with irregularly shaped fuscous patterns on lateral margins of all three tergites and with the shining oval spots on tergite V fuscous. In some specimens the fuscous patterns on tergites III and IV are quite broad, leaving only a narrow orange-brown pattern posterocentrally on tergite III and in the centre of tergite IV. In the specimens with increased areas of melanic pigmentation on tergites III and IV, the oval shining spots on tergite V tend towards black. The ovipositor is strongly developed, red-brown and dorsoventrally compressed.

Comments—D. halfordiae is an incidental pest of citrus in Queensland and also attacks loquat and some myrtaceous fruits. It has been recorded from eastern Australia between Rockhampton (Queensland) and Sydney (New South Wales).

Dacus (Bactrocera) mayi Hardy

(Figure 21)

Material studied—A series of specimens collected at Toowoomba and Yarraman in south-eastern Queensland.

A medium sized pale species; facial spots oval; thorax dark red-brown with a pair of longitudinal dark bands running along the mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell; abdomen basically dark red-brown with a narrow medial longitudinal black band on tergites III to V, generally with dark fuscous along anterior margin of tergite III and occasionally with pale fuscous colouration on lateral margins of tergites III to V.

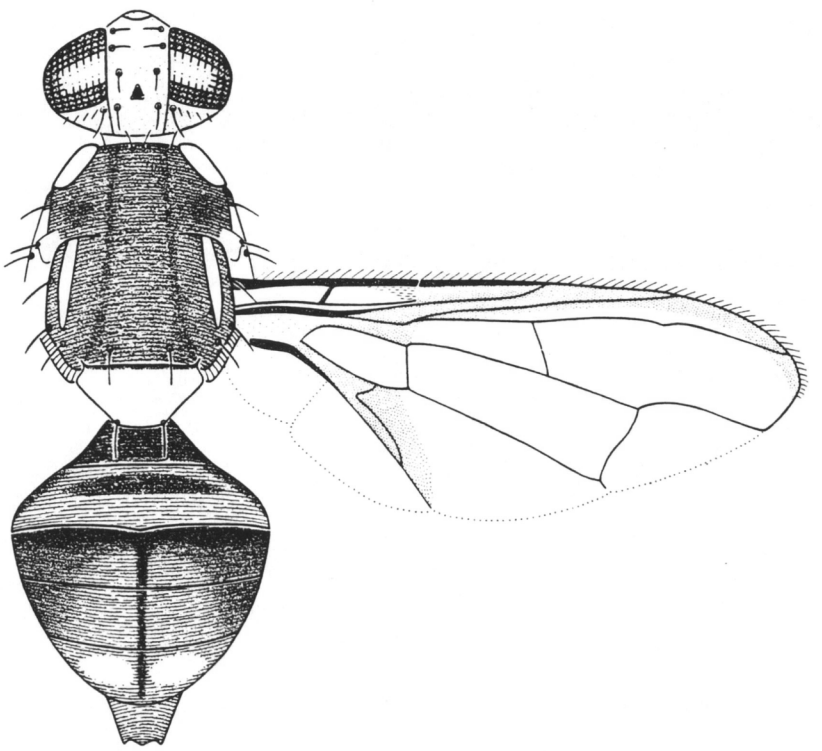

Figure 21—*Dacus (Bactrocera) mayi* Hardy (X13)

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous, without fuscous colouration around orbital bristles and on antero-medial hump (in a small percentage of specimens these fuscous colour patterns are present); antero-medial hump covered with short pale setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous (in a small percentage of specimens the vertex is pale fuscous). *Face* fulvous with medium sized, oval black spots not reaching epistoma. *Genae* fulvous; small, brown sub-ocular spots present; bristles red-brown. *Occiput* red-brown, yellow along eye margin; occipital rows with 3-5 well developed dark bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dark red-brown with fuscous markings as follows: on mesopleura anterior to mesopleural stripes; on sternopleura; below wings; above hind coxae; a large spot each side of mesonotum between humeral and notopleural calli; a small elongate spot along inner posterior margins of lateral

post-sutural vittae; a pair of moderately broad longitudinal bands running down mesonotum either side of the mid line (these bands begin at anterior margin of mesonotum and end before the posterior margin). In some specimens the dark colouration on the pleural areas is pale fuscous and the spots on the mesonotum between the humeral and notopleural calli and along the inner posterior margins of the lateral post-sutural vittae are absent. In some specimens all the dark colour patterns on the mesonotum are absent leaving an entirely dark red-brown mesonotum. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each slightly wider than notopleural callus above, continuing onto sternopleuron below as a small yellow spot, anterior margin straight; upper hypopleural calli (posterior apices dark red-brown to fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder dark red-brown to fuscous); two narrow lateral post-sutural vittae, narrowing posteriorly to end before upper *p.sa.* bristles. *Postnotum* red-brown, tending pale fuscous laterally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except hind tibiae pale fuscous; middle tibiae each with an apical spur. *Wings*: costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, a narrow fuscous costal band extending below R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III of males. Tergite I fuscous to dark fuscous except for a narrow transverse red-brown band along posterior margin and ending before lateral margins; tergite II fulvous (tending whitish) except for a moderately broad transverse fuscous to dark fuscous band just posterior to anterior margin and narrowing laterally to end before lateral margins. Tergites III to V dark red-brown except for a broad fuscous to dark fuscous band along anterior margin of tergite III and a narrow medial longitudinal dark fuscous to black band over all three tergites. There is no distinct colour pattern on the lateral margins of tergites III to V but these margins are often clouded with fuscous colouration. In some specimens the band along the anterior margin of tergite III is pale fuscous and discontinuous in the centre of the tergite. A pair of shining spots on tergite V (these spots vary in colour from red-brown to dark red-brown).

Comments—D. mayi has been recorded from apricots in south-eastern Queensland. It occurs throughout the entire eastern coastal and sub-coastal districts of Queensland and is regarded as a species of minor pest status.

Dacus (Bactrocera) melas (Perkins and May)

Material studied: A series of specimens collected at localities from Brisbane, Nambour, Gatton, Gayndah, Toowoomba (in south-eastern Queensland) to Ayr (in northern Queensland).

A medium sized species; facial spots oval to pear shaped; thorax red-brown with fuscous markings on mesonotum; lateral post-sutural vittae

present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous; microtrichia covering all of both costal cells; abdomen with tergites III to V red-brown with fuscous along the anterior margin of tergite III and laterally over all three tergites.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with short pale setae; bristles red-brown: 1 *s.or.*, 2 *i.or.*; lunule fulvous to fuscous. *Face* fulvous with medium sized, oval to pear shaped black spots not reaching epistoma. *Genae* fulvous; medium sized brown sub-ocular spots present; bristles fulvous. *Occiput* red-brown to pale fuscous, yellow along eye margin; occipital rows with 3-7 well developed red-brown bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

Thorax—Pleural areas generally fuscous except dark red-brown below humeral calli (occasionally the pleural areas are entirely red-brown). Mesonotum dark red-brown with dark fuscous markings as follows: a small spot laterally between humeral and notopleural calli; a spot along the inner posterior margin of the lateral post-sutural vittae; two narrow longitudinal bands running down the mesonotum either side of the central line. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a yellow spot, anterior margin convex; upper hypopleural calli (posterior apices fuscous to black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder fuscous to black); two narrow lateral post-sutural vittae, narrowing sharply posteriorly and ending well before upper *p.sa.* bristles. *Postnotum* fuscous to black. *Scutellum* yellow except for narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae and hind tibiae fuscous (occasionally in the more heavily pigmented specimens the apices of the femora are tinged with fuscous); middle tibiae each with an apical black spur. *Wings*: costal cells fuscous, microtrichia covering all of both costal cells; remainder of wings colourless except fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA+1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval: tergites free; pecten present on tergite III of males. Tergite I fuscous except for a narrow transverse fulvous band along posterior margin but not reaching lateral margins; tergite II fulvous except for a broad transverse fuscous band across anterior $\frac{1}{2}$ of tergite and expanding to cover lateral margins; tergites III to V dark red-brown to fuscous except for darker fuscous markings of varying size as follows: a broad band along anterior margin of tergite III, broad lateral longitudinal bands and a narrow medial longitudinal band on all three tergites. A pair of shining spots on tergite V.

Comments—At present there is some doubt as to whether *D. melas* is a good species. There are only a few specimens available which fit the

description of Perkins and May. Most specimens named *D. melas* in the Department of Primary Industries collection fit *Dacus (Bactrocera) tryoni* (Froggatt). The material which fits *D. melas* has the mesonotal fuscous pattern expanded to cover most of the mesonotum. These specimens appear to be dark forms of *D. tryoni*, possessing increased areas of melanic pigmentation.

D. melas has been bred from 10 hosts which are also hosts of *D. tryoni*—loquat, apple, plum, pear, orange, grapefruit, kumquat, guava, date palm, passionfruit. It occurs throughout the entire eastern coastal area of Queensland.

Dacus (Bactrocera) musae (Tryon)

(Figures 22, 23)

Material studied: A series of specimens collected at localities in northern Queensland.

A medium sized species; facial spots irregularly oval; mesonotum dull black; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell only; abdomen generally orange-brown and occasionally with a dark fuscous to dull black narrow medial longitudinal band of varying length over tergites III to V (in some specimens there are dark fuscous to dull black markings in the anterolateral corners of tergite III).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with a small number of short dark fulvous setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with two irregularly oval black spots not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present (absent in some specimens); bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 5-11 well developed dark fuscous bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a well developed dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura dark fuscous to black with brown below humeral calli, along sutures and above mid coxae. Mesonotum dull black with brown markings below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, above notopleural suture between humeral and notopleural calli, adjacent to humeral calli. Two extremes of melanic development occur, between individuals of this species, on the mesonotum as follows: (1) a reduction in dark colouration, brown patterns occurring on the posterior and anterior margins of the mesonotum; (2) an increase in dark colouration, the only brown markings being below the lateral post-sutural vittae, a very small area along the mesonotal suture and around notopleural calli. Gradations of melanic development between these extremes are always present in a large population sample. Yellow markings as follows: humeral

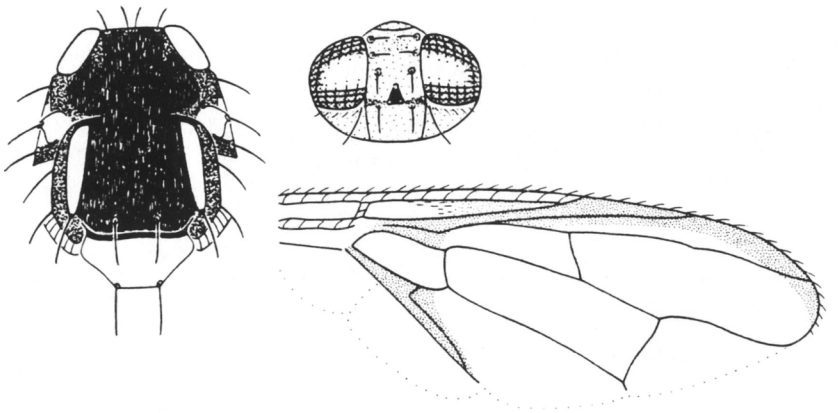

Figure 22—Head, thorax, wing of *Dacus (Bactrocera) musae* (Tryon) (X12)

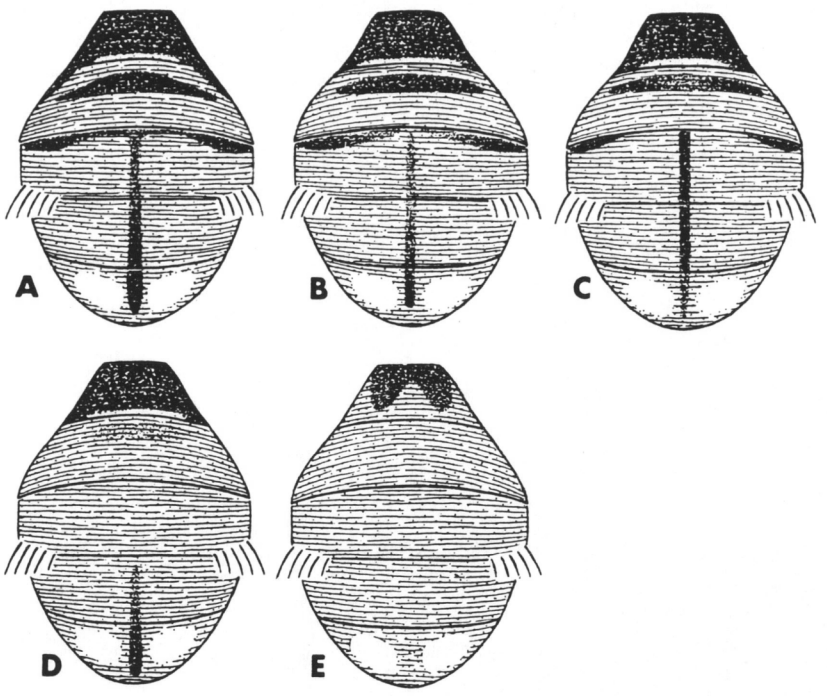

Figure 23—Colour variation in abdomen of *D. musae* (X12)

calli; notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight to slightly convex (this stripe is slightly narrower in some specimens); upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing slightly posteriorly to end at upper *p.sa.* bristles. *Postnotum* dull black. *Scutellum* yellow with a narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous. *Legs:* fore coxae fulvous to dark fulvous, mid and hind coxae fuscous; remainder of legs fulvous (occasionally the fore tibiae are dark fulvous and hind tibiae pale fuscous); rows of long dark fulvous setae on dorsal surface of fore femora; middle tibiae each with apical black spur. *Wings*: costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I dark red-brown to fuscous with a narrow orange-brown band along posterocentral margin; tergite II orange-brown tending whitish posteriorly and with a transverse fuscous to dark fuscous band just behind anterior margin which ends before lateral margins. The colour patterns on tergites III to V vary considerably and five colour forms have been selected (Figure 27); however, it is noted that intermediate variations also occur between these five forms. The five colour forms are as follows: A—tergites III to V orange-brown with a narrow fuscous band across anterior margin of tergite III which widens and becomes dark fuscous in anterolateral corners of this tergite, a medial longitudinal band which is fuscous on anterior region of tergite III and tends towards dark fuscous on anterior region of tergite V (this band ends well before posterior margin of tergite V); B—tergites III to V as for form A except that the narrow fuscous band across anterior margin of tergite III is not continuous in centre of tergite; C—tergites III to V orange-brown with narrow transverse dark fuscous markings on anterolateral margins of tergite III and a medial longitudinal band which is dark fuscous to dull black on tergites III and IV and fuscous on tergite V (this band ends well before posterior margin of tergite V); D—tergites III to V orange-brown with a narrow medial longitudinal dark fuscous band on posterior part of tergite IV and most of tergite V; E—tergites III to V orange-brown with no dark markings or with only the anterolateral corners of tergite III fuscous.

Comments—D. musae (the banana fruit fly) is a major pest of bananas in northern Queensland and Papua New Guinea. Females oviposit in either ripe or green bananas, and they can sting even young fruit as it appears on the bunch. In Queensland it has been recorded along the eastern coast as far south as Mt. Spec (65 km north of Townsville) (Figure 24). It occurs in Papua New Guinea and associated islands, the islands of the Bismarck Archipelago and the Solomon Islands.

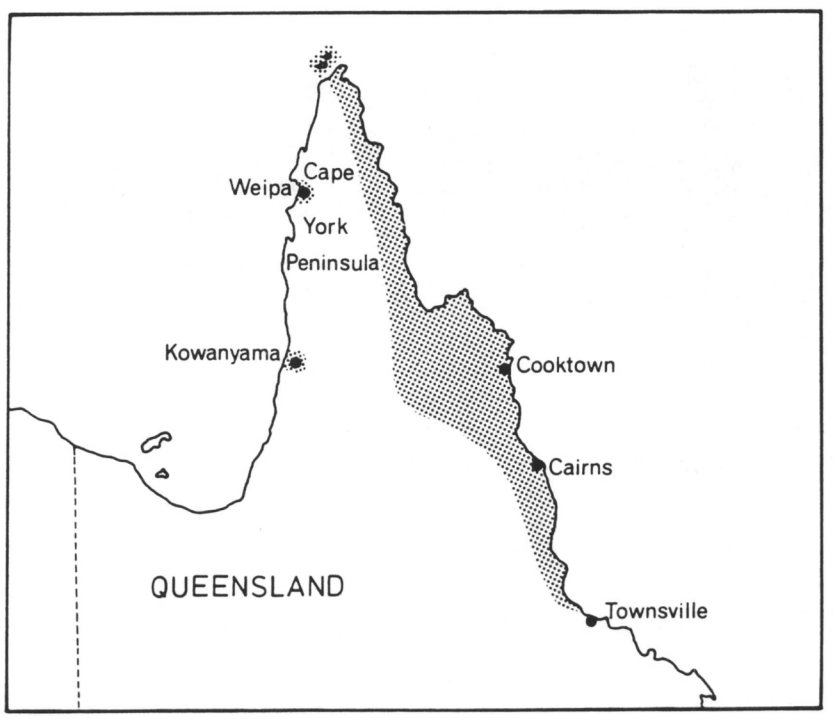

Figure 24—Map of Queensland showing distribution of *D. musae*

Dacus (Bactrocera) mutabilis (May)

(Figure 25)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Atherton (northern Queensland).

A medium sized pale coloured species; facial spots absent; thorax red-brown; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous with microtrichia covering all of second costal cell and most of first costal cell; abdomen generally orange-brown.

Head—Generally fulvous. *Frons* of even width; fulvous with at most pale fuscous around orbital bristles and on antero-medial hump; latter covered with short pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous; facial spots absent. *Genae* fulvous; subocular spots generally absent, when present they are small and

pale brown; bristles fuscous. *Occiput* red-brown, yellow along eye margin; occipital rows with 4-8 well developed red-brown bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on second segment; arista fulvous proximally (remainder fuscous to black).

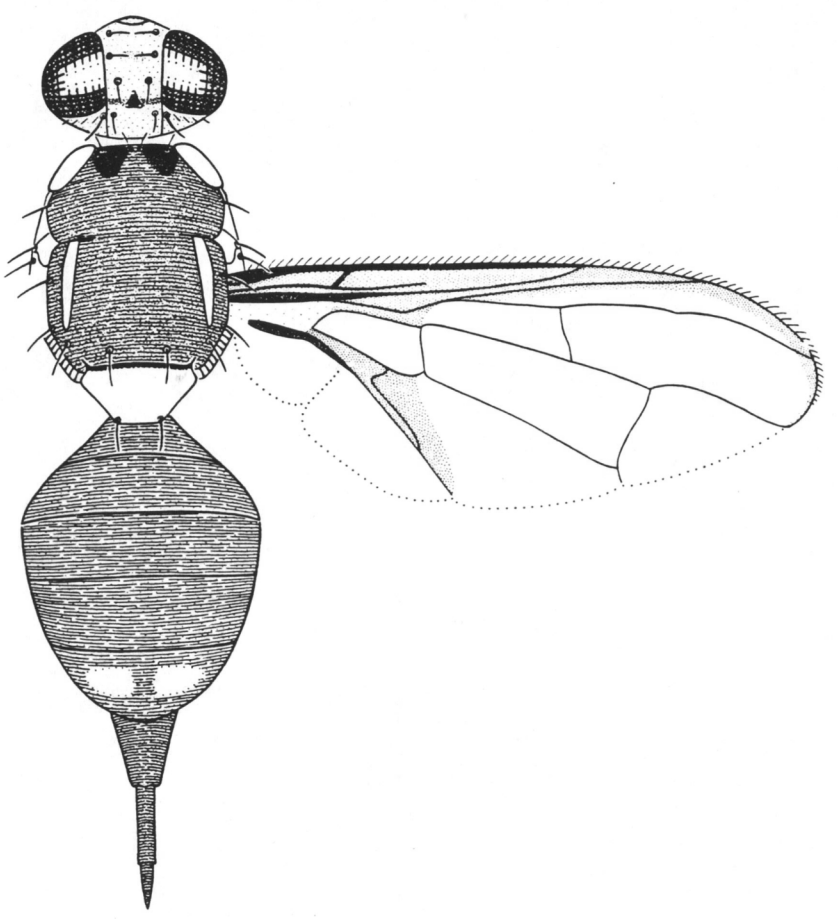

Figure 25—*Dacus (Bactrocera) mutabilis* (May) (X13)

Thorax—Red-brown with black markings as follows: on sternopleura; above hind coxae; a pair of large, oval spots on anterior margin of mesonotum inside each humeral callus. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above,

continuing onto sternopleuron below as a yellow spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ¾ lower hypopleural calli (remainder black); two narrow lateral post-sutural vittae, narrowing sharply posteriorly to end well before upper *p.sa.* bristles. *Postnotum* black, with a narrow dark red-brown band centrally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. In most specimens the *a.sa.* bristles are either weak or absent. *Legs*: fulvous except hind tibiae fuscous; middle tibiae each with an apical black spur. *Wings*: costal cells fuscous (there is a paler spot in the centre of the second costal cell), microtrichia covering all of second costal cell and most of first costal cell; remainder of wings colourless except dark fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and widening beyond extremity of this vein to end between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III of males. All abdominal tergites orange-brown with no dark markings. A pair of shining spots on tergite V. The ovipositor is strongly developed, with the visible portion of oviscape red-brown, elliptical in transverse cross-section and tapering posteriorly in dorsal view.

Comments—D. mutabilis has been bred from kumquat in south-eastern Queensland. It is of only minor economic importance. It occurs along the eastern coast of Queensland and is more prevalent in south-eastern Queensland.

Dacus (Bactrocera) neohumeralis Hardy

(Figure 26)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Cairns and the Atherton Tableland (northern Queensland).

A medium sized species; generally dark in appearance; facial spots medium sized and oval; thorax generally red-brown with a pattern of dark fuscous to black markings; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral calli dark brown to fuscous; notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak; costal cells fuscous with microtrichia covering all of second costal cell and outer ½ of first costal cell; abdomen with tergites III to V generally dark fuscous to dull black and tending towards red-brown medially.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with a large number of short, pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous to fuscous. *Face* fulvous with medium sized, oval black spots not reaching epistoma. *Genae* fulvous; small brown sub-ocular spots present; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-9 well developed dark fulvous bristles each

side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

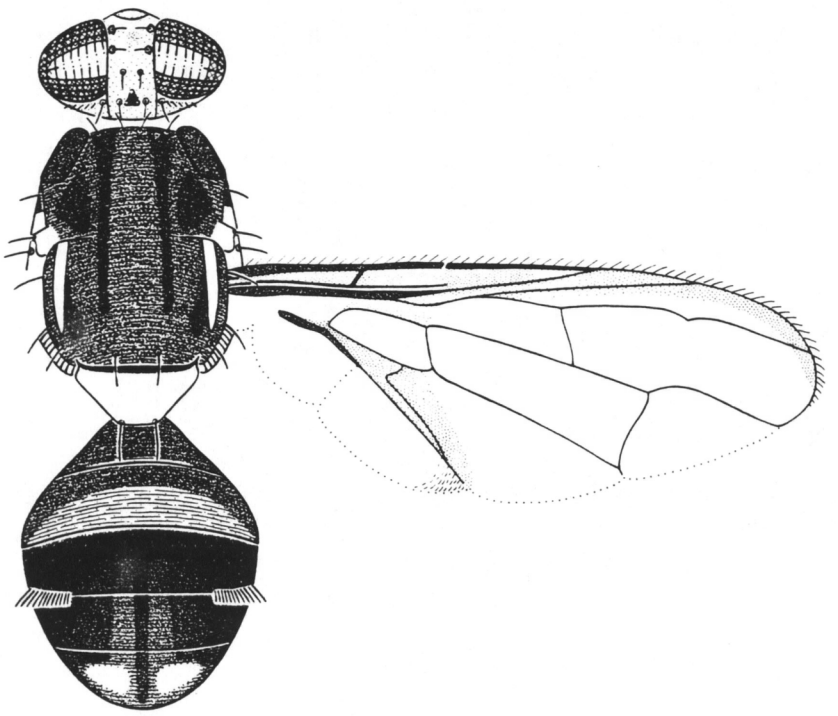

Figure 26—*Dacus (Bactrocera) neohumeralis* Hardy (X13)

Thorax—Dark red-brown (tending towards fuscous) except dark fuscous to black markings as follows: anterior to mesopleural stripes; on pteropleura; below wings; inside posterior $\frac{1}{2}$ of lateral post-sutural vittae; a large oval spot between humeral and notopleural calli dorsal to notopleural sutures; two moderately broad longitudinal bands on mesonotum running from anterior margin of mesonotum to end well before *prsc.* bristles; (the dark markings on the mesonotum vary markedly in size—they may be greatly reduced until almost absent or so enlarged that they almost merge together, giving the appearance of a uniformly darkened mesonotum). Humeral calli dark brown to fuscous. Yellow markings as follows: notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle as above, continuing onto sternopleuron below as a yellow spot, anterior margin slightly convex: upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black);

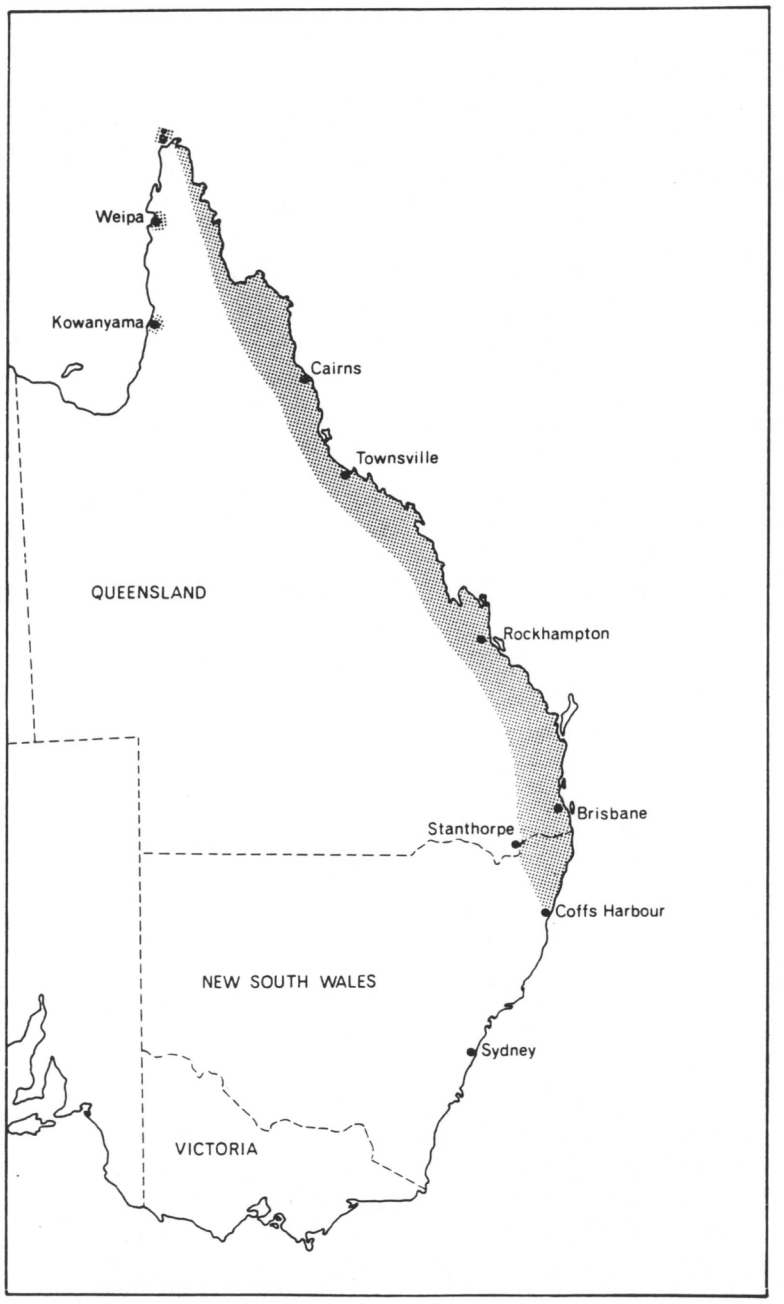

Figure 27—Map of eastern Australia showing distribution of *D. neohumeralis*

two moderately broad lateral post-sutural vittae, narrowing slightly posteriorly and ending before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow except for narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark red-brown. *Legs*: fulvous except coxae and hind tibiae fuscous; middle tibiae each with an apical black spur. *Wings:* costal cells fuscous, microtrichia covering all of second costal cell and outer ½ of first costal cell; remainder of wings colourless except dark fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending just beyond extremity of R_{4+5}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA+1A. Supernumerary lobe weak.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I fuscous except for a narrow transverse orange-brown band along posterior margin but not reaching lateral margins; tergite II fulvous except for broad fuscous transverse band over anterior ½ of tergite and expanding to cover lateral margins; tergites III to V dark fuscous to dull black except for two narrow dark red-brown bands (tending fuscous on tergite III) either side of a narrow medial longitudinal fuscous band from centre of tergite III to posterior margin of tergite V. A pair of shining spots on tergite V.

Comments—D. neohumeralis is a major pest of most commercial fruit crops in Queensland. Taxonomically it is very closely related to *D. tryoni* and both species possess similar host fruits. In some commercial fruits these species occur in a 50:50 ratio, and often, *D. neohumeralis* predominates. *D. neohumeralis* occurs throughout the eastern coast of Australia from Cape York in the north to Coffs Harbour in the south (Figure 27). It is more prevalent in the northern wet tropical areas than in the cooler southern areas. May (1963) recorded this species as one of major economic importance. It occurs in coastal districts of Queensland receiving an annual rainfall greater than 760 mm (30 inches).

Dacus (Bactrocera) tryoni (Froggatt)

(Figures 28, 29)

Material studied: A series of specimens collected at localities throughout Queensland.

A medium sized species; facial spots pear shaped; mesonotum red-brown with fuscous markings; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous; microtrichia covering most of second costal cell and outer ½ of first costal cell; abdomen with tergites III to V blotched fuscous overlying paler red-brown which shows through in central areas of tergites.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule darkened. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous with two pear shaped spots (tending oval) not quite reaching epistoma. *Genae* fulvous; sub-ocular spots pale; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 6-8 strong fuscous

bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; arista fulvous proximally (remainder black).

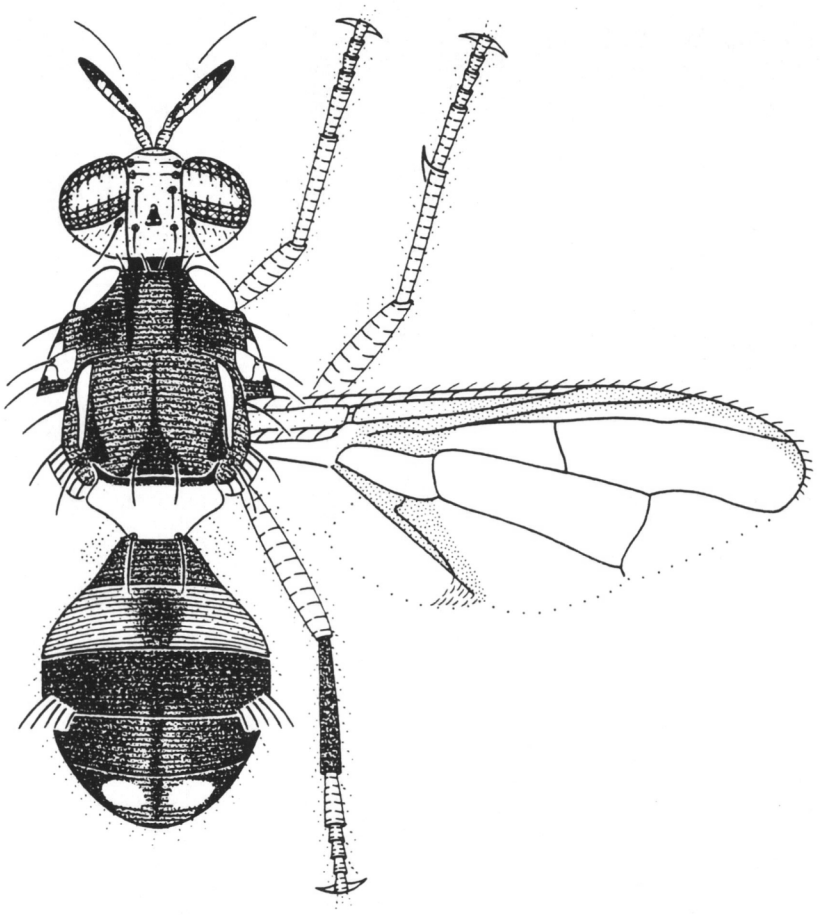

Figure 28—*Dacus (Bactrocera) tryoni* (Froggatt) (X13)

Thorax—Generally rich red-brown. Pleura rich red-brown with black on most of sternopleuron, a spot above hind coxae and beneath wings; blotched fuscous to black along anterior and posterior edges of mesopleural stripes. Mesonotum with a central tomentose band appearing greyish; fuscous markings as follows: two narrow longitudinal bands which run from anterior margin between central tomentose band and humeral calli and end before mesonotal suture; between humeral and notopleural calli; along inner posterior margins of post-sutural vittae; on posterior marginal area of

mesonotum (may be absent in some specimens). Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes ending midway between notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot; upper hypopleural calli (posterior apices red-brown); $\frac{5}{8}$ lower hypopleural calli (remainder red-brown); two narrow, triangular, lateral post-sutural vittae ending before upper *p.sa.* bristles (level with lower *p.sa.* bristle). *Postnotum* fuscous laterally and red-brown centrally. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs:* fulvous except for middle and hind coxae and hind tibiae fuscous; middle tibiae each with apical black spur. *Wings*: costal cell fuscous, microtrichia covering all of second costal cell and outer $\frac{1}{2}$ of first costal cell; remainder of wings colourless except dark fulvous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I dark red-brown to fuscous; tergite II fulvous with posterior $\frac{1}{2}$ tending whitish; tergites III to V blotched fuscous overlying red-brown which shows through chiefly in central areas of each tergite. A faintly visible thin medial longitudinal fuscous band on tergites III to V (not visible in some specimens). A pair of shining spots on tergite V which tend towards yellow-brown. In some specimens tergites III to V are paler in the central areas, the fuscous pattern being confined to the anterior margin of tergite III and lateral margins of the three tergites (Figure 29).

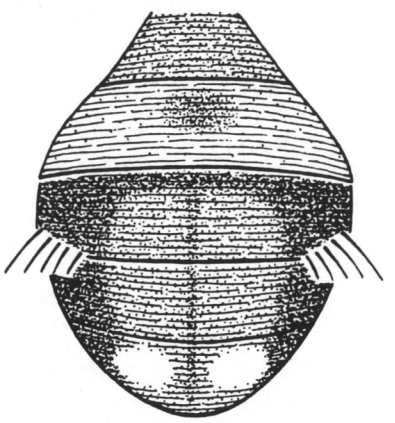

Figure 29—Abdomen of pale form of *D. tryoni* (X18)

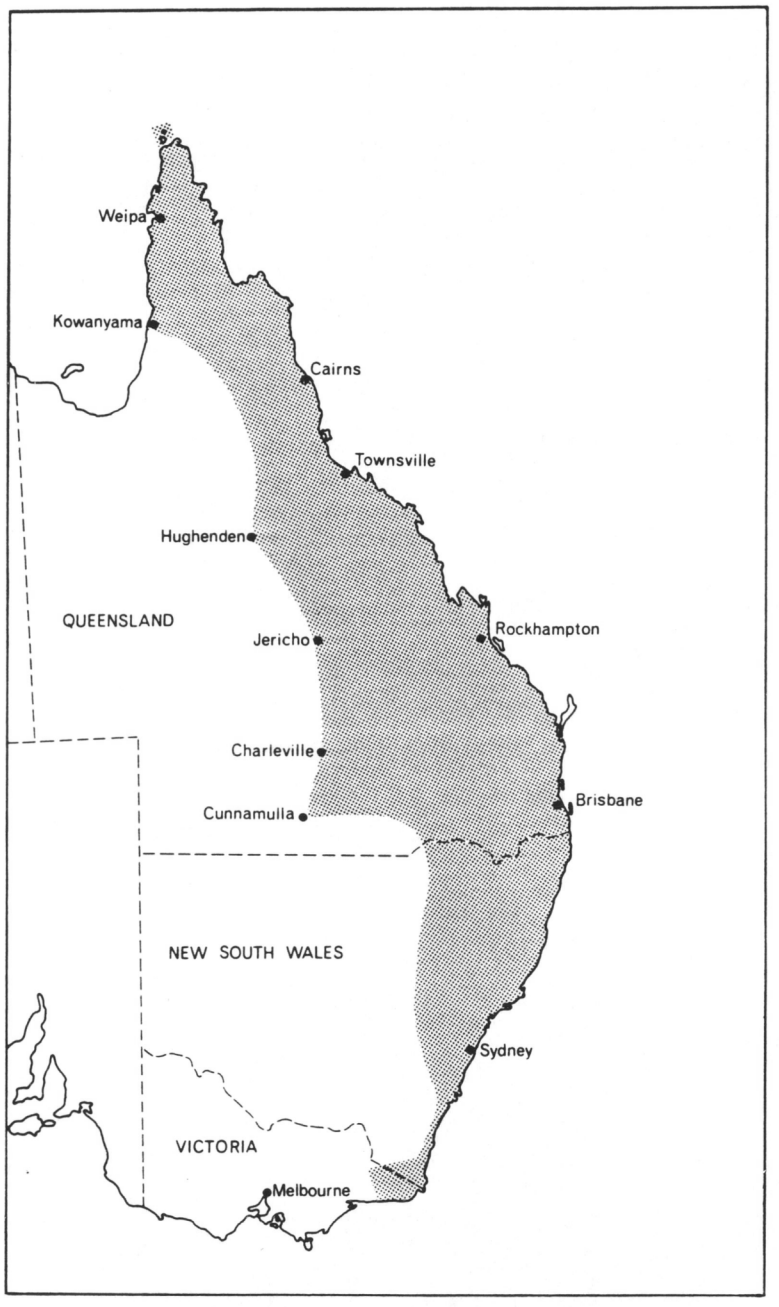

Figure 30—Map of eastern Australia showing distribution of *D. tryoni*

Comments—D. tryoni (the Queensland fruit fly) is the most destructive insect pest of fruit and vegetable crops in Australia. It infests all commercial fruit crops (except pineapple and strawberries) and many vegetable crops. It has been recorded from over 100 host plants in Queensland but probably occurs in many more. Many of the hosts are wild plant fruits which are responsible for the development of extremely large fly populations in forest areas.

It is most probable that *D. tryoni* and *D. dorsalis* are ecological homologues and are of equal pest status. Almost certainly, they infest the same range of fruits and possess similar climatic tolerances.

The distribution of *D. tryoni* within Australia is given in Figure 30. Outside Australia it has been recorded in Papua, New Caledonia, Austral Islands, many islands of the Society group and Easter Island. It was eradicated from Easter Island soon after it was detected in 1971 (see Section III (2C)). It has spread outwards into the South Pacific region from Australia within the last 10 years—an example of how a serious fruit fly pest species can be distributed with the aid of man in the present age of high speed travel. It was first recorded in the Austral Islands (Tubuai) in March 1977 by N. L. H. Krauss (personal communication, D. E. Hardy).

(B) Species outside Australia—Species described in this section do not occur within Australia.

Dacus (Paradacus) decipiens Drew

(Figure 31)

Material studied: A series of specimens collected at localities in New Britain.

A medium sized species; facial spots oval; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with broad pale fuscous costal band and anal streak and with an irregular S-shaped pale fuscous marking across the centre; costal cells extremely pale fuscous; microtrichia in outer $\frac{1}{3}$ of second cell; abdomen generally fulvous with a narrow medial longitudinal fuscous band on tergite V.

Female

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with at most small fuscous markings around orbital bristles; antero-medial hump covered with a large number of short, fulvous setae; bristles black: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous with medium sized, oval, fuscous to black spots not reaching epistoma. *Genae* fulvous; pale brown sub-ocular spots present; bristles black.

Occiput fulvous, small pale fuscous areas dorsally, yellow along eye margin; occipital rows with a large number of strong fulvous bristles each side. *Antennae* fulvous with no dark markings; a strong fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura red-brown except pale fuscous markings as follows: along anterior margin of mesopleural stripes; on sternopleura below yellow spot; on pteropleura behind mesopleural stripes; above hind coxae. Mesonotum red-brown except two broad lateral longitudinal fuscous bands running inside lateral post-sutural vittae from posterior margin to anterior margin. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{5}{6}$ lower hypopleural calli (remainder red-brown); two broad, parallel sided lateral post-sutural vittae beginning anterior to mesonotal suture and ending at upper *p.sa.* bristles; a broad medial post-sutural vitta beginning anterior to mesonotal suture and ending at level of upper *p.sa.* bristles. *Postnotum* black laterally, red-brown centrally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 4, *prsc.* absent, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4 to 7 (inner bristles generally weak and fulvous); *hm.* 5 specimens with one pair which are generally weak and fuscous to black, 1 specimen with one weak pale bristle on one side, 1 specimen with no bristles; all bristles well developed and black except where otherwise stated above. *Legs:* all segments fulvous, femora tending whitish basally; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. *Wings:* costal cells extremely pale fuscous, second cell paler in centre, microtrichia in outer $\frac{1}{3}$ of second costal cell only; remainder of wings colourless except pale fuscous stigma, broad pale fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M_{1+2}, and irregular pale fuscous marking across wing which runs from costal band (enveloping r-m cross vein and forming a large blotch in discoidal cell) to hind margin at M_{3+4} and recurving back along i-m cross vein and then recurving back along M_{1+2}, a broad pale fuscous anal streak ending at wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe very weak.

Abdomen—Oval; tergites free; no pecten on abdominal tergite III. Tergites I to V fulvous except broad lateral fuscous margins on tergite I and a narrow medial longitudinal fuscous band on tergite V (tergites III to V in some specimens). A pair of shining spots on tergite V. Visible portion of oviscape orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown, with one pair of lobes at its tip (Figure 32).

Male

Head—As for female.

Thorax—As for female except as follows: wings (a) with aggregation of microtrichia around CuA + 1A; (b) supernumerary lobe very strong.

Abdomen—As for female except as follows: (a) with pecten on abdominal tergite III; (b) posterior lobe of surstylus long; (c) posterior margin of

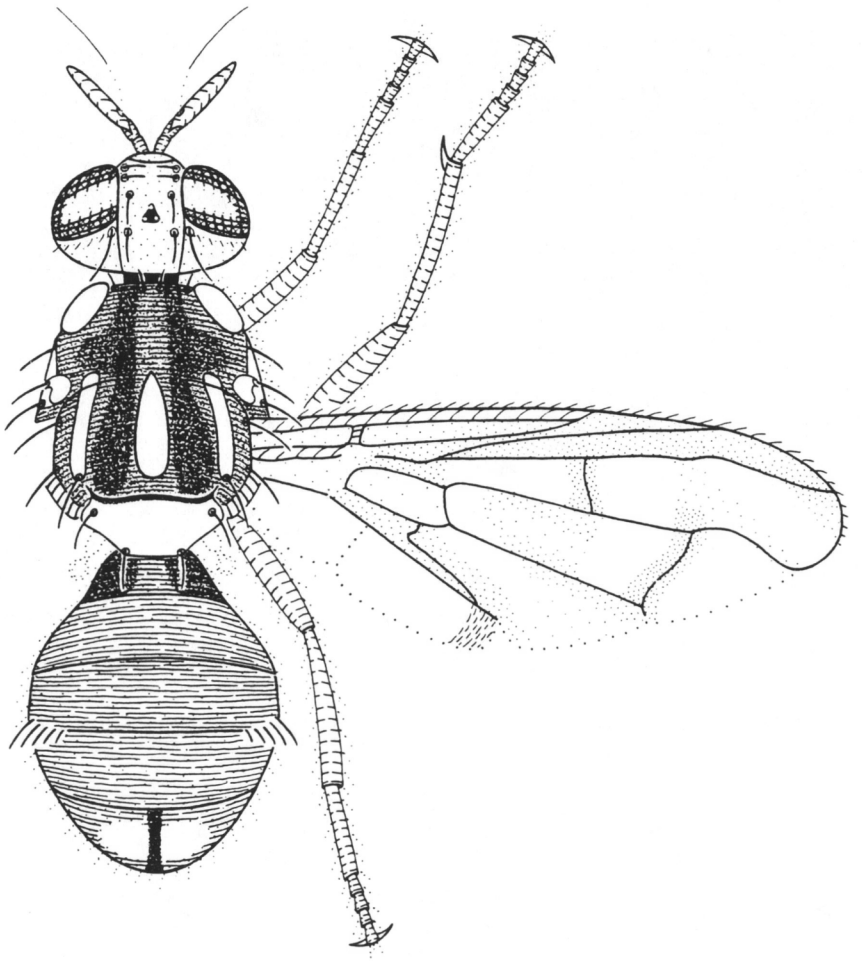

Figure 31—*Dacus (Paradacus) decipiens* Drew (X10)

abdominal sternite V with a slight concavity.

Comments—This species has been recorded only from New Britain where it is a very serious pest of pumpkins. It probably infests a wide range of cucurbits. If introduced into Australia, it could become a more serious pest of cucurbits than the endemic *D. cucumis*. Like *D. cucumis*, *D. decipiens* does not respond to any of the known male lures.

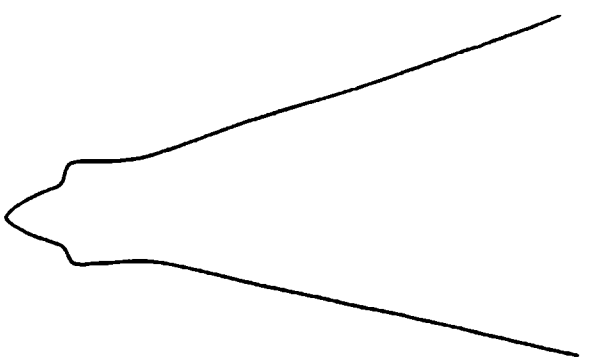

Figure 32—Tip of aculeus of *D. decipiens* (X300)

Dacus (Paratridacus) atrisetosus (Perkins)

(Figure 33)

Material studied: A series of specimens collected at localities in Papua New Guinea.

A medium sized species: facial spots small and circular; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with narrow fuscous costal band and anal streak; costal cells pale fulvous; microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal tergites III to V orange-brown with fuscous on lateral margins of tergite III and a narrow medial fuscous band on tergite V.

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except small fuscous area on antero-medial hump; latter covered with short dark fulvous setae; bristles fuscous: 1 *s.or.*, 2-3 *i.or.*; lunule fulvous. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous with small circular fuscous spots not reaching epistoma. *Genae* fulvous; sub-ocular spots small and pale brown when present; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-6 well developed fulvous bristles and a large number of small paler bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment; a strong fulvous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

Thorax—Red-brown with irregularly shaped fuscous markings as follows: anterior to mesopleural stripes (but not below humeral calli); on pteropleura; on sternopleura; above hind coxae; a very large circular spot between humeral calli and anterior margins of lateral post-sutural vittae; a

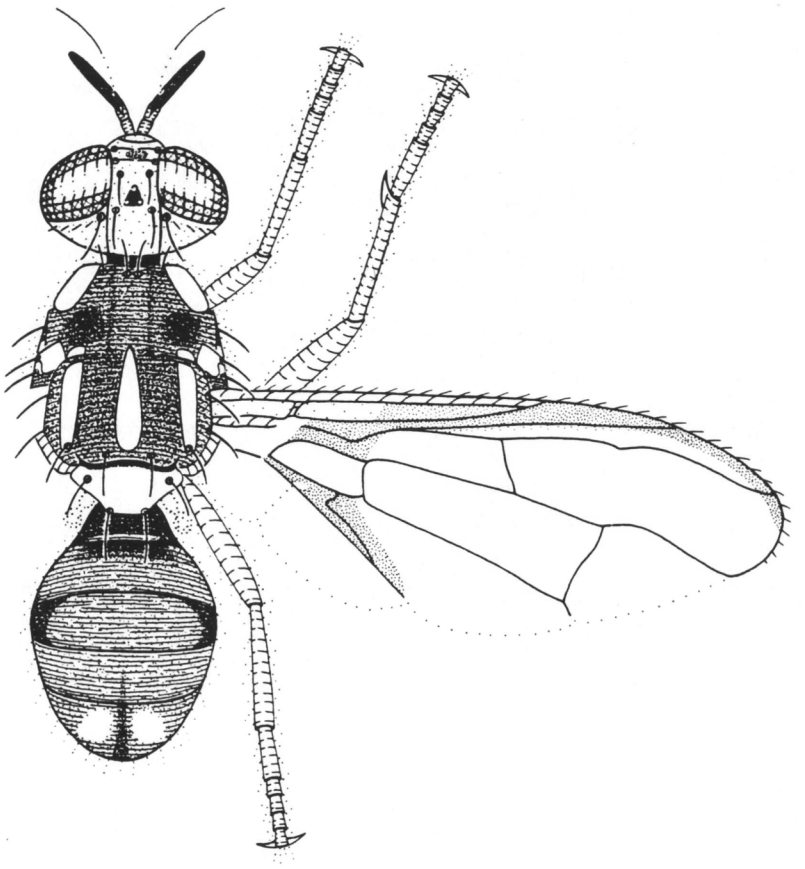

Figure 33—*Dacus (Paratridacus) atrisetosus* (Perkins) (X13)

large pattern between post-sutural vittae which may extend back to posterior margin of mesonotum: a narrow band running from anterior margin of mesonotum just inside each humeral callus to unite with colouration between lateral and medial post-sutural vittae. There is a large amount of variation in the fuscous colour patterns: (1) the pleura vary from red-brown and devoid of fuscous colouration to entirely fuscous with only red-brown below humeral calli—between these extremes there are various developments of infuscation: (2) the mesonotum varies from (a) red-brown with a small amount of infuscation between post-sutural vittae and a large fuscous spot between humeral calli and anterior margin of lateral post-sutural vittae to (b) entirely infuscated except for red-brown area running from anterior point of medial post-sutural vitta to anterior margin of mesonotum between humeral calli—

between these extremes there are various developments of infuscation. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each extending to midway between anterior margin of notopleural callus and anterior *npl.* bristle above, anterior margin slightly convex and continuing onto sternopleuron below as a large transverse spot; upper hypopleural calli (posterior apices red-brown to fuscous); $\frac{5}{7}$ lower hypopleural calli (remainder red-brown to fuscous); two moderately broad, parallel sided, lateral post-sutural vittae beginning anterior to mesonotal suture and ending behind upper *p.sa.* bristles; a broad medial post-sutural vitta beginning at level of *prsc.* bristles and narrowing anteriorly to end just anterior of mesonotal suture. *Postnotum* black except tending brown medially. *Scutellum* yellow except narrow red-brown to fuscous basal band. *Bristles: sc.* 4, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fulvous, rows of long fulvous setae on dorsal surface of fore femora; mid tibiae with apical black spur. *Wings:* costal cells pale fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, and a narrow fuscous anal streak ending before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Elongate oval; tergites free; no pecten on tergite III. Tergite I fuscous except orange-brown along posterior margin; tergite II orange-brown except fuscous along anterior $\frac{1}{3}$ which may not reach lateral margins; tergites III to V orange-brown, sometimes with fuscous on lateral margins of tergite III and generally with a narrow medial fuscous band on tergite V. A pair of shining spots on tergite V.

Comments—D. atrisetosus is known only from Papua New Guinea, where it appears common at higher altitudes. In this area it has been bred from cucurbits. Its pest status would be minor compared with *D. cucurbitae* and *D. decipiens.*

Malloch (1939) recorded a female of *D. cucumis* from Mondo (1,524 m), Papua. *D. cucumis* almost certainly does not occur outside Australia and Malloch probably had a specimen of *D. atrisetosus.*

It does not respond to any of the known male lures and therefore is difficult to monitor.

Dacus (Zeugodacus) cucurbitae Coquillett

(Figure 34)

Material studied: A series of specimens collected at localities in Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island.

A medium sized species; facial spots large and oval; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a broad fuscous costal band and anal streak (costal band expanded into a large spot) and with infuscation on i-m and r-m

cross veins; costal cells colourless; microtrichia in outer portion of second costal cell; abdominal tergites III to V orange-brown with black markings as follows—a narrow transverse band along anterior margin of tergite III, on anterolateral corners of each tergite and a medial longitudinal band on tergites III to V.

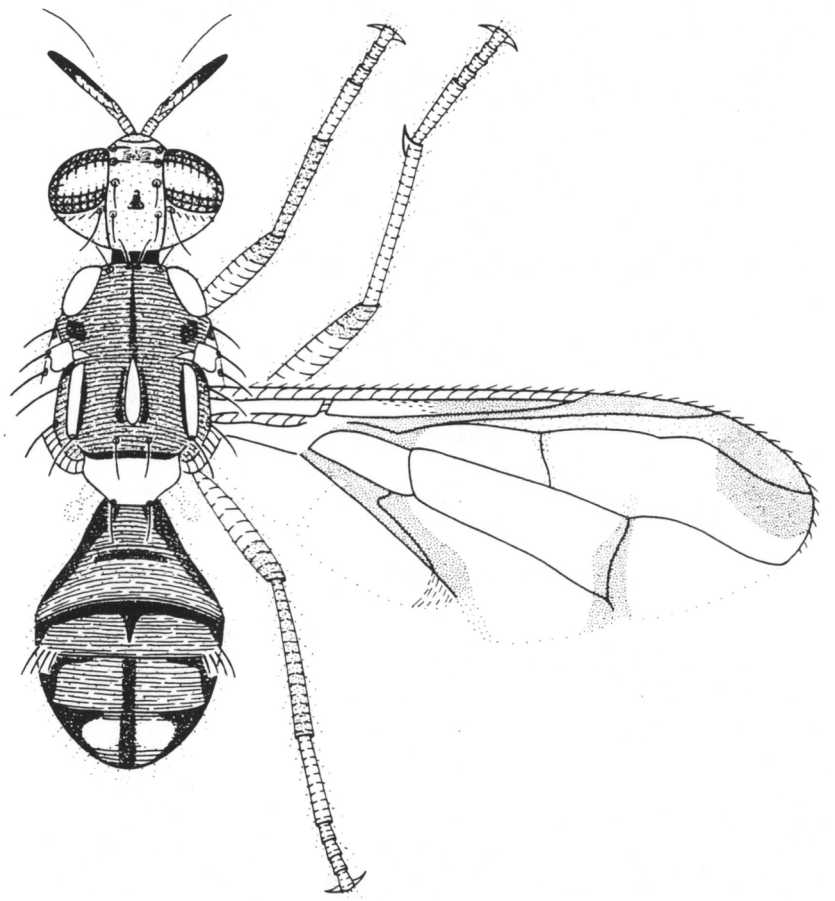

Figure 34—*Dacus (Zeugodacus) cucurbitae* Coquillett (X13)

Head—Generally fulvous. *Frons* of even width; fulvous except pale fuscous around orbital bristles and on antero-medial hump (absent in a few specimens); latter covered with short setae; bristles fuscous: 1 *s.or.*, 3 *i.or.* (4 *i.or.* bristles in a few specimens); lunule darkened. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous except large oval facial spots not reaching

epistoma. *Genae* fulvous; brown sub-ocular spots present; bristles fuscous. *Occiput* fulvous, yellow along eye margin; occipital rows well developed, with many long pale bristles each side. *Antennae* fulvous, with fuscous on apex and outer surface of third segment; a long fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

Thorax—Red-brown with variation from no dark markings to fuscous markings as follows: along anterior margin of mesopleural stripes: on sternopleura; above hind coxae; on pteropleura; posterior to notopleural calli; along inner margin of lateral post-sutural vittae; an irregular marking between humeral calli and notopleural calli; a narrow band around medial post-sutural vitta which extends forward medially to the anterior margin of the mesonotum (variation in the above colour characters occurs irregularly throughout the specimens studied—the patterns that are most variable are as follows: on sternopleura; on pteropleura; the band around the medial post-sutural vitta). Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown); two moderately broad, lateral post-sutural vittae beginning before mesonotal suture and narrowing slightly posteriorly to end at the upper *p.sa.* bristles; a short, narrow, medial post-sutural vitta beginning at level of mesonotal suture and widening posteriorly to end before level of *prsc.* bristles. *Postnotum* red-brown (with a fuscous tinge on lateral margins in some specimens). *Scutellum* yellow, except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; bristles mostly well developed and fuscous. This species has a large variation in chaetotaxy. The chaetotaxy mentioned above is the normal pattern for this species; however, the following variations occur; *sc.*—4; *prsc.*—3 or 4; *a.sa.*—1 bristle on one side only or bristles absent on both sides; *npl.*—3 bristles on one side and 2 on the other side; *scp.* 1, 2, or 3 strong bristles with a corresponding number of weak bristles to make 4 bristles, or 1 or 2 outer bristles with 1 weak fulvous inner bristle, or 3 well developed bristles only. The percentage variation based on the number of specimens having irregular chaetotaxic patterns are as follows: *sc.* 22%; *prsc.* 19%; *a.sa.* 22%; *npl.* 4%; *scp.* 37%. There is a large amount of variation in the bristles which are important in subgeneric classification, namely, *sc.*, *prsc.*, and *a.sa.* These variations do not show any pattern between geographic localities. *Legs:* all segments fulvous except fore and hind tibiae and apical $\frac{1}{3}$ of all femora dark fulvous (in some specimens the fore tibiae are fulvous); rows of long fulvous setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except a broad fuscous costal band confluent with R_{4+5} (except a narrow clear area above this vein distal to r-m cross vein) and ending at apex of wing in a large dark fuscous spot which does not reach extremity of M_{1+2}, a band of dark fuscous colouration around i-m cross vein which reaches wing margin, a narrow tint of infuscation around r-m cross vein, a broad fuscous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. A dense aggregation

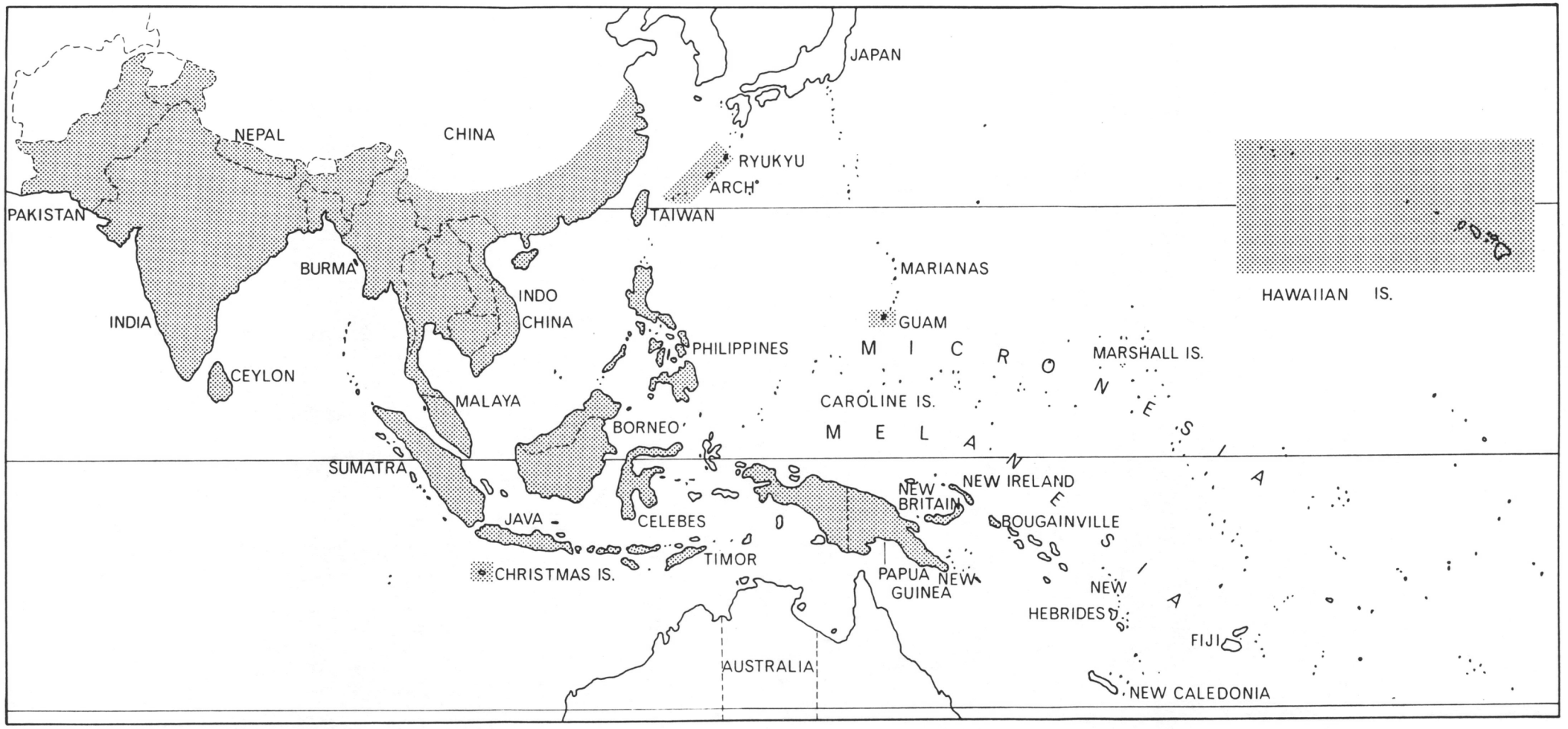

Figure 35—Map of Asian and Pacific regions showing distribution of *D. cucurbitae*

of microtrichia around CuA + 1A. Supernumerary lobe strong in males, weak in females.

Abdomen—Elongate oval; tergites free; pecten present on tergite III. Tergite I orange-brown with broad fuscous lateral bands; tergite II orange-brown, tending whitish on posterior ½ and with narrow fuscous bands on anterolateral margins, and in some specimens, with a narrow transverse fuscous band centrally just posterior of anterior margin; tergites III to V orange-brown except a narrow transverse black band along anterior margin of tergite III which expands over anterolateral corners, a narrow medial longitudinal dark fuscous to black band from anterior margin of tergite III and widening posteriorly to end at or just before posterior margin of tergite V (this band is usually absent on posterior portion of tergite III or across intersegmental line between tergites III and IV), and anterolateral margins of tergites IV and V fuscous (reduced or absent in a few specimens). A pair of shining spots on tergite V.

Comments—In the South Pacific area, *D. cucurbitae* has been recorded from Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island. Its worldwide distribution is shown in Figure 35.

D. cucurbitae is the major fruit fly pest of vegetable crops and one of the world's most active and serious fruit fly pest species. Its introduction into Australia would cause problems of enormous magnitude and for this reason its presence in Papua New Guinea and associated islands must be regarded with great concern. It is the only fruit fly pest of cucurbits that responds to a male lure and this makes the monitoring of its populations easier. It is also subject to eradication or suppression using the male annihilation technique.

Dacus (Notodacus) xanthodes (Broun)

(Figure 36)

Material studied: A series of specimens collected at localities in Fiji, Tonga and Western Samoa.

In the original description, this species was listed as being found in fruit imported into New Zealand from Rarotonga (Cook Islands), Suva and Tonga. It appears that these records were based on the occurrence of larvae in fruit and not on adults bred from the larvae. *D. xanthodes* has never been subsequently recorded from Rarotonga Islands and so this record is probably incorrect.

A medium sized species; facial spots small and circular; mesonotum transparent and possessing a shining orange-brown colouration; lateral and medial post-sutural vittae present; humeral and notopleural calli joined by a yellow band; posterior ⅔ humeral calli yellow; notopleural calli orange-brown; mesopleural stripe reduced in size and not reaching notopleural callus dorsally; scutellum orange-brown with lateral margins yellow; wing with a narrow fuscous costal band and broad fulvous anal streak; costal cells pale fulvous; microtrichia in outer portion of second costal cell; abdominal tergites pale orange-brown with no dark markings.

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump small and covered with a small number of short fulvous setae; bristles black: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small circular facial spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles black. *Occiput* fulvous; occipital rows with 2-6 well developed fulvous bristles and many small pale bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment and the outer surface of first segment; a strong fuscous bristle on the second segment; arista fulvous proximally (remainder black).

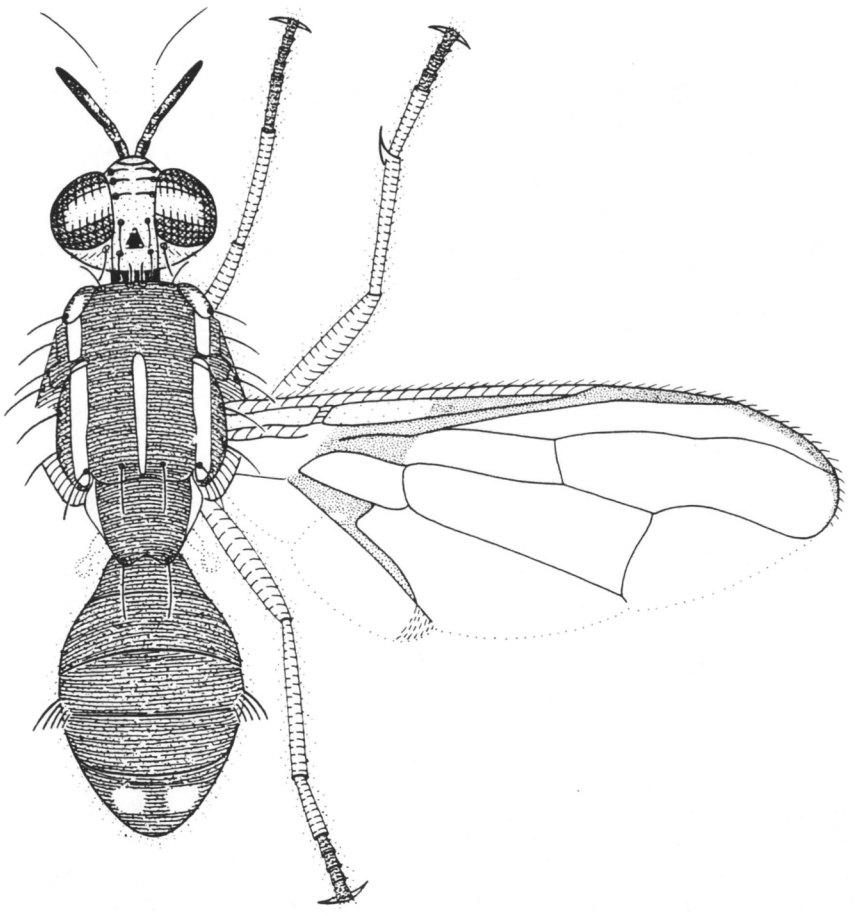

Figure 36—*Dacus (Notodacus) xanthodes* (Broun) (X13)

Thorax—Pleura transparent and with a shining fulvous colouration produced by internal muscle attachments; mesonotum transparent and with a shining orange-brown colouration except irregular dark markings due to attachments of large dorsoventral flight muscles. Yellow markings as follows: broad band on posterior $\frac{2}{3}$ of humeral calli (remainder of humeral calli fulvous); a broad lateral yellow band running from humeral calli to end just before lateral post-sutural vittae; two broad lateral post-sutural vittae beginning before mesonotal suture and narrowing slightly posteriorly to end at posterior margin of mesonotum; a narrow medial longitudinal vitta beginning at level of mesonotal suture and ending at level of lower *p.sa.* bristles; a large central spot on posterior $\frac{2}{3}$ of anepisternum and this continues onto anterior margin of anepimeron; anterior $\frac{1}{3}$ lower hypopleural calli (remainder orange-brown). Notopleural calli orange-brown. Upper hypopleural calli fulvous. *Postnotum* orange-brown. *Scutellum* orange-brown with lateral margins yellow; the scutellum is elongate with dorsal surface flattened and posterior margin drawn out to a point at bases of bristles. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *hm.* 1, *scp.* 4; all bristles well developed and black except inner scapulars reduced and fulvous in some specimens. *Legs:* fulvous except fore tarsi and apical four segments of mid and hind tarsi dark fulvous; middle tibiae with apical black spur. *Wings:* costal cells extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings extremely pale fulvous except narrow fuscous costal band confluent with R_{2+3} and ending betweeen extremities of R_{4+5} and M_{1+2}, a broad fulvous anal streak darkest in anal cell and ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; tergites free; pecten present on tergite III. All tergites transparent and shining; colour of tergites pale orange-brown with no dark markings; pair of spots on tergite V present but not shining.

Female

Head—As for male.

Thorax—As for male except as follows: (1) no dense aggregation of microtrichia around vein CuA + 1A; (2) supernumerary lobe weak.

Abdomen—As for male except as follows: (1) no pecten on tergite III; (2) visible portion of oviscape with basal $\frac{1}{3}$ pale orange-brown (remainder dark fuscous), dorsoventrally flattened and tapering posteriorly in dorsal view. Length of visible portion of oviscape to length of tergite V, 2.5:1. Aculeus strongly sclerotized, red-brown, needle shaped at its tip (Figure 37).

Comments—This species has the following distinctive characters: (1) 3 *i.or.* bristles on frons; (2) presence of one pair of well developed *hm.* bristles; (3) the integument of the head, thorax and abdomen is generally transparent giving the specimens a mottled appearance as internal tissues are visible; (4) the integument is soft and this is particularly noticeable on the abdominal tergites which curl inwards ventrally in dead specimens; (5) the pair of spots on abdominal tergite V have a rough appearance compared with the smooth shining spots of most species.

D. xanthodes has been recorded from Fiji, Western Samoa and Tonga.

This species has been bred from pineapple. citrus, papaya, granadilla, guava and tomatoes. It has the potential to become a very serious pest if introduced into areas where extensive horticulture is carried out.

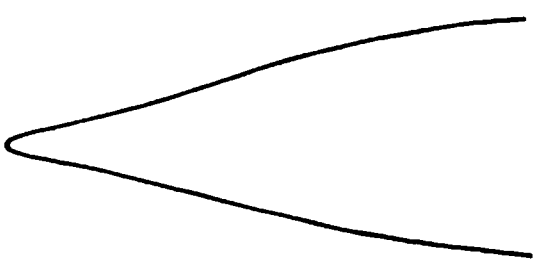

Figure 37—Tip of aculeus of *D. xanthodes* (X145)

Dacus (Bactrocera) curvipennis Froggatt

(Figure 38)

Material studied: A series of specimens collected in New Caledonia.

A small species; facial spots elongate and pale fuscous; mesonotum black; lateral post-sutural vittae present: humeral and notopleural calli yellow; mesopleural stripes narrow; scutellum yellow: wing with a broad fuscous costal band and anal streak; costal cells pale fuscous, microtrichia covering second costal cell; abdominal tergites III to V orange-brown with a narrow fuscous band along anterior margin of tergite III, fuscous to black laterally on tergite III and fuscous anterolaterally on tergites IV and V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except pale fuscous markings around orbital bristles; antero-medial hump covered with a small number of short pale setae; bristles dark fulvous: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* dark fulvous. *Face* fulvous with very small, elongate, pale fuscous spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin: occipital rows well developed, with 3-7 strong dark fulvous bristles each side. *Antennae* fulvous, with fuscous on the apex and outer surface of the third segment; a strong dark fulvous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Black with dark brown below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli and inside humeral calli (in one specimen the humeral and notopleural calli are connected by a broad dark brown band above the notopleural suture); with brown below

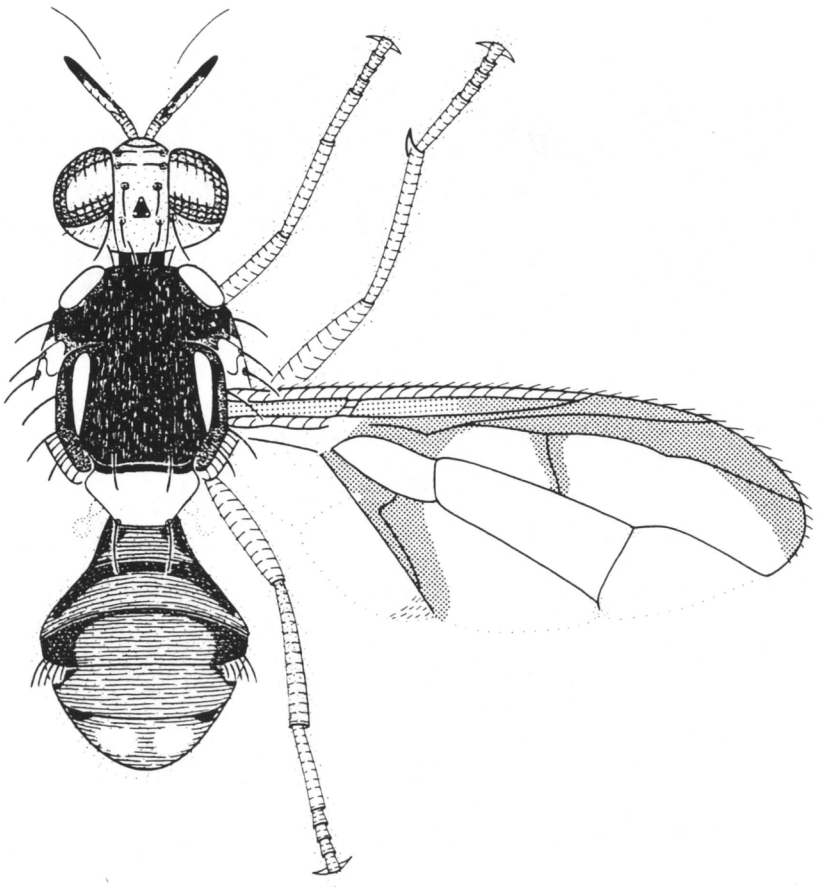

Figure 38—*Dacus (Bactrocera) curvipennis* Froggatt (X16)

humeral calli and above middle coxae. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, extending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); posterior $\frac{3}{5}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing posteriorly to end before the upper *p.sa.* bristles as a result of brown colouration surrounding this bristle and covering the yellow vitta at its extremity. *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fulvous. One specimen has 3 *prsc.*

bristles, one specimen has three pair of *p.sa.* bristles, and one specimen has 3 *p.sa.* bristles on one side. *Legs:* all segments fulvous except mid and hind coxae and hind tibiae dark fulvous; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells pale fuscous, microtrichia covering all of second costal cell and outer portion of first costal cell; remainder of wings colourless except broad fuscous costal band confluent with R_{4+5} and ending just before extremity of M_{1+2}, a broad fuscous band along r-m cross vein, a broad fuscous anal streak ending at wing margin and including area covered with dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I orange-brown with broad fuscous bands on lateral margins (these fuscous bands may be reduced in size in some specimens); tergite II orange-brown with a narrow transverse fuscous band just posterior of anterior margin and which widens to cover the anterolateral margins (this fuscous band decreases in size in some specimens and is absent except for a very faint transverse infuscation in other specimens); tergites III to V orange-brown with a narrow transverse fuscous band along anterior margin of tergite III which merges into broad lateral black margins, and anterolateral corners of tergites IV and V fuscous (in some specimens the fuscous band along the anterior margin of tergite III and the fuscous anterolateral corners of tergites IV and V are absent, leaving only the broad black lateral margins of tergite III). A pair of shining spots on tergite V.

Female

Head—As for male.

Thorax—As for male except (1) no aggregation of microtrichia around CuA + 1A; (2) supernumerary lobe weak; (3) proportion of anal cell extension to CuA + 1A, 1.65:1.

Abdomen—As for male except (1) no pecten on abdominal tergite III; (2) visible portion of oviscape flattened, narrowing posteriorly in dorsal view and dark fulvous to fuscous in colour; length of visible portion of oviscape to length of tergite V, 0.82:1.

Comments—D. curvipennis infests citrus in New Caledonia. It presently is not known outside this locality.

Dacus (Bactrocera) facialis Coquillett

(Figure 39)

Material studied: A series of specimens collected on islands in Tonga.

A small species; facial spots absent; mesonotum black; lateral post-sutural vittae very short and narrow; humeral and notopleural calli yellow; mesopleural stripes broad; scutellum generally yellow but sometimes with a fuscous to black triangular pattern on dorsal surface; wing with a narrow fuscous costal band and pale fuscous anal streak; costal cells colourless; microtrichia in outer corner of second cell; abdominal tergites III to V orange-brown with lateral and medial longitudinal fuscous to black bands over all

three tergites (the lateral bands are usually broken on the posterolateral corners of tergite IV).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump covered with short fulvous setae; bristles dark fuscous: 1 *s.or*.. 2 *i.or*.; lunule fulvous. *Ocellar triangle* dark fuscous to black. *Vertex* fulvous. *Face* fulvous; facial spots absent. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous ventrally, fuscous to black dorsally, yellow along eye margin; occipital rows with 5-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on outer surface of third segment; a well developed fuscous bristle on dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

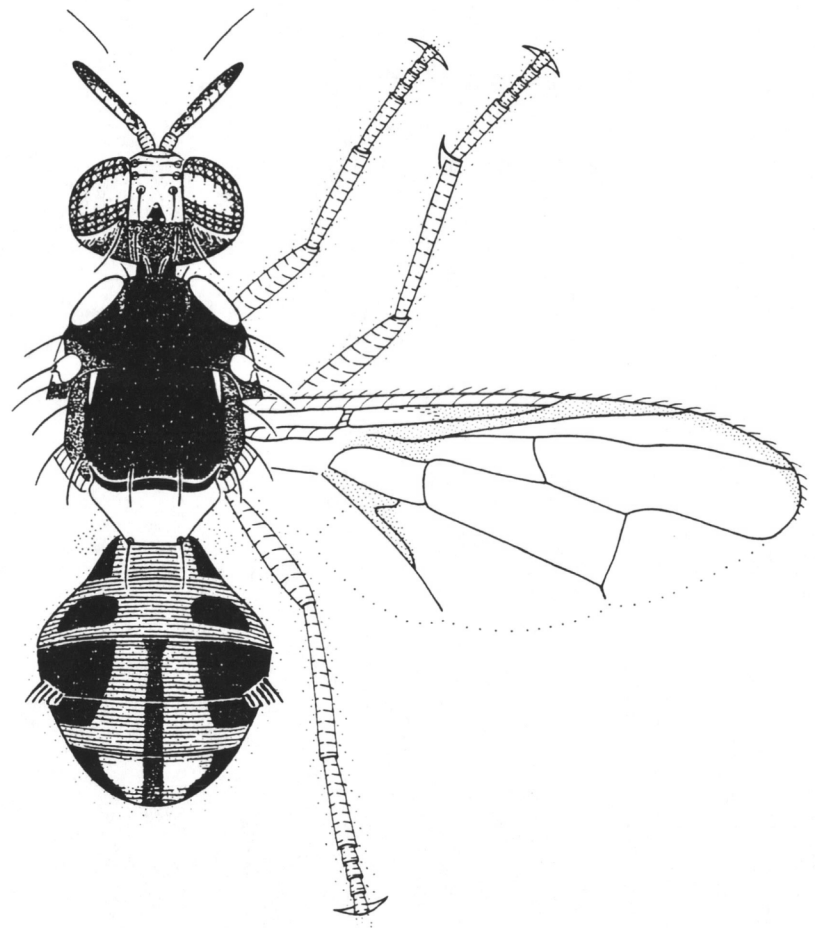

Figure 39—*Dacus (Bactrocera) facialis* Coquillett (X14)

Thorax—A variable amount of melanic pigmentation is evident. Pleura fulvous without dark markings or with dark markings between two extremes as follows: (1) pale fuscous markings on sternopleuron and on the lower ½ of anepimeron posterior to mesopleural stripe; (2) black with red-brown below humeral calli and above mid coxae. Mesonotum generally dark fuscous to black, the area of which varies as follows: (1) in specimens where the pleura are mostly fulvous, there are brown markings on the mesonotum as follows—below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, a narrow stripe inside humeral calli; (2) in specimens with pleura mostly black, the mesonotum is black with brown markings as follows—a small area below *a.sa.* bristle; above notopleural calli; a small elongate spot in some specimens replacing the lateral post-sutural vittae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, each ending just before humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); two narrow short lateral post-sutural vittae narrowing posteriorly to end just behind level of *a.sa.* bristles. *Postnotum* dark fuscous to black, tending brown centrally. *Scutellum* mostly yellow but with variable fuscous to black patterns (these patterns vary from a narrow basal band to a medial longitudinal triangular band over the entire scutellum). *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs:* all segments fulvous; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae with apical fuscous to dark fuscous spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and broadening after crossing extremity of R_{2+3} to end between extremities of R_{4+5} and M_{1+2}, a narrow pale fuscous anal streak ending well before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I orange-brown with no dark markings or with two large lateral fuscous to dark fuscous spots; tergite II orange-brown with two large transverse fuscous to black spots on lateral margins; a small medial longitudinal fuscous spot is present on each of tergites I and II in some specimens; tergites III to V orange-brown with broad lateral fuscous to black margins on tergite III, anterolateral margins of tergites IV and V fuscous to black, a moderately broad medial longitudinal fuscous to black band running from anterior margin of tergite III to posterior margin of tergite V (in some specimens the dark markings on tergites III to V are increased in size so that there are two broad lateral longitudinal fuscous to black bands running from anterior margin of tergite III to posterior margin of tergite V and which meet along anterior margin of tergite III). A pair of shining spots on tergite V.

Female

Head—As for male.

Thorax—As for male except as follows: (1) no aggregation of microtrichia around CuA + 1A; (2) supernumerary lobe weak.

Abdomen—As for male except as follows: (1) no pecten on abdominal tergite III; (2) visible portion of oviscape fuscous to dark fuscous, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown, with apex needle shaped.

Comments—D. facialis has been recorded infesting a range of fruits and vegetables, including citrus, peach, mango, guava, capsicum and tomato. It is recognised as a serious pest species with the potential to be of major importance if introduced into major fruit and vegetable producing countries.

This species has been recorded from Tongatapu island and the Ha'apai Group in Tonga. It is probably widespread throughout the islands of Tonga.

Dacus (Bactrocera) kirki Froggatt

(Figure 40)

Material studied: A series of specimens collected at localities in Western Samoa, American Samoa, Tonga, Niue Island and Tahiti.

A medium sized species; facial spots large and oval; mesonotum glossy black; post-sutural vittae absent; humeral calli yellow (anterodorsal margin black); notopleural calli yellow; mesopleural stripes of medium width; scutellum glossy black with yellow lateral margins; wing with a narrow pale fuscous costal band and anal streak; costal cells extremely pale fuscous; microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal tergite I glossy black, abdominal tergites II to V orange-brown with a broad glossy black transverse band on base of tergite II and broad lateral and medial longitudinal glossy black bands over all four tergites.

Head—Generally fulvous. *Frons* narrowing posteriorly; dark fulvous with pale fuscous around orbital bristles; antero-medial hump with, at most, only a few short dark fulvous setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* dark fulvous. *Face* fulvous with large oval facial spots reaching epistoma. *Genae* dark fulvous; brown sub-ocular spots present; bristles dark fuscous to black. *Occiput* black dorsally, dark fulvous ventrally, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* with first and second segments fulvous to dark fulvous, third segment fuscous except dark fulvous on inner basal surface; a strong fuscous bristle on dorsal surface of second segment; arista dark fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (anterodorsal margin black); notopleural calli; mesopleural stripes of medium width, each slightly wider than notopleural callus above, continuing onto sternopleuron below as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black). Lateral post-sutural vittae absent. *Postnotum* black. *Scutellum* glossy black with extreme lateral margins yellow. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae dark fulvous, mid and hind coxae dark fuscous to black; all femora dark fulvous; fore tibiae fuscous, mid tibiae dark fulvous, hind tibiae dark fuscous to black; fore tarsi dark fuscous

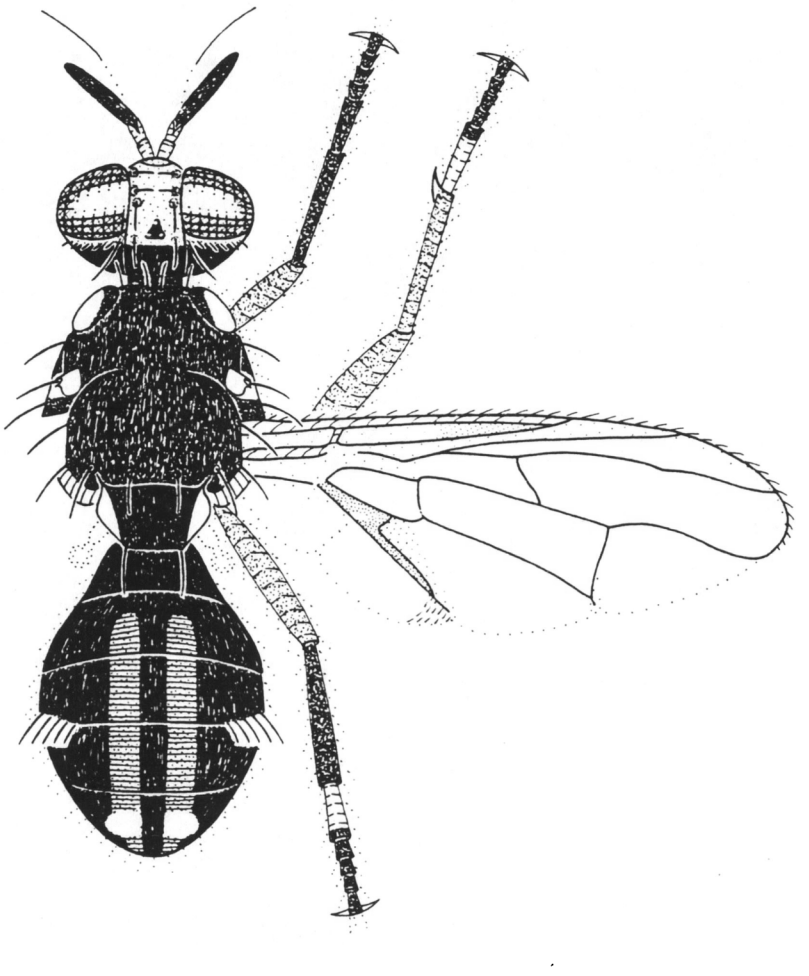

Figure 40—*Dacus (Bactrocera) kirki* Froggatt (X12)

to black (tending paler proximally), mid and hind tarsi with apical four segments and apex of basal segment fuscous (remainder fulvous); fore femora with rows of long dark setae on dorsal surface; middle tibiae with apical black spur. *Wings:* costal cells tinged with extremely pale fuscous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except fuscous stigma, narrow pale fuscous costal band confluent with R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow pale fuscous tinge around r-m and i-m cross veins, a narrow fuscous anal streak becoming paler towards and ending at wing margin. A dense aggregation of microtrichia

around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I glossy black with a pair of orange-brown spots on posterior margin either side of the medial line; tergites II to V orange-brown with glossy black markings as follows: a broad transverse band across basal $\frac{1}{3}$ of tergite II; two broad lateral longitudinal bands running from basal band on tergite II to posterior margin of tergite V; a broad medial longitudinal band running from basal band on tergite II and narrowing posteriorly to end at posterior margin of tergite V. A pair of shining spots on tergite V which are red-brown in colour.

Comments—This species has been recorded from Western Samoa, American Samoa, Tonga, Niue Island and Tahiti and has been bred from peach, mango, guava and capsicum.

Dacus (Bactrocera) melanotus Coquillett

(Figure 41)

Material studied: A large series of specimens collected at Mitiaro Island and Rarotonga Island in the Cook Islands.

A medium sized species; facial spots absent; mesonotum glossy black; post-sutural vittae absent; humeral calli yellow; notopleural calli glossy black; mesopleural stripes broad; scutellum glossy black; wing with a narrow pale fuscous costal band; anal streak reduced to a pale tinge in anal cell; costal cells colourless; microtrichia in outer corner of second costal cell; all abdominal tergites glossy black.

Head—Generally dark fulvous. *Frons* narrowing posteriorly; dark fulvous with two broad fuscous bands running along eye margins from vertex to *s.or.* bristles; antero-medial hump with only a few short dark fulvous setae; bristles black; 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* dark fulvous; facial spots absent. *Genae* dark fulvous; sub-ocular spots absent; bristles black. *Occiput* black dorsally, dark fulvous ventrally and along eye margin; occipital rows with 4-7 well developed black bristles each side. *Antennae* with all segments dark fuscous except dark fulvous on inner basal surface of third segment; a strong black bristle on dorsal surface of second segment; arista dark fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (anterolateral corners black); broad mesopleural stripes each extending to (or nearly to) humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder black). Notopleural calli glossy black. Post-sutural vittae absent. *Postnotum* glossy black. *Scutellum* glossy black. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae dark fulvous, mid and hind coxae dark fuscous to black; fore femora dark fuscous (tending dark fulvous basally), mid and hind femora black (tending dark fuscous on basal halves); fore and mid tibiae dark fuscous, hind

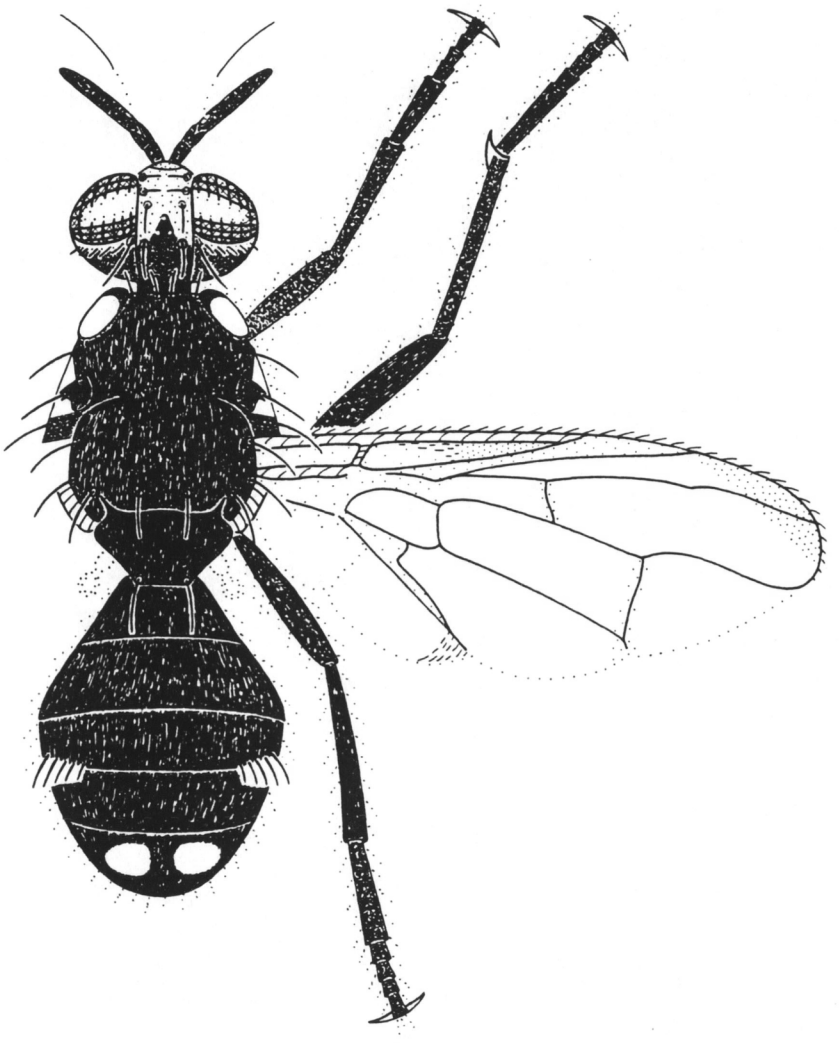

Figure 41—*Dacus (Bactrocera) melanotus* Coquillett (X14)

tibiae black; all tarsal segments dark fuscous to black; rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless or with, at most, a very faint tinge of fuscous colouration, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, a narrow pale fuscous costal band confluent with R_{2+3} and darkening to fuscous and widening

beyond extremity of R_{2+3} to end midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous tinge around r-m and i-m cross veins, a narrow fuscous tinge in anal cell and extending to wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. All tergites glossy black. A pair of shining spots on tergite V.

Comments—D. melanotus has been recorded only from the Cook Islands. It is a very serious pest of citrus and has also been found infesting mango and guava.

Dacus (Bactrocera) passiflorae Froggatt

(Figure 42)

Material studied: A series of speciments collected at Fiji, Tonga and Niue Island.

A small species; facial spots absent; mesonotum glossy black; postsutural vittae absent; humeral calli glossy black; notopleural calli yellow; mesopleural stripes broad; scutellum yellow; wing with narrow fuscous costal band and pale fuscous anal streak; costal cells colourless; microtrichia in outer portion of second costal cell; all abdominal tergites glossy black except posterior margin of tergite V dark fuscous.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous bands on lateral margins running from vertex to base of *s.or.* bristle; anteromedial hump with a few short pale setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous; facial spots absent. *Genae* fulvous; brown sub-ocular spots present; bristles fulvous. *Occiput* black dorsally, fulvous ventrally, yellow along eye margin; occipital rows strong with 5-9 large black bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment (sometimes pale fuscous on the inner surface of the third segment); a strong dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: notopleural calli; moderately broad mesopleural stripes, each reaching to or beyond anterior *npl.* bristle above, extending onto sternopleuron below as a small transverse spot in only a few specimens, anterior margin markedly convex, upper hypopleural calli (posterior apices glossy black); anterior $\frac{5}{8}$ lower hypopleural calli (remainder glossy black). Humeral calli glossy black. Post-sutural vittae absent. *Postnotum* glossy black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous to black. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous; rows of long dark fulvous setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless with microtrichia in outer portion of second costal cell only; remainder of wings colourless except narrow fuscous costal band confluent with R_{2+3}, widening

slightly after crossing extremity of R_{2+3} and extending midway between extremities of R_{4+5} and M_{1+2}, and a narrow pale fuscous anal streak ending at extremity of anal cell extension. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

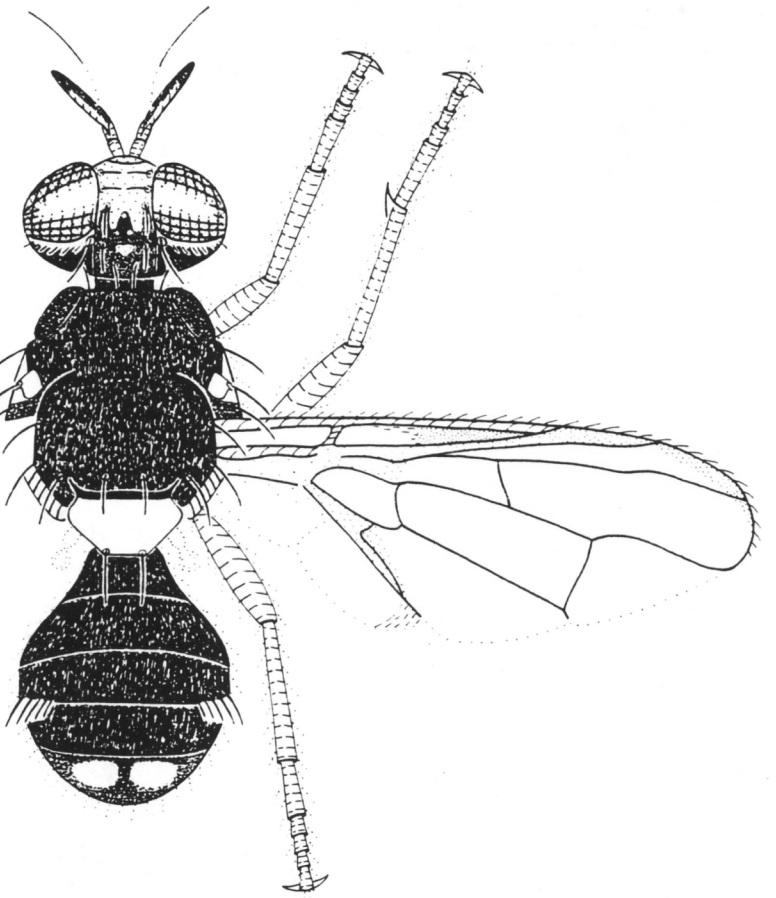

Figure 42—*Dacus (Bactrocera) passiflorae* Froggatt (X16)

Abdomen—Oval; tergites free; pecten present on tergite III. Tergites I to IV glossy black; tergite V either glossy black with posterior margin dark fuscous or fuscous with a medial longitudinal black band. A pair of large oval shining spots on tergite V.

Comments—*D. passiflorae* has been found infesting citrus, passionfruit, mango and granadilla.

This species has been recorded from Fiji, Niuatoputapu Island (Tonga) and Niue Island.

Dacus (Bactrocera) psidii (Froggatt)

(Figure 43)

Material studied: A series of specimens collected at New Caledonia.

A small species: facial spots small and elongate; mesonotum glossy black; lateral post-sutural vittae present; humeral calli yellow (anterodorsal corner black); notopleural calli yellow; mesopleural stripes narrow; scutellum yellow with a broad triangular marking on dorsal surface; wing with costal band

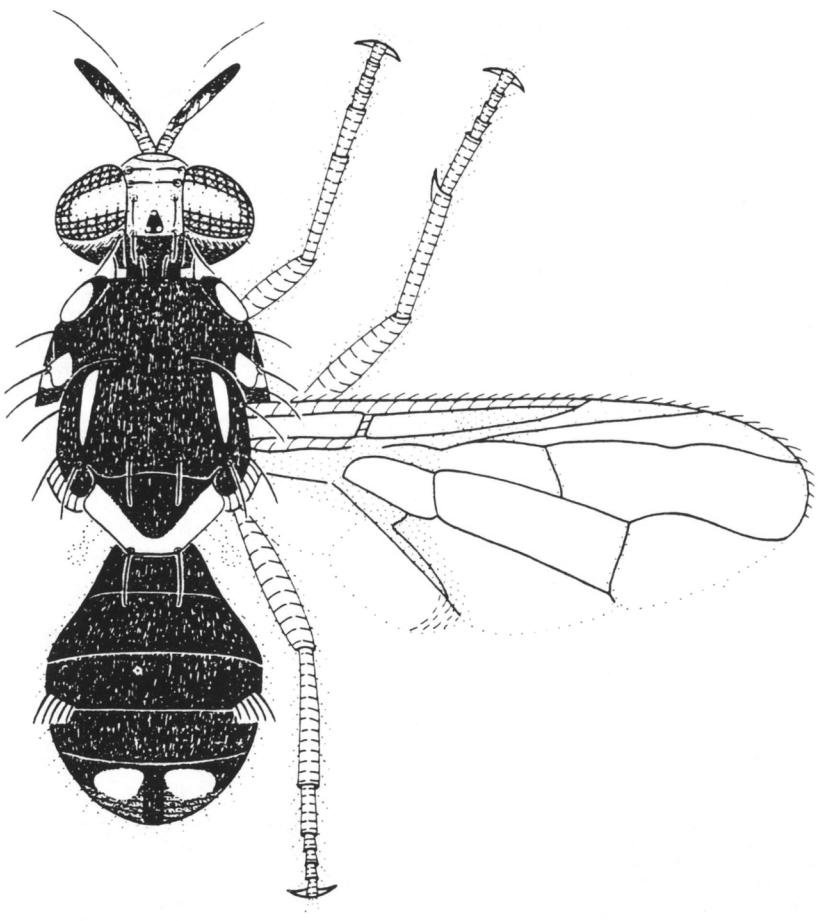

Figure 43—*Dacus (Bactrocera) psidii* (Froggatt) (X15)

reduced to an extremely pale fuscous tinge around costal margin; anal streak narrow and fulvous; costal cells colourless; microtrichia in outer corner of second costal cell; all abdominal tergites glossy black.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump with a small number of short pale setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous and generally with small fuscous to dark fuscous elongate spots not reaching epistoma (about 25 per cent of specimens have facial spots absent). *Genae* fulvous; pale brown sub-ocular spots present; bristles dark fulvous. *Occiput* dark fuscous to black dorsally, fulvous ventrally, yellow along eye margin; occipital rows with 5-8 well developed dark fuscous bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a strong dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (except anterodorsal corner black); notopleural calli; narrow mesopleural stripes, each equal in width to notopleural callus above, continuing onto sternopleuron below, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing slightly posteriorly to end well before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow with a broad triangular black marking on dorsal surface. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous; fore femora with rows of long pale setae on dorsal surface; middle tibiae with apical black spur. *Wings:* costal cells colourless to extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fulvous stigma, a narrow tinge of extremely pale fuscous colouration around costal margin which ends between extremities of R_{4+5} and M_{1+2} (darker around extremity of R_{4+5}), a narrow tinge of fuscous colouration around r-m and i-m cross veins (darker around r-m cross vein), a narrow fulvous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. All tergites glossy black; in a few specimens tergite V tends to be dark red-brown especially around hind margin and along either side of a broad medial longitudinal black band. A pair of shining spots on tergite V.

Comments—D. psidii has been bred from citrus, mango, granadilla and guava.

It has only been recorded from New Caledonia. It has the capacity to become a serious pest of horticultural crops in regions where the above crops are developed. In New Caledonia, however, the introduced *D. tryoni* (Queensland fruit fly) will probably become more important economically that *D. psidii*.

Dacus (Bactrocera) trivialis Drew

(Figure 44)

Material studied: A series of specimens collected at localities throughout Papua New Guinea and West Irian Jaya.

A medium sized species; facial spots pear shaped; mesonotum dull black; lateral post-sutural vittae present; humeral and notopleural calli yellow; mesopleural stripes narrow; scutellum yellow; wing with narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer corner of second costal cell; abdominal tergites III to V generally dull black to dark fuscous except fulvous on central areas of tergites IV and V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except fuscous around orbital bristles and on antero-medial hump; latter covered with short fuscous setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous centrally, fuscous lateral to antennae. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with pear shaped facial spots pointed anteriorly but not reaching epistoma. *Genae* fulvous; large, brown sub-ocular spots present; bristles red-brown to fuscous. *Occiput* fulvous except yellow along eye margin; occipital rows strong with 4-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of the third segment; a well developed fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

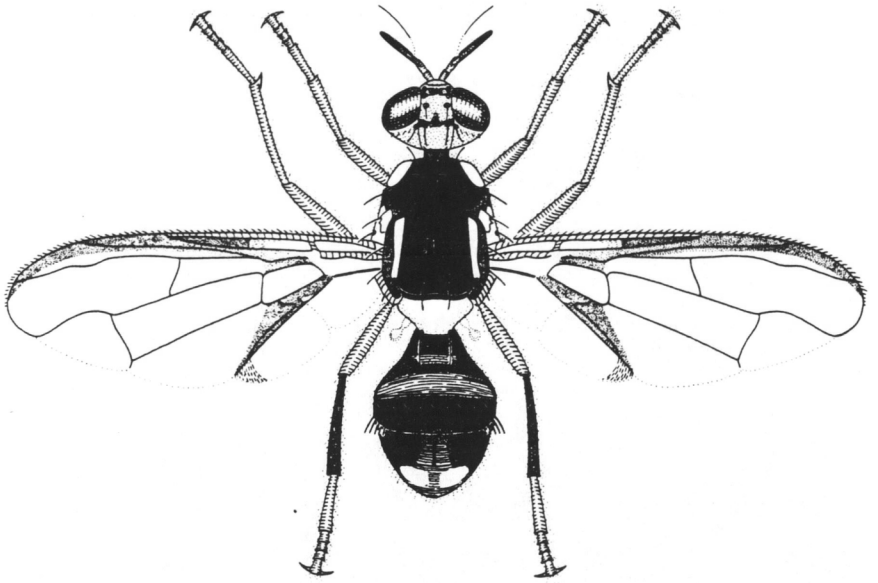

Figure 44—*Dacus (Bactrocera) trivialis* Drew (X8)

Thorax—Pleura brown with dark markings as follows: fuscous anterior to mesopleural stripe to a line level with anterior notopleural bristle, sternopleuron black, dark red-brown to fuscous along posterior margins of mesopleural stripe and above hind coxae; mesonotum dull black, approaching fuscous posteriorly to a line just anterior of prescutellar bristles and with brown markings as follows: below and behind lateral post-sutural vittae, around notopleural calli and above notopleural suture between notopleural and humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, each ending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder fuscous); two moderately broad, lateral post-sutural vittae narrowing slightly posteriorly to end at the upper *p.sa.* bristles. *Postnotum* black except red-brown centrally. *Scutellum* yellow except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous except for hind tibiae fuscous; rows of long fulvous setae along dorsal surface of fore femora; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except dark fulvous stigma, narrow fuscous costal band extending over vein R_{2+3} into cell R_{2+3} and crossing vein R_{4+5} at its tip to end between extremities of veins R_{4+5} and M_{1+2}, narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around vein CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; tergites free; pecten present on abdominal tergite III. Tergite I fuscous; tergite II fuscous over most of anterior $\frac{1}{2}$ which extends backwards on lateral margins to posterior margin, fulvous centrally along anterior margin and remainder of tergite whitish; tergite III black, tending brown centrally along posterior margin; tergite IV black except brown centrally along anterior margin, fulvous on central posterior portion and a suggestion of a narrow medial fuscous band on the latter fulvous area; tergite V fulvous except fuscous on anterolateral margins. A pair of brown shining spots on tergite V.

Comments—D. trivialis has been bred from peach and guava. It is very closely related taxonomically to *D. dorsalis* (oriental fruit fly) and could become a pest of horticultural crops if such crops are developed in Papua New Guinea.

Dacus (Bactrocera) umbrosus Fabricius

(Figures 45, 46)

Material studied: A large series of specimens collected at localities from South-East Asia, Papua New Guinea, islands of the Bismarck Archipelago, Solomon Islands, New Hebrides and New Caledonia.

A medium sized species; facial spots present; mesonotum black; lateral post-sutural vittae present; humeral and notopleural calli yellow; mesopleural

stripes broad; scutellum yellow; wing with broad fuscous costal band and anal streak and with two broad transverse fuscous bands running from costal band to hind margin; costal cells fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal tergites III to V orange-brown with or without lateral and medial longitudinal dark bands.

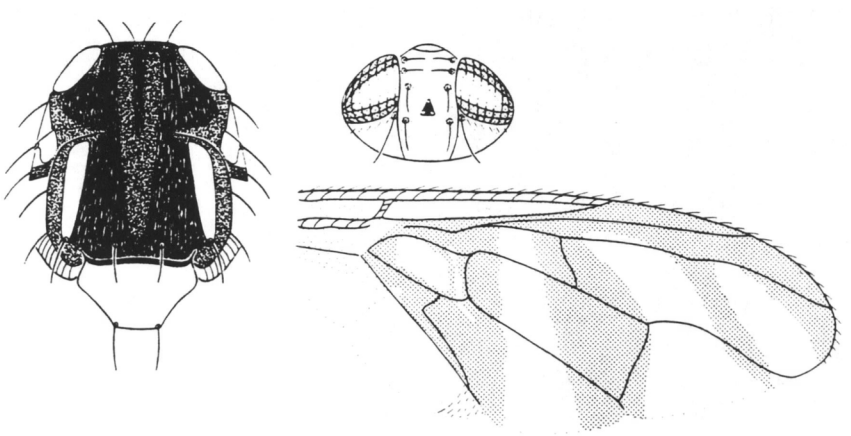

Figure 45—Head, thorax, wing of *Dacus* (*Bactrocera*) *umbrosus* Fabricius (X12)

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without pale fuscous around orbital bristles and on antero-medial hump; latter covered with dark fulvous setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with medium sized circular facial spots not reaching epistoma. *Genae* fulvous; subocular spot absent; bristle fuscous. *Occiput* fulvous, tending fuscous dorsolaterally, yellow along eye margin; occipital row with 2-7 well developed fuscous bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; a well developed dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Black with brown markings below humeral calli, above mid coxae, below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, a band between humeral and notopleural calli dorsal to notopleural suture, inside humeral calli, a broad medial longitudinal band running along mesonotum from anterior margin to level of *prsc.* bristles (this band varies in size and is often divided longitudinally into two narrow bands by a narrow black band). The brown markings vary in size and shape usually being larger in specimens from Papua New Guinea and smaller in specimens from New Hebrides and New Caledonia. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, each extending to humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural callus (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two broad lateral

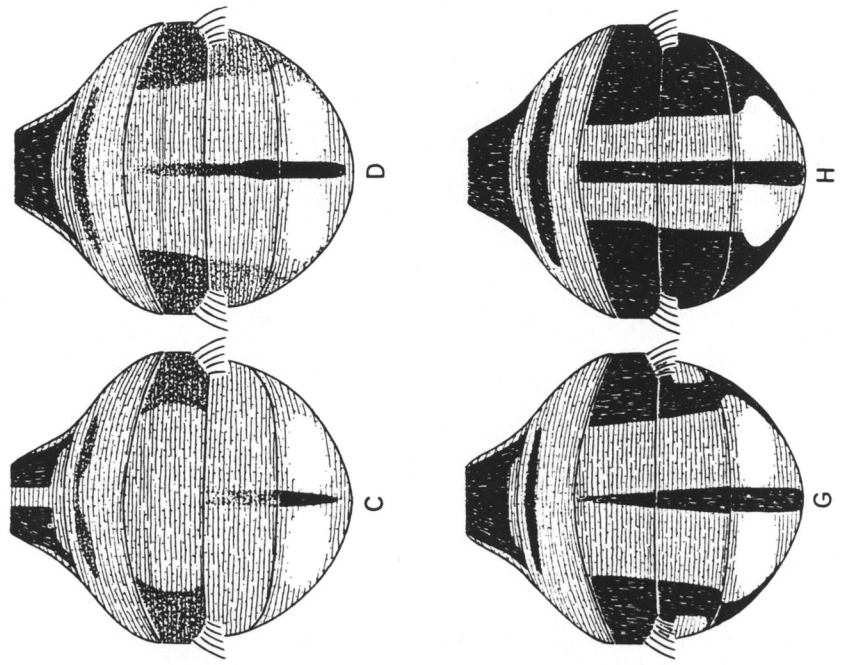

Figure 46—Colour variation in abdomen of *D. umbrosus* (X20)

post-sutural vittae ending at or just behind the upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* all segments fulvous; rows of long pale setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings*: costal cells fulvous with microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except dark fulvous stigma, broad fuscous costal band confluent with R_{4+5} (except for a small area distal to r-m cross vein in some specimens) and ending between extremities of R_{4+5} and M_{1+2}, a broad transverse fuscous band across centre of wing from costal band to hind margin and enveloping both cross veins, a narrower transverse fuscous band from costal band to hind margin at apex of wing, a broad transverse fuscous band from costal band to anal streak, a broad fuscous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; tergites free; pecten present on tergite III. Tergite I dark fuscous to black with a broad orange-brown basal band centrally. Tergites II to V show wide variation in colour pattern. Eight colour forms (Figure 46 A-H) have been selected to show the variation that occurs in the abdominal colour patterns. This variation has been shown to be geographic, representing a gradual change over a geographic range from Papua New Guinea to New Caledonia (Drew, 1974b). The extremes of the colour pattern range have been regarded previously as separate species by some authors, viz., *D. umbrosus* Fabricius with a pale coloured abdomen and *D. frenchi* Froggatt with a dark coloured abdomen.

Comments—D. umbrosus has been bred from citrus and breadfruit and could have the capacity to become a pest of horticultural crops.

It is widely distributed throughout South-East Asia, Papua New Guinea and associated islands, islands of the Bismarck Archipelago, Bougainville Island, Solomon Islands, New Hebrides and New Caledonia.

(5) ASSESSMENT OF ECONOMIC IMPORTANCE AND SUMMARY OF GEOGRAPHIC DISTRIBUTION OF PEST SPECIES

The species discussed in Section I (4) have all been bred from one or more commercial fruit or vegetable hosts.

Quarantine action against fruit fly pest species should be governed, to some extent, by whether or not they are major or minor pests. Recognition of species as being major or minor pests is complicated by the fact that some currently lesser known pest species have the capability to become major pests. To be of maximum value, judgements regarding these potentially major pest species must be made on criteria presently available and before they have attained their pest potential. It is believed that the occurrence of these potentially major pest species should be brought to the attention of quarantine and agriculture officers throughout the world.

The major pest species have a broad host range (both commercial and

wild fruits), a wide climatic tolerance and a large geographic distribution. Other species with these characteristics must be regarded as potentially major pest species. In contrast the many non-pest species and minor pest species of Dacinae occupy only one or very few host fruits and have a limited geographic distribution and climatic tolerance.

The potentially major pest species and their known distributions are as follows:

Dacus decipiens Drew. . . . . .New Britain
Dacus facialis Coquillett . . . . . .Tonga
Dacus frauenfeldi Schiner. . . . . .Papua New Guinea
Dacus kirki Froggatt . . . . . .Western Samoa, American Samoa, Tonga, Niue Is., Tahiti
Dacus melanotus Coquillett . . . . .Cook Islands
Dacus passiflorae Froggatt. . . . . .Fiji, Niue Is., Tonga
Dacus psidii (Froggatt). . . . . .New Caledonia
Dacus xanthodes (Broun). . . . . .Fiji, Western Samoa, Tonga

Most islands or island groups in the South Pacific each have an endemic fruit fly species which could become of similar pest status to *D. dorsalis*, *D. tryoni* and *D. cucurbitae* (Figure 47). The risk of introduction of these species may be small while horticulture industries in the localities where they occur are in their infancy. However, as these industries develop the fruit fly problem will intensify and cause a greater risk of introduction to major production regions such as Australia and the United States of America (including the Hawaiian Islands).

To date, the recognised major pest species of tropical fruit flies are *D. dorsalis* (oriental fruit fly), *D. tryoni* (Queensland fruit fly) and *D. cucurbitae* (melon fly). *D. tryoni* has been recorded from Papua on one occasion and has been introduced into New Caledonia, Islands of the Tahiti group, Austral Islands and Easter Island (subsequently eradicated from the latter). In Figure 47, only the endemic distribution of *D. tryoni* is shown. *D. cucurbitae* (melon fly) has been introduced into Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island. This serious pest species must be regarded as a major threat to Australian horticulture in the light of its expanded distribution.

(6) SPECIES WHICH MAY BE CONFUSED WITH *DACUS DORSALIS* (HENDEL)

Within the *Dacus dorsalis* complex, three species not described in Section I (4), closely related to *D. dorsalis* and very difficult to separate taxonomically are *Dacus (Bactrocera) endiandrae* (Perkins and May), *Dacus (Bactrocera) occipitalis* (Bezzi) and *Dacus (Bactrocera) pedestris* (Bezzi). The pest status of *D. endiandrae* and *D. occipitalis* is unknown, while *D. pedestris* is known to infest commercial fruits. To assist in identifying these species, the following definitions and illustrations are given.

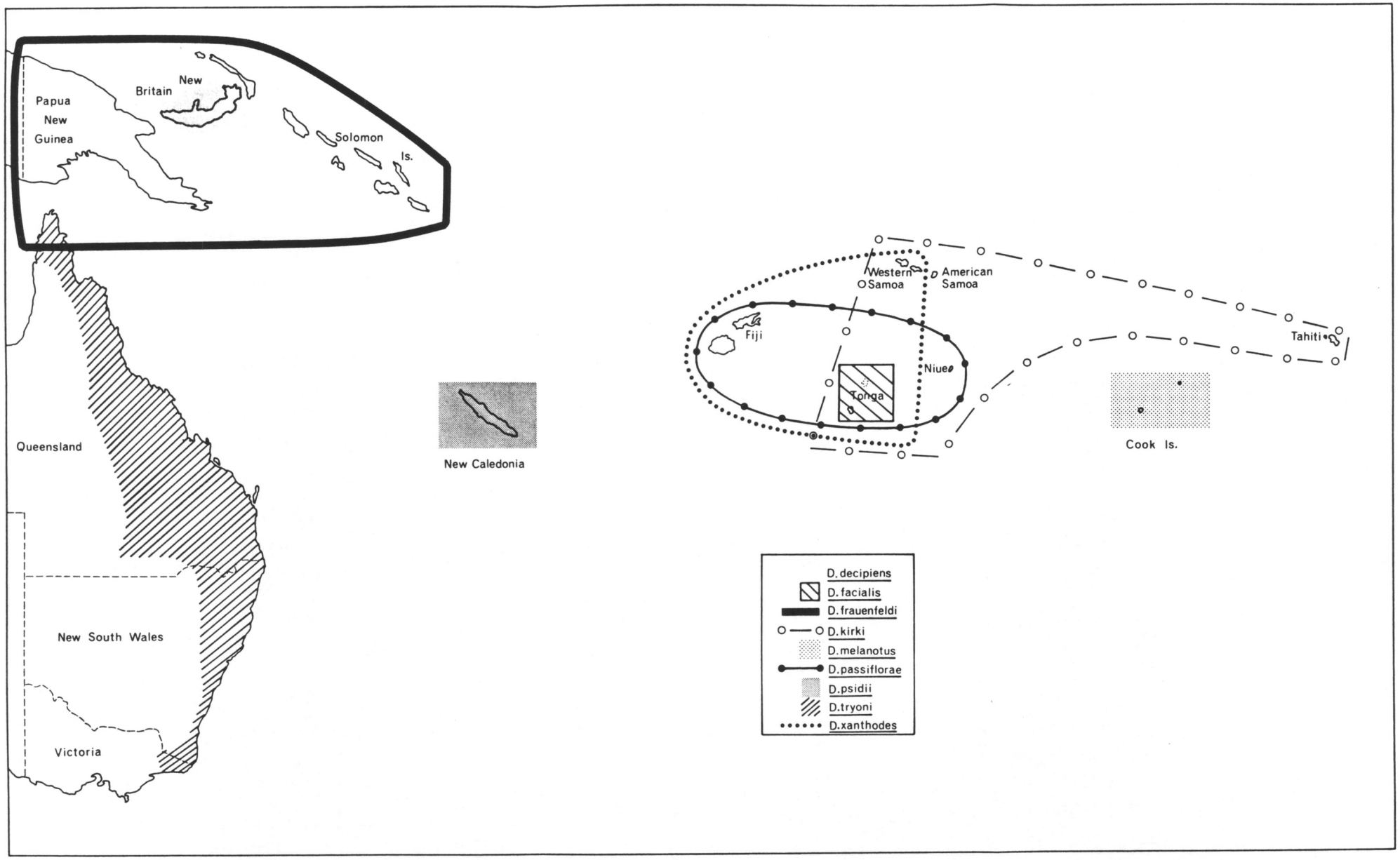

Figure 47—Map of South Pacific region showing distribution of endemic species having economic pest status

Dacus (Bactrocera) endiandrae (Perkins and May)

(Figure 48)

A medium sized species, facial spots oval, mesonotum black except red-brown around lateral margins, lateral post-sutural vittae present and not reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band overlapping vein R_{2+3} and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen orange-brown with transverse dark fuscous to black band along base of tergite III, a medial longitudinal dark fuscous to black band on tergites III to V, moderately broad lateral fuscous to pale fuscous margins on tergites III to V.

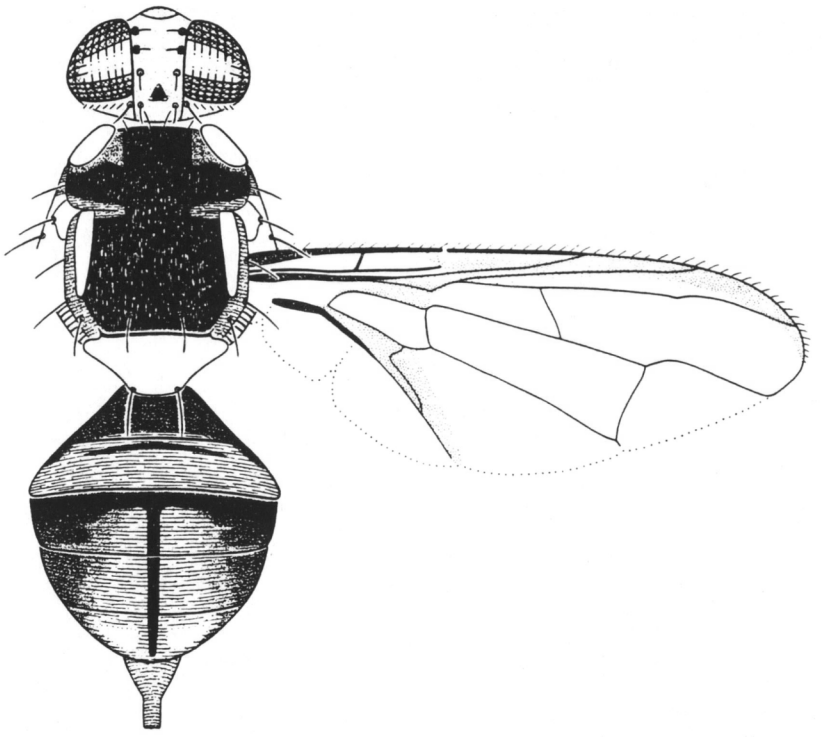

Figure 48—*Dacus (Bactrocera) endiandrae* (Perkins and May) (X13)

Dacus (Bactrocera) occipitalis (Bezzi)

(Figure 49)

A medium sized species, facial spots large and oval, mesonotum black except brown around lateral and posterior margins, lateral post-sutural vittae present and reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band overlapping vein R_{2+3} and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen orange-brown with transverse black band along base of tergite III, a medial longitudinal black band on tergites III to V and anterolateral corners of tergites IV and V black to dark fuscous.

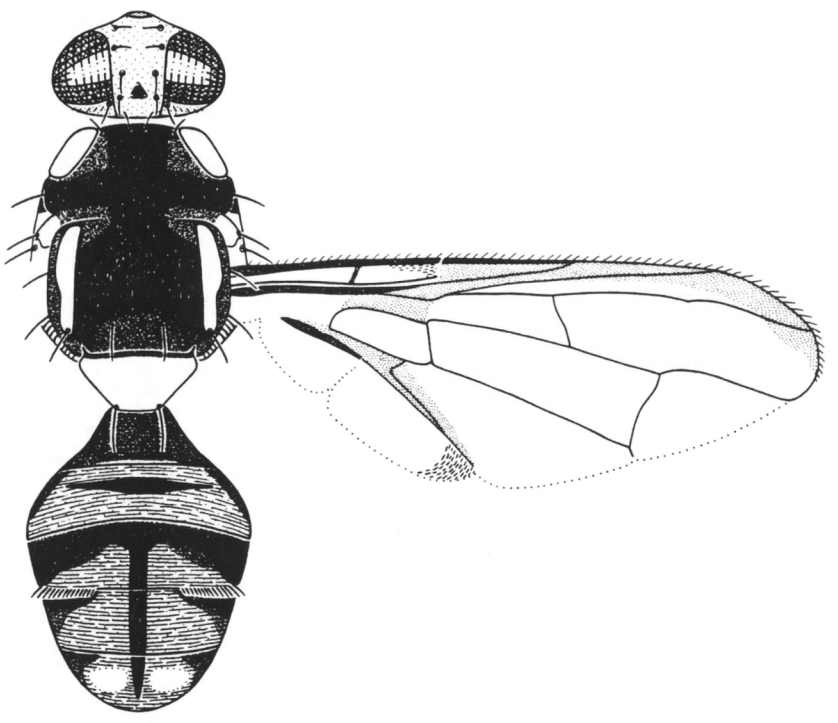

Figure 49—*Dacus (Bactrocera) occipitalis* (Bezzi) (X12)

Dacus (Bactrocera) pedestris (Bezzi)
(Figure 50)

A medium sized species, facial spots large and oval, thorax black except brown around lateral margins, lateral post-sutural vittae present and reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band confluent with vein R_{2+3} and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen with tergites III to V fulvous to orange-brown except for transverse black band across base of tergite III, and a broad medial longitudinal black band and two broad lateral longitudinal dark fuscous to black bands on tergites III to V.

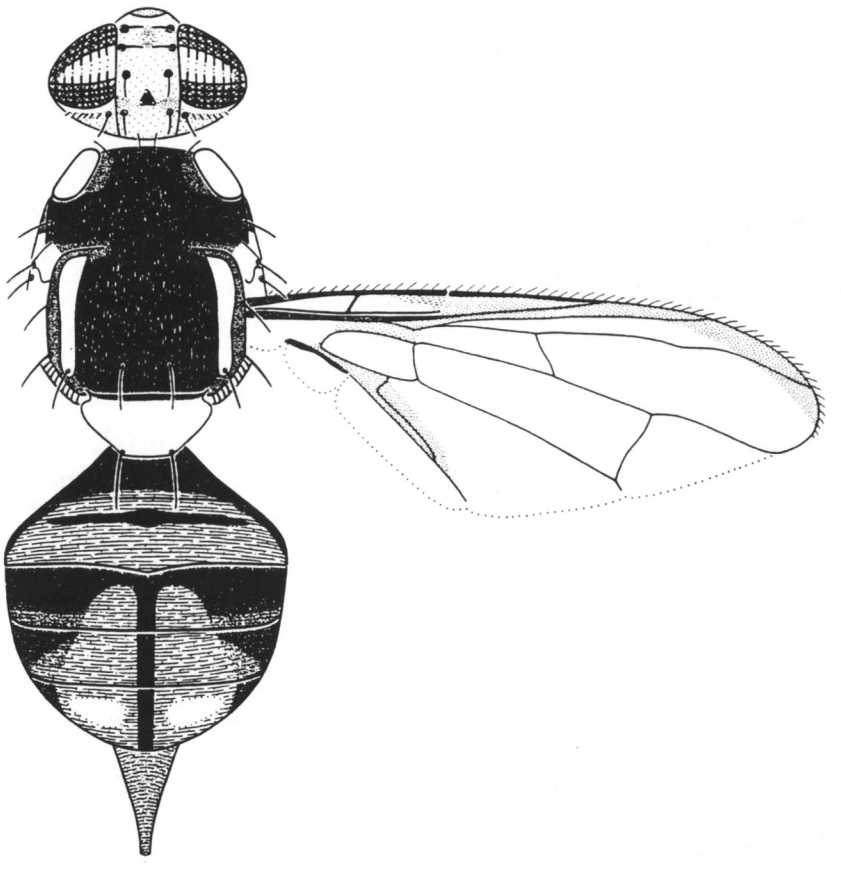

Figure 50—*Dacus (Bactrocera) pedestris* (Bezzi) (X11)

(7) THE RESPONSES OF THE ECONOMIC SPECIES TO MALE ATTRACTANTS

The responses of fruit fly species in the South Pacific area to male attractants has been published previously (Drew, 1974a) and the responses of Australian species is presently being studied and will be published in the near future.

It is important to note that some of the economic pest species do not respond to any of the known male attractants. Consequently, for these species, population monitoring is more difficult and the male annihilation method of eradication can not be used in suppression or eradication programmes.

No species have been found responding to medlure and trimedlure.

Knowing the attractant responses is of assistance in the identification of species, especially in the situation where two similar species are attracted to different lures.

The following table lists the species discussed in Section I (4) and their responses to lures.

Species	Cue-Lure	Methyl Eugenol	No Response
Callantra aequalis (Coquillett)	√		
D. jarvisi (Tryon)			√
D. cucumis French			√
D. breviaculeus Hardy	√		
D. bryoniae (Tryon)	√		
D. cacuminatus (Hering)		√	
D. dorsalis (Hendel)		√	
D. frauenfeldi Schiner	√		
D. halfordiae Tryon			√
D. mayi Hardy		√	
D. melas (Perkins and May)	√		
D. musae (Tryon)		√	
D. mutabilis (May)			√
D. neohumeralis Hardy	√		
D. tryoni (Froggatt)	√		
D. decipiens Drew			√
D. atrisetosus (Perkins)			√
D. cucurbitae Coquillett	√		
D. xanthodes (Broun)		√	
D. curvipennis Froggatt	√		
D. facialis Coquillett	√		
D. kirki Froggatt	√		
D. melanotus Coquillett		√	
D. passiflorae Froggatt	√		
D. psidii (Froggatt)	√		
D. trivialis Drew	√		
D. umbrosus Fabricius		√	

(8) KEY TO SPECIES OF FRUIT FLIES (TEPHRITIDAE: DACINAE) OCCURRING IN AUSTRALIA (This key includes *D. cucurbitae* (melon fly) which does not occur in Australia).

For identification of species occurring in the South Pacific area outside Australia, refer to keys in a previous publication (Drew, 1972b).

The following key is for species collected within Australia. *D. cucurbitae* (melon fly) does not occur in Australia but is included in this key because of the economic importance of the species and because of the high risk of introduction to Australia from adjacent Pacific Islands. When using this key, refer to figures 1-7 and 51-53 for assistance in understanding the key characters.

1. Antennae elongate, first and second segments approximately of equal length, the second and third segments combined generally about equal to vertical length of head, the combined lengths of all segments thus being greater than vertical length of head; abdomen elongate, strongly clavate and petiolate, segment I approximately parallel sided or narrower at its posterior margin in dorsal view; abdomen strongly arched posteriorly and with the suture between tergites III and IV strongly concave forwards in lateral view; abdomen with sternites I and II generally longer than wide .. .. Genus **Callantra** Walker 2

   Antennae comparatively short, first segment approximately one half as long as second segment, the combined lengths of all segments less than vertical length of head; abdomen elongate oval or oval, not strongly petiolate, segment I much wider across posterior margin than anterior margin in dorsal view; abdomen slightly arched centrally and with the suture between tergites III and IV generally straight in lateral view; abdomen with sternites I and II wider than long.. .. Genus **Dacus** Fabricius 5

2. Costal band (Figure 51) extended well below vein R_{4+5} for its entire length 3

   Costal band confluent with vein R_{4+5} and crossing this vein only at apex of wing .. .. .. **Callantra pusilla** May

3. Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein .. **Callantra aequalis** (Coquillett)

   Costal band not attaining vein M_{1+2} for its entire length 4

4. A row of spines present beneath fore femora (Figure 52); black spot on eye margin level with base of antenna; facial spot elongate; oviscape short .. **Callantra petioliforma** May

   No spines beneath fore femora; no spot on eye margin level with base of antenna; facial spot pear shaped or oval; oviscape elongate .. .. **Callantra smieroides** Walker

5. Costal band present 6

   Costal band absent .. .. **D. niger** Tryon (some specimens)

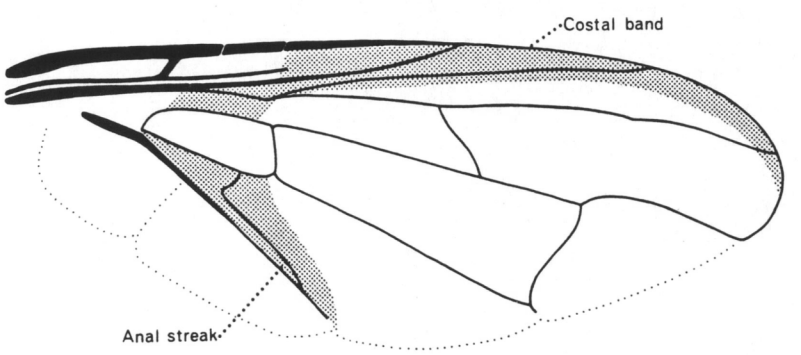

Figure 51—Diagram of wing showing costal band and anal streak

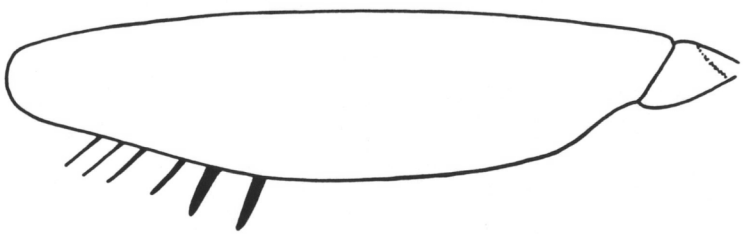

Figure 52—Lateral view of fore femur of *Callantra petioliforma* May showing spines on ventral surface (X41)

6. Costal band broken in middle, forming an isolated apical spot 7
Costal band entire.. 8

7. Notopleural callus brown; r-m cross vein infuscated .. .. **D. (Afrodacus) furvus** May (Males)
Notopleural callus yellow; r-m cross vein not infuscated .. .. **D. (Afrodacus) tigrinus** (May) (Males)

8. Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein .. .. **D. absonifacies** (May)
Costal band not attaining vein M_{1+2} 9

9. Costal band confluent with vein R_{4+5} for its entire length (in *D. visendus* there is a small pale fuscous area distal to r-m cross vein), not or barely crossing this vein except at or beyond r-m cross vein. 10
Costal band narrow, not attaining vein R_{4+5} distal to r-m cross vein except on wing margin after crossing extremity of vein R_{2+3} 17

10. Infuscation on wing in addition to costal band and anal streak 11
No infuscation on wing other than costal band and anal streak (Figure 51) 15

11. Mesopleural stripe broad, attaining humeral callus dorsally .. 12
Mesopleural stripe not attaining humeral callus dorsally 14

12. Medial post-sutural vitta present; *a.sa.* bristles absent; *prsc.* bristles absent .. .. .. **D. (Daculus) visendus** Hardy
Medial post-sutural vitta absent; *a.sa.* bristles present; *prsc.* bristles present.. 13

13. Costal cells colourless; microtrichia in outer portion of second costal cell only; no medial dark stripe on abdomen .. .. **D. (Bactrocera) alyxiae** (May)
Costal cells coloured; microtrichia covering most of second costal cell and outer portion of first cell; a medial black stripe present on abdomen.. **D. (Bactrocera) recurrens** (Hering)

14. Mesopleural stripe broad, extending to anterior *npl.* bristle dorsally; apical third of wing fuscous; lateral post-sutural stripe broad, parallel sided, ending behind upper *p.sa.* bristle .. .. **D. (Bactrocera) amplexiseta** (May)
Mesopleural stripe narrow, about as wide as notopleural callus; infuscation over central portion of wing only; lateral post-sutural stripe narrow and ending before upper *p.sa.* bristle .. .. ..**D. (Bactrocera) pulcher** (Tryon)

15. Mesonotum black; microtrichia in outer portion of second costal cell only. .. .. **D. (Bactrocera) bryoniae** (Tryon)
Mesonotum red-brown, with or without a pattern of black markings; microtrichia covering most of second costal cell and at least outer $\frac{1}{2}$ of first costal cell 16

16. A small species: mesonotum red-brown with a medial longitudinal black band; last three abdominal tergites mostly fuscous .. **D. (Bactrocera) notatagena** (May)
A large species; mesonotum mostly red-brown; last three abdominal tergites red-brown except darker laterally and with a thin dark medial band . .. . **D. (Paratridacus) expandens** Walker

17. Four scutellar bristles 18
Two scutellar bristles 26

18. Medial yellow vitta present on mesonotum 19
No medial yellow vitta on mesonotum 24

19. Infuscation on i-m cross vein; costal band widening at wing apex 20
No infuscation on i-m cross vein; no widening of costal band at wing apex 21

20. Costal band expanded into a distinct dark fuscous spot at apex of wing; usually with a broad dark fuscous band along i-m cross vein; mesonotum mostly red-brown .. .. **D. (Zeugodacus) cucurbitae** Coquillett
Costal band only slightly widened at apex of wing; a narrow pale infuscation along i-m cross vein; mesonotum red-brown with a pattern of small fuscous markings .. .. .. **D. (Zeugodacus) choristus** (May)

21. Prescutellar bristles present 22
Prescutellar bristles absent 23

22. *a.sa.* bristles absent: supernumerary lobe absent in wing .. .. **D. (Hemizeugodacus) aglaiae** Hardy
a.sa. bristles present; supernumerary lobe very strong .. .. **D. (Zeugodacus) fallacis** Drew

23. Medial yellow vitta on mesonotum long and narrow, with apex commencing level with posterior borders of humeral calli; facial spots large, tending oval; a medial black oval spot on fifth abdominal tergite; pecten present on tergite III of male abdomen; strong supernumerary lobe and dense aggregation of microtrichia at extremity of vein CuA+1A, in male .. .. **D. (Diplodacus) signatifer** Tryon
Medial yellow vitta on mesonotum broadening posteriorly and apex commencing level with mesonotal suture; facial spots small and circular; a medial black stripe present on fifth abdominal tergite which may extend forward on to fourth tergite; no pecten on male abdomen; supernumerary lobe very weak and no microtrichia at extremity of vein CuA+1A, in male .. .. **D. (Austrodacus) cucumis** French

24. Small flies, entirely black on mesonotum; lateral post-sutural stripes absent. .. .. **D. niger** Tryon
Medium to large flies, predominantly red-brown on mesonotum; lateral post-sutural stripes present 25

25. Scutellum yellow except for narrow, dark brown, basal band; no infuscation on wing other than costal band and anal streak; weak, brown, medial stripe on posterior ½ of abdomen; *a.sa.* bristles present .. .. **D. (Paratridacus) expandens** Walker

Scutellum yellow except for brown apical spot and narrow, dark brown, basal band; a band of infuscation on wing embracing r-m cross vein and outer portion of discal cell; broad, medial, fuscous band present over abdominal tergites I to V; *a.sa.* bristles absent .. .. **D. (Hemizeugodacus) aureus** (May)

26. Prescutellar bristles present 27
Prescutellar bristles absent 67
27. Post-sutural vittae absent . .. . **D. (Bactrocera) mendosus** (May)
Post-sutural vittae present 28
28. A medial yellow vitta in addition to lateral post-sutural vittae on mesonotum. 29
Only lateral post-sutural vittae on mesonotum 32
29. Costal band expanded into a distinct dark fuscous spot in apex of wing .. .. **D. (Zeugodacus) cucurbitae** Coquillett
Costal band not expanded at apex 30
30. r-m cross vein infuscated; notopleural calli dark brown .. .. **D. (Afrodacus) furvus** (May) (Females)

No infuscation on r-m cross vein; notopleural calli yellow 31
31. Thorax entirely black (except for yellow calli and vittae); black transverse band or lateral black spots present on abdominal tergites I and II . .. **D. (Afrodacus) tigrinus** (May) (Females)

Thorax red-brown with fuscous or black markings behind mesonotal suture; first and second abdominal tergites entirely fulvous .. .. **D. (Afrodacus) flavinotus** (May) (Females)

32. Anterior supra-alar bristle present 33
Anterior supra-alar bristle absent 63
33. Infuscation on wing other than costal band and anal streak .. 34
Wings not infuscated except for costal band and anal streak .. 37
34. A transverse band across wing enclosing both the r-m and i-m cross veins. 35
Only one of the cross veins infuscated.. 36
35. Humeral calli black; scutellum yellow with a black triangle; mesonotum black .. .. **D. (Bactrocera) frauenfeldi** Schiner

Humeral calli yellow; scutellum entirely yellow; mesonotum red-brown .. .. .. **D. (Bactrocera) strigatus** (Perkins)

36. r-m cross vein infuscated; distinct facial spots present .. .. **D. (Bactrocera) fuscatus** (Perkins and May)

i-m cross vein infuscated; facial spots absent . .. . **D. (Bactrocera) hispidulus** (May)

37. Scutellum entirely brown or with dark markings at apex 38
Scutellum wholly yellow on apical ½ 39
38. Facial spots absent; scutellum uniformly pale brown; mesopleural stripe broad, almost reaching humeral callus dorsally . .. .. . **D. (Bactrocera) phaleriae** (May)
Facial spots present; scutellum dark brown or black on apical ⅓; mesopleural stripe narrow, about as wide as notopleural callus .. .. **D. (Bactrocera) bancroftii** (Tryon)
39. Costal cells fuscous; microtrichia covering most of second costal cell and a portion of first cell 40
Costal cells colourless or pale fulvous, never fuscous; microtrichia confined to outer portion of second costal cell only 44
40. Lateral post-sutural stripe ending posterior to upper *p.sa.* bristle; costal band broad, overlapping vein R_{2+3} for its entire length; first and second femora brown .. .. **D. (Bactrocera) notatagena** (May) (teneral specimens)
Lateral post-sutural stripe ending anterior to upper *p.sa.* bristle; costal band relatively narrow, crossing vein R_{2+3} only at its extremity; first and second femora wholly or partly fulvous 41
41. Facial spots absent; abdomen uniformly yellow-brown; lateral post-sutural stripe narrow, parallel sided for part of its length and tapering to end just before the upper *p.sa.* bristle .. .. . **D. (Bactrocera) mutabilis** (May)
Large oval facial spots present; abdomen fuscous or reddish-brown with fuscous markings; lateral post-sutural stripe broad, triangular and ending well before upper *p.sa.* bristle .. 42
42. Humeral callus brown or dark brown.. .. .. **D. (Bactrocera) neohumeralis** Hardy
Humeral callus yellow 43
43. Mesonotum and abdomen dark red-brown and usually with a pattern of fuscous markings (Figure 28); mid and hind femora fulvous. .. .. **D. (Bactrocera) tryoni** (Froggatt)
Mesonotum and abdomen chiefly fuscous with a pattern of darker fuscous to black markings; apical ½ of mid and hind femora fuscous.. **D. (Bactrocera) melas** (Perkins and May)
Mesonotum and abdomen uniformly fulvous, without fuscous markings; pleura fulvous; mid and hind femora fulvous, with some pale fuscous markings on hind femora .. ..**D. (Bactrocera) aquilonis** (May)
44. Mesonotum mostly black 45
Mesonotum red-brown, with or without a pattern of fuscous markings 50
45. Abdomen with a pronounced broad medial black vitta on tergites III to V 46
Abdomen without a broad medial black vitta on tergites III to V (occasionally a faint narrow fuscous line) 49

46. Lateral post-sutural stripe not broad, narrowing posteriorly and ending before upper *p.sa.* bristle 47
Lateral post-sutural stripe broad, parallel sided and ending at or beyond upper *p.sa.* bristle **D. (Bactrocera) dorsalis** (Hendel)
47. Facial spots linear and poorly defined; costal band wider than stigma; no pecten of hairs on abdominal tergite III and with supernumerary lobe weak in male .. .. .. **D. (Gymnodacus) calophylli** (Perkins and May)
Facial spots oval or top shaped; costal band not wider than stigma; a pecten of hairs on abdominal tergite III and a definite supernumerary lobe on wing in male 48
48. Abdominal tergites III to V fulvous except for a moderately broad medial black stripe over all tergites and fuscous to black on the anterior $\frac{1}{2}$ of tergite III and lateral margins of tergites III and IV; mesonotum black; pleura red-brown beneath humeri and wings; only hind tibiae dark fulvous or brown .. .. **D. (Bactrocera) endiandrae** (Perkins and May)
Abdomen fuscous or black except for red-brown on the central portions of tergites IV and V surrounding a broad medial black stripe; mesonotum black except red-brown posterocentrally; pleura chiefly black; all tibiae dark fulvous or brown .. **D. (Bactrocera) silvicola** (May) (melanic form)
49. Abdomen uniformly orange-brown, especially on tergites III to V; brown spot on apex of scutellum; costal band narrower than stigma beyond extremity of vein R_{2+3}; mesopleural stripe about as wide as notopleural callus and with anterior margin straight .. .. **D. (Bactrocera) bancroftii** (Tryon)
Abdomen orange-brown or reddish-brown except tending fuscous on anterior portion of tergite III; without brown spot on apex of scutellum; costal band at least as broad as stigma beyond extremity of vein R_{2+3}; mesopleural stripe slightly wider than notopleural callus and convex on anterior margin .. .. .. **D. (Bactrocera) musae** (Tryon)
50. A well defined medial black vitta on abdomen, either as a band on the last three tergites or as an elongated spot on the posterior portion 51
No medial black vitta on abdomen 58
51. Last three abdominal tergites with broad lateral longitudinal dark bands; always fuscous on anterior $\frac{1}{2}$ of tergite III 52
Last three abdominal tergites chiefly red-brown or ferruginous (not fuscous) on lateral margins and only occasionally fuscous on anterior margin of tergite III 54
52. Costal cells colourless 53
Costal cells fulvous or lightly infuscated .. .. **D. (Bactrocera) rufescens** (May)

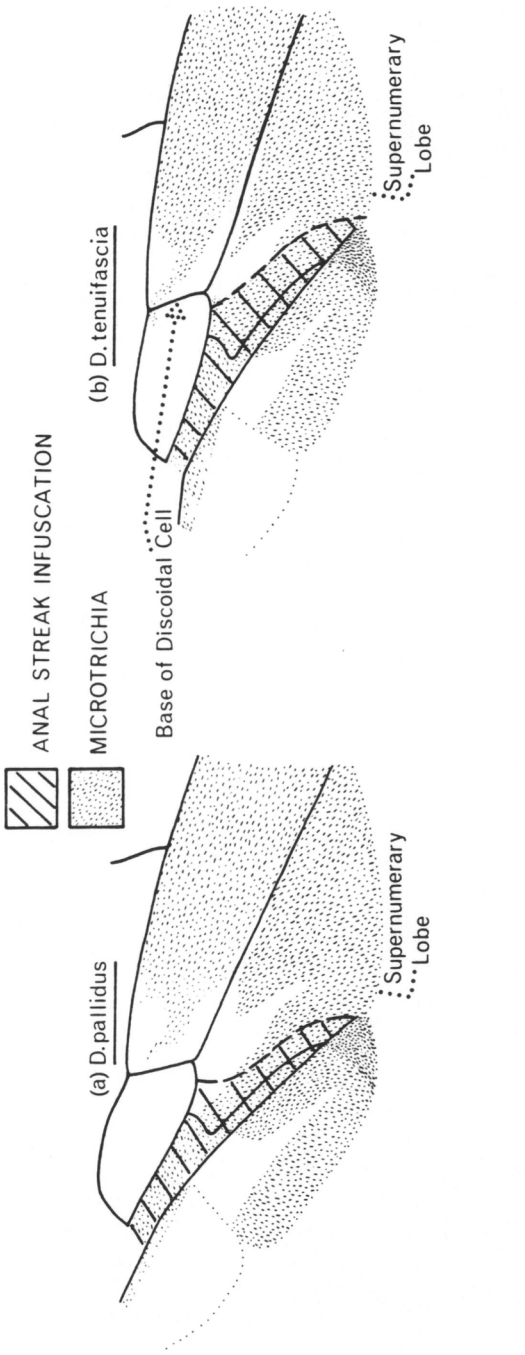

Figure 53—Anal sections of wings of (a) *Dacus pallidus* (Perkins and May) and (b) *Dacus tenuifascia* (May) showing differences in infuscation and microtrichia patterns

53. A medial (usually lanceolate) black pattern on mesonotum; costal band widening perceptibly as it crosses vein R_{2+3}; mesopleural stripe moderately broad, almost attaining anterior notopleural bristle above (Figure 14) .. .. .. **D. (Bactrocera) cacuminatus** (Hering)

Mesonotum always red-brown medially; costal band not widening beyond the tip of vein R_{2+3} (about as wide as stigma); mesopleural stripe narrow, almost parallel sided, and approximating width of notopleural callus .. .. **D. (Bactrocera) silvicola** (May)

54. Mesopleural stripe narrow, parallel sided; lateral post-sutural stripe reaching upper *p.sa.* bristle; facial spot large and oval; apical $\frac{1}{2}$ of each femora brown .. ..**D. (Bactrocera) quadratus** (May)

Mesopleural stripe wider than notopleural callus, not parallel sided; lateral post-sutural stripe not reaching upper *p.sa.* bristle; facial spot of medium size, almost circular; femora fulvous 55

55. Costal cells pale fulvous; broad brown basal band on scutellum; aculeus distinctly lobed. .. .. **D. (Bactrocera) bidentatus** (May)

Costal cells colourless; very narrow basal band on scutellum; aculeus not lobed 56

56. Lateral post-sutural stripe broad, almost parallel sided for part of its length; mesonotum pale red-brown or red-brown, seldom marked with fuscous and then only laterally before mesonotal suture and along inner margins of lateral post-sutural stripe; abdomen pale orange-brown or red-brown.. 57

Lateral post-sutural stripe not broad, narrowing sharply posteriorly; mesonotum and abdomen dark red-brown, usually with a pair of longitudinal parallel black bands centrally on mesonotum .. .. **D. (Bactrocera) mayi** Hardy

57. Anal streak broad, reaching almost to base of discoidal cell and covered with microtrichia for entire width (Figure 53b); mesonotum and abdomen red-brown .. .. **D. (Bactrocera) tenuifascia** (May)

Anal streak narrow, approximating width of anal cell (or much paler if extending towards base of discoidal cell), with microtrichia never extending over the entire coloured streak (Figure 53a); mesonotum pale red-brown; abdomen pale orange-brown .. .. **D. (Bactrocera) pallidus** (Perkins and May)

58. Shining spots on abdominal tergite V dark brown to black .. 59

Shining spots on abdominal tergite V not dark in colour 61

59. Mesopleural stripe broad, attaining at least anterior notopleural bristle dorsally; facial spots circular; lateral post-sutural stripe broad, parallel sided and attaining upper *p.sa.* bristle .. .. **D. (Bactrocera) robiginosus** (May)

Mesopleural stripe narrow, not attaining anterior notopleural bristle dorsally; facial spots elongate, pointed anteriorly; lateral post-sutural stripe narrow and ending before upper *p.sa.* bristle 60

60. Mesonotum and abdomen uniformly red-brown; rarely with narrow longitudinal fuscous bands on mesonotum; fuscous areas on extreme lateral margins of abdominal tergites III and IV only; mesopleural stripe not wider than notopleural callus; lateral post-sutural stripe not broad and narrowing posteriorly .. .. **D. (Bactrocera) halfordiae** (Tryon)

Mesonotum red-brown with or without a pattern of fuscous markings; abdomen usually fuscous over most of tergites III and IV and laterally on tergite V; mesopleural stripe 1½ times width of notopleural callus; lateral post-sutural stripe parallel sided for most of its length .. .. **D. (Bactrocera) kraussi** Hardy

61. Mesonotum dark red-brown with a pair of longitudinal fuscous bands.. .. .. **D. (Bactrocera) breviaculeus** Hardy

Mesonotum pale, uniformly reddish-brown or yellowish-brown, devoid of fuscous markings 62

62. Abdomen uniformly coloured (no fuscous markings); facial spot elongate, pointed anteriorly .. .. **D. (Bactrocera) fagraea** (Tryon)

Abdomen reddish-brown except fuscous laterally on tergites III and IV; facial spot large, almost circular .. .. **D. (Bactrocera) barringtoniae** (Tryon)

63. r-m cross vein infuscated; mesopleural stripe L-shaped and reaching humeral callus dorsally .. .. **D. (Afrodacus) brunneus** (Perkins and May)

No infuscation on r-m cross vein; mesopleural stripe not attaining humeral callus dorsally 64

64. Humeral and notopleural calli joined by a broad yellow band .. .. **D. (Afrodacus) jarvisi** (Tryon)

Humeral and notopleural calli not joined by a broad yellow band 65

65. Costal cells brown; microtrichia covering most of second costal cell and a portion of first cell; facial spots absent .. .. **D. (Bactrocera) mutabilis** (May) (some specimens)

Costal cells pale fulvous or colourless; microtrichia in outer portion of second costal cell only; facial spots present .. 66

66. Mesonotum mostly black; lateral post-sutural stripes not broad, narrowing posteriorly and ending before upper *p.sa.* bristle .. .. .. **D. (Afrodacus) mesoniger** (May)

Mesonotum mostly red-brown; lateral post-sutural stripes very broad, parallel sided and ending at or beyond upper *p.sa.* bristle .. .. .. **D. (Daculus) murrayi** (Perkins)

67. Post-sutural vittae on mesonotum present 68
Post-sutural vittae on mesonotum absent (except an elliptical yellow spot in centre of mesonotum in *D. newmani*) 71
68. Medial post-sutural vitta on mesonotum absent 69
Medial post-sutural vitta on mesonotum present 70
69. Lateral post-sutural vittae broad, parallel sided, ending posterior to upper *p.sa.* bristle .. **D. (Daculus) murrayi** (Perkins)
Lateral post-sutural vittae parallel sided for ½ its length but narrowing posteriorly to end in a blunt point just anterior to upper *p.sa.* bristle . .. . **D. (Daculus) decurtans** (May)
70. Humeral and notopleural calli connected by a yellow band .. .. **D. (Pacifodacus) strigifinis** Walker
Humeral and notopleural calli not connected by a yellow band .. .. **D. (Diplodacus) signatifer** Tryon (some specimens)
71. r-m cross vein infuscated; broad mesopleural stripe attaining humeral callus dorsally; abdomen fulvous with fuscous markings on first four tergites .. .. .. **D. exiguus** (May)
r-m cross vein not infuscated; mesopleural stripe not attaining humeral callus dorsally; abdomen uniformly coloured on first four tergites 72
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No facial spots; mesopleural stripe narrow, slightly wider than notopleural callus; mesonotum rich chocolate brown with a central elliptical yellow spot posterior to mesonotal suture; central area of wing colourless .. .. **D. (Dacus) newmani** (Perkins)

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THE GENUS *DACUS* FABRICIUS (DIPTERA: TEPHRITIDAE)—TWO NEW SPECIES FROM NORTHERN AUSTRALIA AND A DISCUSSION OF SOME SUBGENERA

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Abstract

Two new species, *Dacus (Bactrocera) allwoodi* and *Dacus (Didacus) hardyi*, are described and figured. Subgenera *Dacus* Fabricius, *Didacus* Collart and *Polistomimetes* Enderlein (= *Daculus* Speiser syn. n.) are defined. *Dacus (Dacus) armatus* Fabricius, the type-species of subgenus *Dacus*, *Dacus (Polistomimetes) minax* (Enderlein), the type-species of subgenus *Polistomimetes*, are described and figured from their type specimens.

Introduction

The genus *Dacus* Fabricius contains most World species of the subfamily Dacinae. As the type-species, *D. armatus* Fabricius (an African species), has never been described in detail, the subgenus *Dacus* needs to be defined according to recent concepts of generic and subgeneric characters. The detailed description of the holotype of *D. armatus* below allows this.

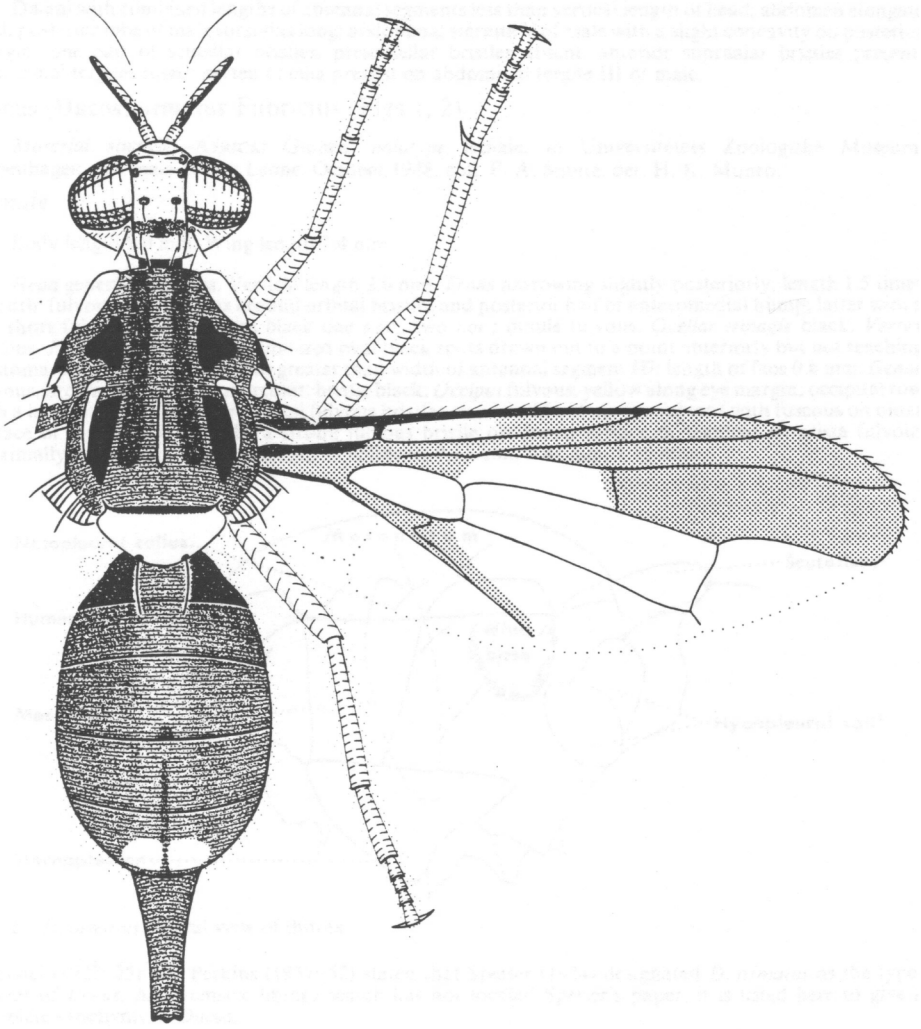


FIG. 1—*Dacus armatus* Fabricius.

Extensive, continuous fruit fly collecting throughout northern Australia since 1972 has provided valuable information on the species of fruit flies and their distribution in that region. Two new species collected in the Northern Territory are described below. One belongs to subgenus *Bactrocera* Macquart which is widespread throughout the Oriental and Pacific regions. The other belongs to subgenus *Didacus* Collart, an African subgenus which previously was not known by any endemic species outside that area. One species, *D. ciliatus* Loew, has been introduced into India from Africa. As *D. ciliatus* is the type-species of *Didacus*, it is discussed below to allow a definition of the subgenus. Taxonomically, *Didacus* is very close to the subgenus *Dacus*.

In these studies, subgenus *Daculus* Speiser was found to be a synonym of subgenus *Polistomimetes* Enderlein. The subgenus *Polistomimetes* is now more clearly defined as a result of study of the type specimens of the type-species *P. minax* Enderlein.

Subgenus **Dacus** Fabricius

Dacus Fabricius, 1805: 272 [type-species: *Dacus armatus* Fabricius, 1805: 272 (by designation of Speiser, *fide* Hendel, 1927: 25: Speiser, 1924, *fide* Perkins, 1937: 52)]*; Hardy, 1955: 428 (as subgenus).

Dacus (Tridacus) Bezzi, 1915: 86 (type-species: *Dacus armatus* Fabricius, 1805 by designation of Collart, 1935: 9); Hendel, 1927: 24 (syn.).

Neodacus Perkins, 1937: 58 (type-species: *Neodacus newmani* Perkins, 1937, by original designation; May, 1963: 41-42 (syn.).

Dacini with combined lengths of antennal segments less than vertical length of head; abdomen elongate oval; posterior lobe of male surstylus long; abdominal sternite V of male with a slight concavity on posterior margin; one pair of scutellar bristles; prescutellar bristles absent; anterior supraalar bristles present; abdominal tergites fused; pecten of cilia present on abdominal tergite III of male.

Dacus (Dacus) armatus Fabricius (Figs 1, 2)

Material studied.—AFRICA: Guinea: *holotype* female, in Universitetets Zoologiske Museum, Copenhagen; one male, Sierra Leone, October 1948, coll. F. A. Squire, det. H. K. Munro.

Female

Body length 9.0 mm. Wing length 7.4 mm.

Head generally fulvous. Vertical length 2.0 mm. *Frons* narrowing slightly posteriorly; length 1.5 times breadth; fulvous with fuscous around orbital bristles and posterior half of anteromedial hump; latter with a few short fulvous setae; bristles black one *s.or.*, two *i.or.*; lunule fulvous. *Ocellar trinagle* black. *Vertex* fuscous. *Face* fulvous with medium-sized oval black spots drawn out to a point anteriorly but not reaching epistoma; width of spot (0.26 mm) greater than width of antennal segment III; length of face 0.6 mm. *Genae* fulvous; brown subocular spot present; bristle black. *Occiput* fulvous, yellow along eye margin; occipital row with a large number of well developed fulvous bristles on each side. *Antennae* fulvous with fuscous on outer surface of segments II and III; a strong fulvous bristle on dorsal surface of segment II; arista fulvous proximally (remainder fuscous); length of segments 0.33 mm, 0.47 mm, 1.15 mm.

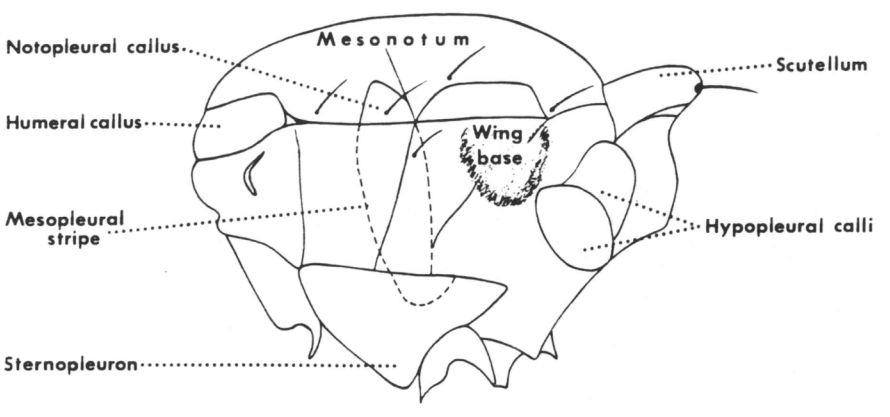


FIG. 2—*D. armatus*, lateral view of thorax.

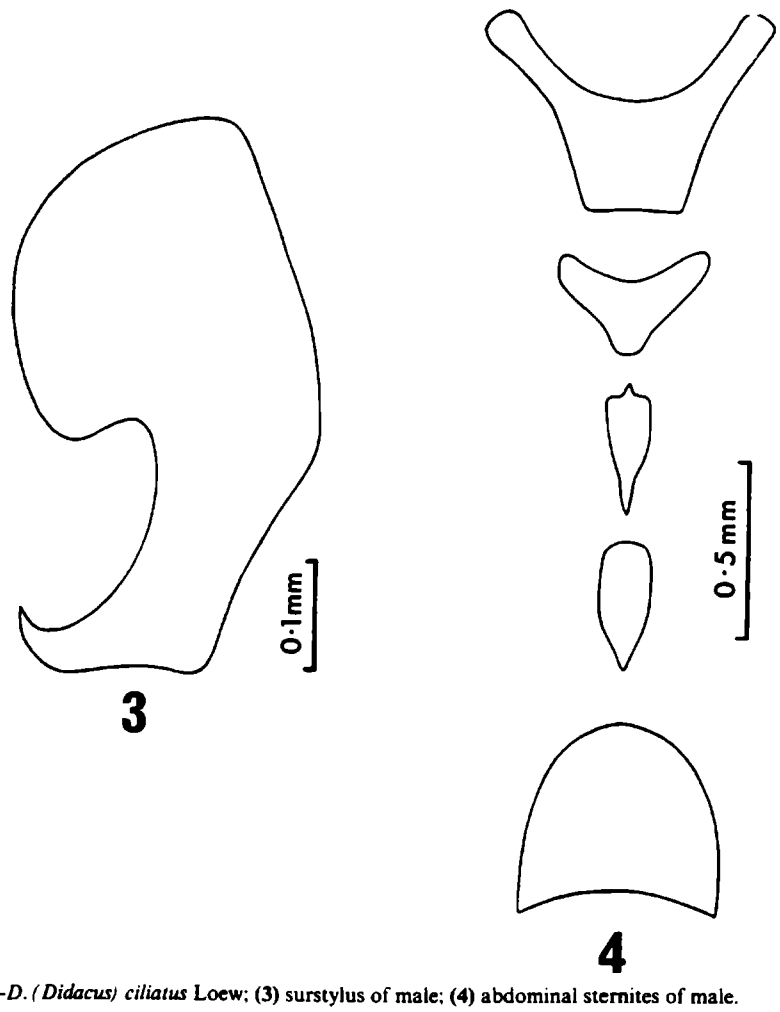
*Hendel (1927: 25) and Perkins (1937: 52) stated that Speiser (1924) designated *D. armatus* as the type-species of *Dacus*. An extensive library search has not located Speiser's paper, it is listed here to give a complete synonymy of *Dacus*.

Thorax.—Pleura red-brown except black on sternopleura, fuscous anterior to mesopleural stripe and above hind coxae. Mesonotum dark red-brown except dark markings as follows: two broad medial longitudinal dark fuscous to black bands running laterally to medial postsutural vitta from anterior margin of mesonotum to end behind level of *a.sa.* bristles; two broad medial longitudinal black bands inside lateral postsutural vittae; large black spot between humeral callus and mesonotal suture. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, slightly wider than notopleural callus above, continuing onto sternopleuron below as a large transverse spot, anterior margin straight (Fig. 2); upper hypopleural callus (posterior apex fuscous); anterior five-sevenths of lower hypopleural callus (remainder fuscous); two narrow lateral postsutural vittae beginning anterior to mesonotal suture and narrowing posteriorly to end midway between levels of *a.sa.* and upper *p.sa.* bristles; a narrow medial postsutural vitta beginning at level of mesonotal suture and ending at same level as lateral postsutural vittae. *Postnotum* fuscous, tending red-brown centrally. *Scutellum* yellow except for narrow fuscous basal band. *Bristles* all well developed and black *sc.* two, *prsc.* absent, *p.sa.* two, *a.sa.* one, *mpl.* one, *npl.* two, *scp.* four.

Legs.—All segments fulvous, with fore and middle femora darker on apical third; middle tibiae each with an apical black spur.

Wings.—Costal cells fuscous, microtrichia covering outer half of second costal cell; remainder of wings colourless except dark fuscous stigma, broad dark fuscous costal band confluent with R_{4+5} until it expands (just before r-m cross vein) to be confluent with M_{1+2} to apex of wing, a narrow dark fuscous anal streak ending before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak. Second costal cell shorter than stigma in proportion 0.92:1. Cross vein r-m dividing M_{1+2} above discoidal cell in proportion 1, 4:1. Proportion of anal cell extension to CuA + 1A 1.33:1.

Abdomen elongate oval, tergites fused, no pecten on tergite III. Tergite I red-brown with lateral fuscous markings; tergite II red-brown, tending darker anterolaterally; tergites III-V red-brown with darker broad lateral margins and with an interrupted narrow medial longitudinal fuscous band running from posterior area of tergite III to posterior margin of tergite V. A pair of shining spots on tergite V. Visible portion of



FIGS 3,4—*D. (Didacus) ciliatus* Loew; (3) surstylus of male; (4) abdominal sternites of male.

oviscape red-brown, oval in transverse cross section and tapering slightly posteriorly in dorsal view. Length of visible portion of oviscape to length of tergite V, 1.6:1. Aculeus strongly sclerotised, red-brown, needle shaped at its tip.

Male

Wing length 7.4 mm.

Head as for female.

Thorax as for female except as follows: wings (a) with aggregation of microtrichia around CuA + 1A; (b) proportion of anal cell extension to CuA + 1A 2.1:1.

Abdomen as for female except as follows: (a) with pecten on tergite III, (b) posterior lobe of surstylus long, (c) posterior margin of abdominal sternite V with a slight concavity.

Subgenus **Didacus** Collart

Dacus (Didacus) Collart, 1935: 33 [type-species: *Dacus (Didacus) ciliatus* Loew, 1862, by original designation].

Dacini with combined lengths of antennal segments less than vertical length of head, abdomen elongate oval, posterior lobe of male surstylus long (Fig. 3), abdominal sternite V of male with a slight concavity on posterior margin (Fig. 4), one pair of scutellar bristles, prescutellar bristles absent, anterior supraalar bristles absent, abdominal tergites fused, pecten of cilia present on abdominal tergite III of male.

Comments

Collart (1935) included 11 African species in *Didacus*. Munro (1964) described some characters of *D. ciliatus*, discussed this species as a pest of cucurbits and stated that it was widespread in Africa and also occurred in Mauritius and India. Probably, *D. ciliatus* has been introduced to India and, previous to the description of *D. hardyi* sp. n. below, was the only known representative of *Didacus* outside Africa. Specimens of *D. ciliatus* were received for study from the Department of Agricultural Technical Services, Pretoria.

Dacus (Didacus) hardyi sp. n. (Figs 5, 6, 9)

Types.—AUSTRALIA: NORTHERN TERRITORY: *holotype* male, two male *paratypes*, January 1978, coll. A. Ohta, Fogg Dam; one male *paratype*, November 1975 and two male *paratypes*, December 1975, coll. A. Beckinsale, Cobourg Peninsula; two male *paratypes* (cue lure), December 1976, coll. W. Mollah, Smith Point Reserve; eight female *paratypes* and three male *paratypes* (bred ex *Cynanchum* sp.), July 1976, coll. A. Smith, Border Store, East Alligator River; one male *paratype* (cue lure), 16.iii.1977, coll. T. Angeles, Garden Point, Melville Island; two male *paratypes* (cue lure), 13.ix.1977, Smith Point, Cobourg Peninsula.

Holotype (Reg. No. T. 7788) and two paratypes (Reg. Nos T. 7789-7790) in Queensland Museum, Brisbane; four paratypes in Australian National Insect Collection, CSIRO, Canberra; 15 paratypes in Department of Primary Industries, Brisbane.

Male

Wing length: holotype 5.2 mm, range for type series 4.8-5.5 mm, mean 5.1 mm.

Head generally fulvous. Vertical length range for type series 1.4-1.5 mm, mean 1.5 mm. *Frons* narrowing slightly posteriorly, length 1.6 times breadth, fulvous with pale fuscous around *s.or.* bristles and on anteromedial hump, latter covered with a small number of short dark setae, bristles black one *s.or.*, two *i.or.*; lunule fulvous. *Ocellar triangle* fuscous. *Vertex* fulvous. *Face* fulvous with large oval black spots not reaching epistoma, width of spot (0.17 mm) greater than width of antennal segment III, length of face 0.45 mm. *Genae* fulvous with no dark spots, bristle fulvous. *Occiput* fulvous, yellow along eye margin; occipital row with three to eight well developed black bristles on each side. *Antennae* fulvous except fuscous on apex and outer surface of segment III and outer surface of segment II, a strong fulvous bristle on dorsal surface of segment II, arista fulvous proximally (remainder black), length of segments 0.17 mm, 0.31 mm, 0.77 mm.

Thorax red-brown with a pale fuscous tint along anterior margin of mesopleural stripes. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse yellow spot, anterior margin convex; a triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of suture; a transverse rectangular marking across posterior region of mesonotum (this marking has a small point in centre of anterior margin); upper hypopleural calli (posterior apices red-brown); anterior two-thirds of lower hypopleural calli (remainder red-brown). Lateral postsutural vittae absent. *Postnotum* red-brown. *Scutellum* yellow except for narrow red-brown basal band. *Bristles* all well developed and black. *sc.* two, *prsc.* absent, *p.sa.* two, *a.sa.* absent, *mpl.* one, *npl.* two, *scp.* four.

Legs fulvous (basal half of all femora paler fulvous), middle tibiae each with an apical black spur.

Wings.—costal cells fuscous, microtrichia covering all of second costal cell and outer half of first cell, remainder of wings colourless except fuscous stigma, narrow fuscous costal band reaching almost to R_{4+5}

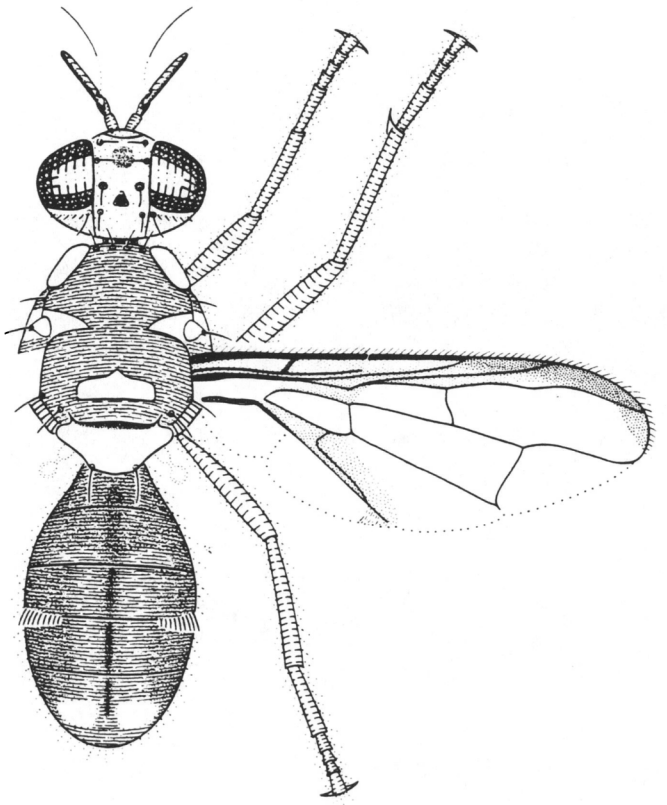
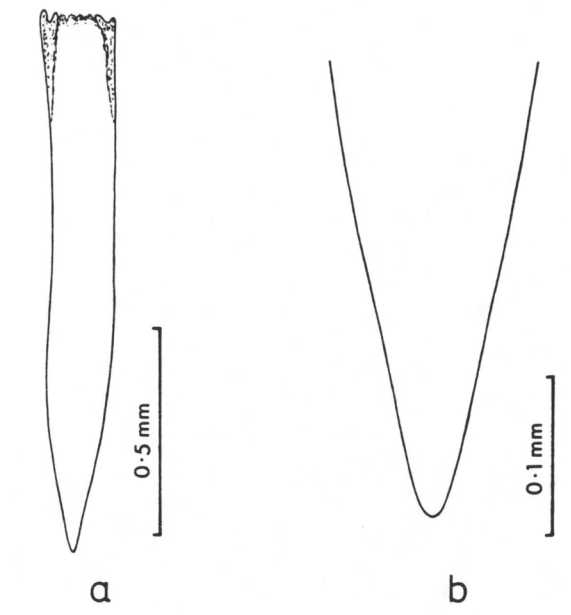


FIG. **5**—*Dacus (Didacus) hardyi* sp. n.



FIGS **6a,b**—Aculeus of *D. hardyi* sp. n.

and ending between extremities of R_{4+5} and M_{1+2} (this band is darker fuscous adjacent to margin of wing between extremities of R_{2+3} and R_{4+5}), a narrow fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak.

Abdomen elongate oval, tergites fused, pecten present on abdominal tergite III. Tergite I dark red-brown tending towards pale fuscous. Tergite II dark red-brown tending towards pale fuscous, except whitish posteriorly. Tergites III-V orange-brown, darkening to red-brown (and even dark red-brown) laterally, with a narrow intermittent medial longitudinal fuscous band running from posterior margin of tergite I to the centre of tergite V. A pair of shining spots on tergite V. Posterior margin of sternite V with a slight concavity and posterior lobe of surstylus long.

Female

Wing length: mean for type series 5.5 mm.

Head as for male.

Thorax as for male except wings without aggregation of microtrichia around CuA + 1A.

Abdomen as for male except as follows: (a) no pecten on tergite III; (b) visible portion of oviscape orange-brown to red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; length of visible portion of oviscape to length of tergite V, 0.6:1; aculeus strongly sclerotised, red-brown, needle shaped at its tip, preapical setae absent (Figs 6a,b).

Comments

It is a pleasure to name this species after Dr D. Elmo Hardy, who has made an outstanding contribution to our knowledge of Tephritidae in the Asian and Pacific areas.

There are only three other species known from the South Pacific region with fused abdominal tergites (all in subgenus *Dacus*) *D. absonifacies* (May), *D. newmani* (Perkins) and *D. signatifrons* (May). *D. hardyi* is a very distinctive species, being easily separated from the above three species by the absence of *a.sa.* bristles, the presence of a large transverse yellow spot across the posterior region of the mesonotum and the general orange-brown to red-brown body coloration (this being dark brown in the above three species). The African species of *Didacus* closest to *D. hardyi* are *D. gypsoides* Munro and *D. vertebratus* Bezzi. These differ from *D. hardyi* in lacking a medial postsutural yellow marking on the mesonotum. In addition, *D. gypsoides* differs in possessing a black face and wide costal band, and *D. vertebratus* in lacking a medial longitudinal dark band on the abdomen.

The known distribution of *D. hardyi* is shown in Fig. 9. It has been collected only in coastal and subcoastal areas of the Northern Territory and occurs in very small numbers in cue lure trap catches.

Subgenus **Polistomimetes** Enderlein

Polistomimetes Enderlein, 1920: 358 (type-species: *Polistomimetes minax* Enderlein, 1920, by original designation).

Daculus Speiser, 1924: 140 (type-species: *Musca oleae* Gmelin, 1788, by original designation); Hardy, 1951: 125 (as subgenus of *Dacus*); May, 1963: 40-41. Syn. n.

Dacus (Heterodaculus) Hardy, 1951: 134 [type-species *Dacus (Heterodaculus) visendus* Hardy, 1951, by original designation]; May, 1963: 40 (syn.)

Dacini with combined lengths of antennal segments less than vertical length of head, abdomen elongate oval, posterior lobe of male surstylus short, abdominal sternite V of male with a deep concavity on posterior margin, one pair of scutellar bristles, anterior supraalar and generally prescutellar bristles absent, abdominal tergites free, pecten of cilia present on abdominal tergite III of male.

Comments

A study of specimens from the type series of *Polistomimetes minax* shows that subgenus *Daculus* is a synonym of *Polistomimetes*. The South Pacific species now included in *Polistomimetes* are *D. decurtans* (May), *D. murrayi* (Perkins), *D. pagdeni* Malloch, *D. toxopeusi* (Hering) and *D. visendus* Hardy.

Dacus (Polistomimetes) minax Enderlein (Fig. 7)

Material studied.—SIKHIM: two males and one female from type series, coll. Bingham, in Zoologisches Museum für Naturkunde, Humboldt-Universität, Berlin.

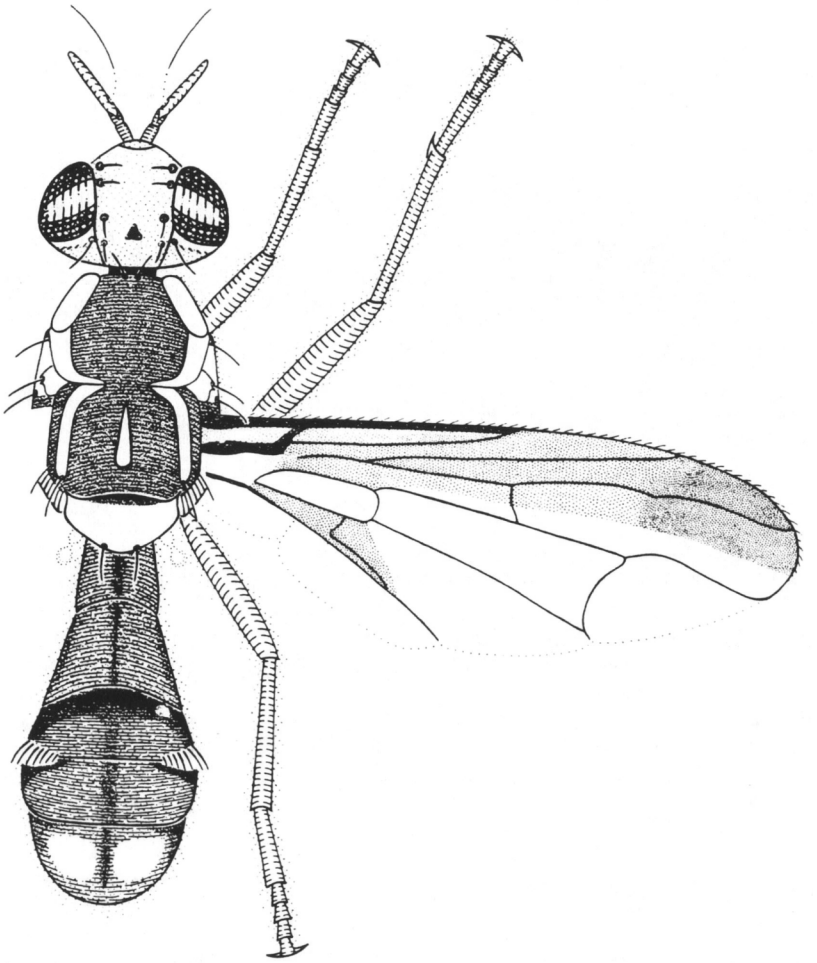


FIG. 7—*Dacus (Polistomimetes) minax* Enderlein.

Male

Wing length 10.8 mm.

Head generally fulvous. Vertical length 2.4 mm. *Frons* narrowing slightly posteriorly; length 1.2 times breadth; fulvous with, at most, small fuscous markings around orbital bristles; anteromedial hump prominent and covered with short pale setae; bristles fuscous to black one *s.or.*, two *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with elongate facial spots reaching epistoma, width of spot (0.19 mm) less than width of antennal segment III, length of face 0.98 mm. *Genae* fulvous, pale brown subocular spot present, bristle fulvous. *Occiput* fulvous, yellow along eye margin; occipital row with five to six weak pale bristles each side. *Antennae* fulvous, a strong fulvous bristle on dorsal surface of segment II, arista fulvous proximally (remainder black), length of segments 0.26 mm, 0.51 mm, 1.25 mm.

Thorax.—Pleura pale red-brown with no dark markings. Mesonotum red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; a broad band above notopleural suture connecting humeral and notopleural calli; mesopleural stripe of medium width, extending to anterior *npl.* bristle above, anterior margin slightly convex, continuing onto sternopleuron below as a large transverse spot; a triangular marking anterior to mesonotal suture, with base against dorsal margin of notopleural callus and apex on inner margin of mesonotal suture; upper hypopleural callus (posterior apex red-brown); anterior seven-ninths lower hypopleural callus (remainder red-brown); two broad lateral postsutural vittae curved along mesonotal suture anteriorly and ending at upper *p.sa.* bristle posteriorly; a medial longitudinal postsutural vitta, broadly rounded posteriorly and beginning at a point anterior to lower *p.sa.* bristles and narrowing anteriorly to end posterior to level of mesonotal suture. *Postnotum* red-brown. *Scutellum* yellow with narrow red-brown basal band. *Bristles* all well developed and black except *scp.* sometimes weak and red-brown to fuscous *sc.* two, *prsc.* absent, *p.sa.* two, *a.sa.* absent, *mpl.* one, *npl.* two, *scp.* two.

Legs fulvous with, at most, fuscous on apical halves of ventral surfaces of all femora; middle tibiae with apical black spur.

Wings.—Costal cells fuscous, microtrichia in outer corner of first costal cell and outer half of second costal cell: remainder of wings colourless except fuscous stigma, broad fuscous costal band overlapping R_{4+5} and forming a distinct darker fuscous spot apically and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak fading out before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak. Second costal cell shorter than stigma in proportion 0.81:1. Cross vein r-m dividing M_{1+2} above discoidal cell in proportion 1.45:1. Proportion of anal cell extension to CuA + 1A 1.1:1.

Abdomen elongate oval and petiolate, tergites free, pecten present on tergite III. Tergite I orange-brown with a medial longitudinal pale fuscous band; tergite II orange-brown with a medial longitudinal pale fuscous band (broader than band on tergite I) and with narrow pale fuscous lateral margins; tergites III-V orange-brown with a broad transverse fuscous band across anterior half of tergite III and expanding into fuscous lateral margins, anterolateral corners of tergite IV fuscous and anterolateral corners of tergite V pale fuscous, a narrow medial longitudinal pale fuscous band running from transverse band on tergite III to end before posterior margin of tergite V. A pair of shining spots on tergite V. Posterior lobe of surstylus short; abdominal sternite V with a deep concavity on posterior margin.

Female

Wing length 10.8 mm.

Head as for male.

Thorax as for male except as follows: proportion of anal cell extension to CuA + 1A 0.90:1.

Abdomen as for male except as follows: (a) no pecten on tergite III, (b) visible portion of oviscape red-brown, cylindrical and drawn out to a narrow elongate section distally. Length of visible portion of oviscape to length of tergite V, 1.87:1. Aculeus strongly sclerotised, dark red-brown with apex needle shaped.

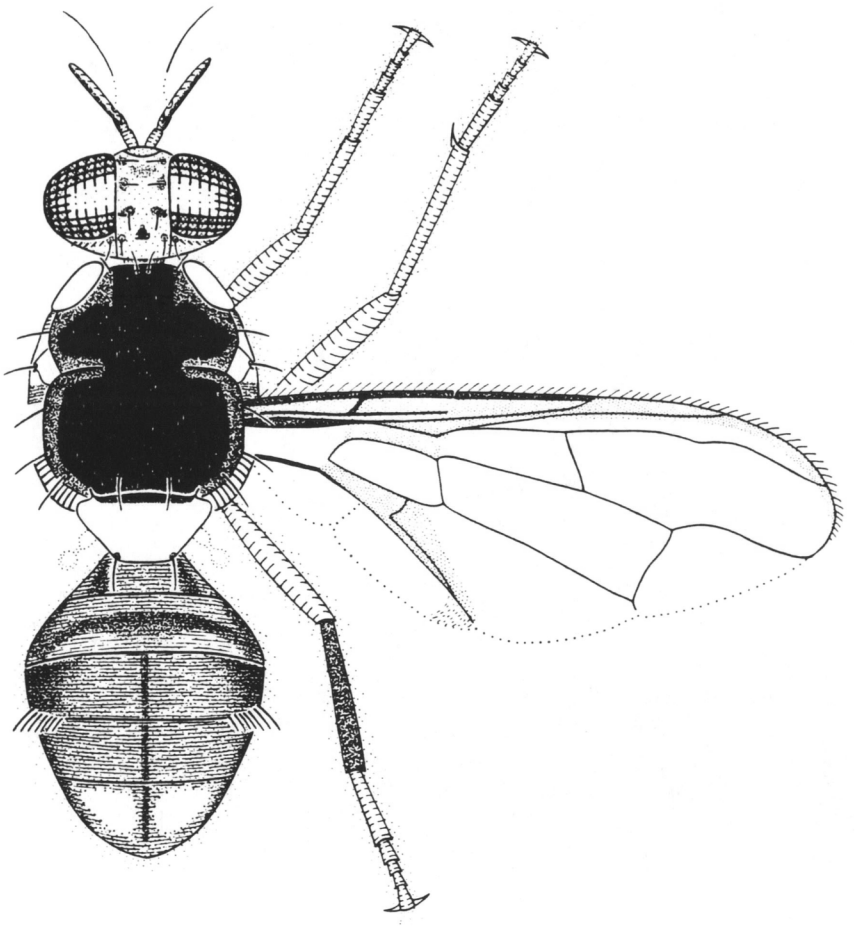


FIG. 8—*Dacus (Bactrocera) allwoodi* sp. n.

Subgenus **Bactrocera** Macquart

Bactrocera Macquart, 1835: 452 (type-species: *Bactrocera longicornis* Macquart, 1835, by monotypy).

Dacus (Bactrocera) allwoodi sp. n. (Figs 8, 9)

Types.—AUSTRALIA: NORTHERN TERRITORY: *holotype* male (cue lure), 10 male *paratypes* (cue lure), September 1976, coll. A. Smith, Smith Point, Cobourg Peninsula; four male *paratypes* (cue lure), December 1976, coll. W. Mollah, Smith Point, Cobourg Peninsula; 19 male *paratypes* (cue lure), November-December 1976, coll. W. Mollah, Croker Island (near Cobourg Peninsula); 19 male *paratypes* (cue lure), November-December 1976, coll. W. Mollah, Gove Peninsula; eight male *paratypes* (cue lure), November 1976, coll. W. Mollah, Alyangula, Groote Eylandt.

Non-type material studied.—One male (Willison's lure), 15.iv.1969, East Point, Darwin; one male (Willison's lure), 8.vii.1969, coll. A. Allwood; one male (Willison's lure), Lee Point, Darwin, 27.ix.1969, coll. K. Hodder; two males (cue lure), Numbulwar, 21.iv.1977, coll. S. Collins; one male (cue lure), Groote Eylandt, 18.xi.1976, coll. W. Mollah; one male (cue lure), Nhulunbuy (Gove), 18.xi.1976, coll. W. Mollah; one male (cue lure), Gove, 21.iv.1977, coll. S. Collins; one male (cue lure), Croker Island, 19.i.1977, coll. D. Benson; one male (cue lure), Croker Island, 16.xi.1976, coll. W. Mollah.

Additional locality records.—Melville Island (Paru and Pullempulli), Maningrida, Milingimbi, Elcho Island.

Holotype (Reg. No. T. 7777) and 10 paratypes (Reg. Nos T. 7778-7787) in Queensland Museum, Brisbane; 10 paratypes in Australian National Insect Collection, CSIRO, Canberra; 40 paratypes in Department of Primary Industries, Brisbane.

Male

Wing length: *holotype* 5.2 mm, range for type series 4.7-5.6 mm, mean 5.1 mm.

Head generally fulvous. Vertical length range for type series 1.4-1.6 mm, mean 1.5 mm. *Frons* narrowing slightly posteriorly, length 1.7 times breadth, fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered with a small number of short dark setae, bristles black one *s.or.*, two *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with large circular spots not reaching epistoma, width of spot (0.19 mm) greater than width of antennal segment III, length of face 0.45 mm. *Genae* fulvous, pale fuscous subocular spot present, bristle red-brown. *Occiput* fulvous, yellow along eye margin; occipital row strong with four to six well developed fuscous to black bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of segment III, a strong red-brown bristle on dorsal surface of segment II, arista fulvous proximally (remainder black), length of segments 0.20 mm, 0.30 mm, 0.87 mm.

Thorax.—Pleura red-brown with fuscous anterior to mesopleural stripes, a fuscous spot posterior to mesopleural stripes, dark fuscous above hind coxae and on sternopleura. Mesonotum dull black, bordered with brown around lateral margins, along mesonotal sutures, above notopleural sutures (between humeral and notopleural calli) and around inner margins of humeral calli. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior two-thirds lower hypopleural calli (remainder black). Postsutural vittae absent, an indication of a very narrow and short lateral postsutural vitta present in a few specimens. *Postnotum* red-brown centrally, black laterally. *Scutellum* yellow except for narrow black basal band. *Bristles* all well developed and red-brown *sc.* two, *prsc.* two, *p.sa.* two, *a.sa.* one, *mpl.* one, *npl.* two, *scp.* four to six.

Legs.—All segments fulvous except hind tibiae fuscous, rows of long fulvous setae on dorsal surfaces of fore femora, middle tibiae each with an apical fuscous spur.

Wings.—Costal cells pale fuscous, second cell slightly paler in outer third; microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak reaching wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen oval; tergites free; pecten present on tergite III. Tergite I red-brown tending fuscous laterally; tergite II red-brown with an overlying transverse fuscous band and narrow fuscous lateral margins, whitish posteriorly; tergites III-V red-brown except for a broad fuscous lateral margin on tergite III, narrow fuscous lateral margins on tergites IV-V, a narrow medial longitudinal fuscous to dull black band over all three tergites but ending before posterior margin of tergite V. A pair of shining spots on tergite V. Posterior margin of sternite V with a deep concavity, posterior lobe of surstylus short.

Comments

This species is named after Mr Alan Allwood who has organised extensive fruit fly collecting and host studies in the Northern Territory.

Dacus mendosus (May) is the only other species of *Bactrocera* in Australia that lacks postsutural vittae. *D. allwoodi* differs from *D. mendosus* in having a black mesonotum, lacking microtrichia over the costal cells, lacking a dark spot on the apex

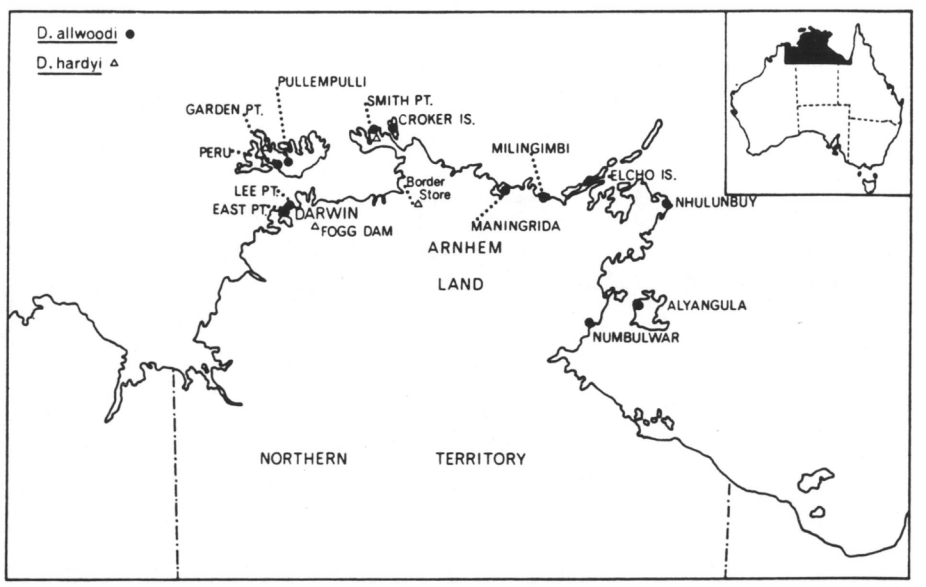


FIG. 9—Map showing distribution of *D. allwoodi* sp. n. and *D. hardyi* sp. n.

of the scutellum, lacking a yellow triangle along the mesonotal suture, and in having abdominal tergites III-V red-brown with a medial longitudinal dark band.

The known distribution of *D. allwoodi* is shown in Fig. 9. It is restricted to coastal areas of the Northern Territory and makes up a high percentage of total cue lure trap catches in October-November each year.

Acknowledgments

Specimens for study and additional information on the distribution of species were received from Mr A. Allwood, Animal Industry and Agriculture Branch, Department of Northern Territory, Darwin. Specimens were received from Mr A. Smith, CSIRO, Division of Entomology, Darwin, and from the Department of Agricultural Technical Services, Pretoria, South Africa. Type specimens were received for study from Universitetets Zoologiske Museum, Copenhagen, and the Zoologisches Museum, Universität zu Berlin. Dr T. E. Woodward, Department of Entomology, University of Queensland, read the manuscript and made recommendations for its improvement. Mrs M. C. Romig prepared the illustrations.

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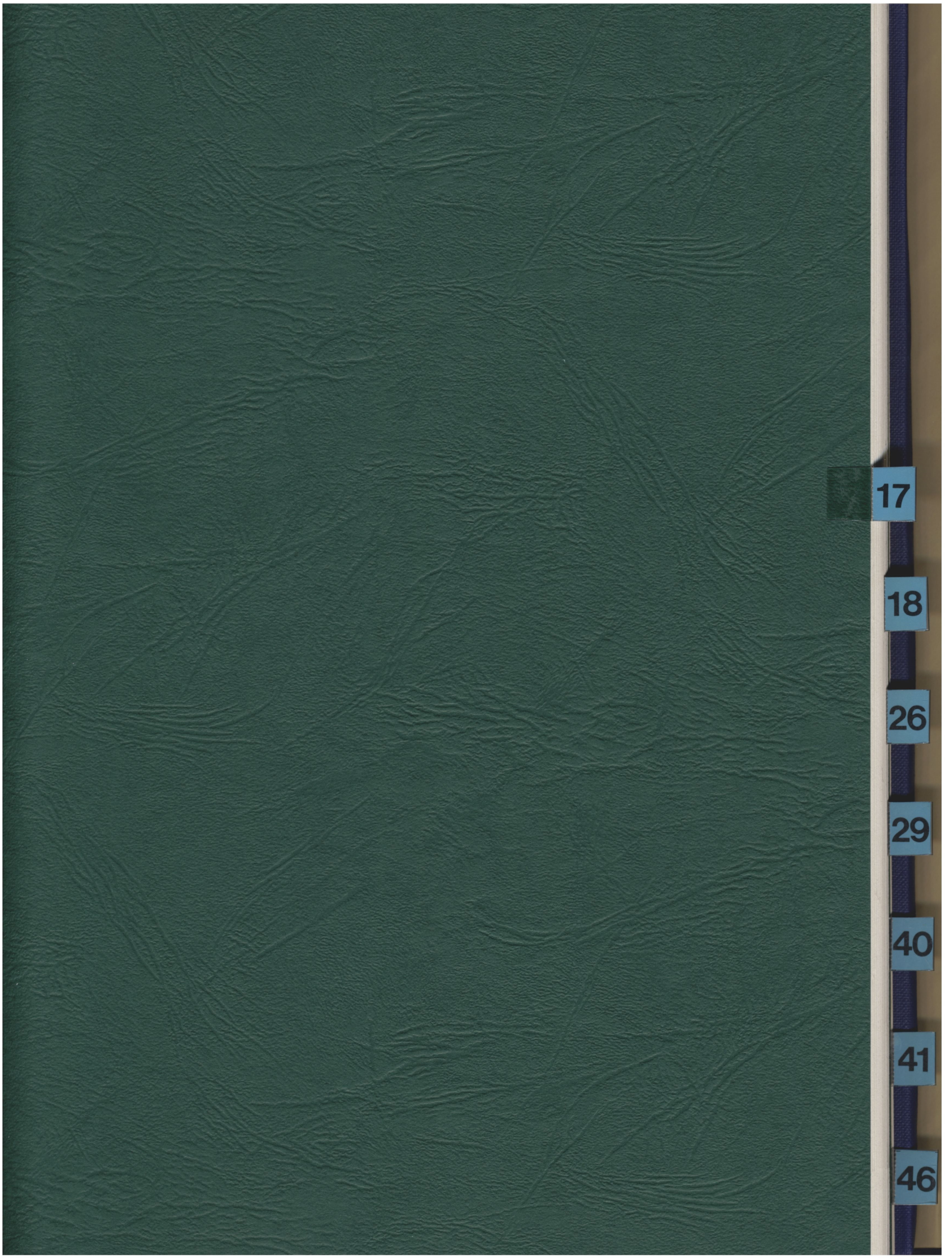
[*Manuscript received* 11 *August* 1978].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Aust. J. Zool., 1981, **29**, 49–91

Australian Dacinae (Diptera: Tephritidae): New Species from Cape York Peninsula, a Discussion of Species Complexes and Key to Species

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Abstract

Fourteen new species of *Dacus* are described from Cape York Peninsula, northern Queensland: *D. (Dacus) bellulus, D. (Pacifodacus) salamander, D. (Bactrocera) absconditus, D. (B.) aeroginosus, D. (B.) antigone, D. (B.) aurantiacus, D. (B.) erubescentis, D. (B.) fuliginus, D. (B.) humilis, D. (B.) peninsularis, D. (B.) perkinsi, D. (B.) romigae, D. (B.) rufofusculus, D. (B.) russeolus.* In addition, closely related species are assigned to species complexes and a key provided for the 78 recorded Australian species.

Introduction

Recent taxonomic studies of the South Pacific Dacinae (Drew 1971, 1972*a*, 1972*b*, 1973, 1974, 1975) preceded present studies of the Australian fauna. Because of the economic importance of this group much attention has been paid to ecological studies of fruit flies in their natural environment, particularly the forest areas of northern Australia. Regular quarantine surveys are undertaken for the early detection of introduced exotic species of fruit fly in Cape York. By means of these studies new species have been collected and are described in this paper. In order to describe the new species, it was important for us to study type material of closely related species. This has in turn led to the placing of Australian species into complexes, which are presented in this paper.

The most recent keys to Australian species are those of May (1963) and Drew (1978). Since publication of these keys, there have been additions to the known Australian fauna: five species described by May (1965, 1967); three species described by Drew (1972*b*, 1979); one introduction of an exotic species (*Dacus (Bactrocera) frauenfeldi* Schiner); and the 14 new species described in this paper. These 23 species have been placed in the key to species, which is an improved key that utilizes species complexes.

New Species

Genus **Dacus** Fabricius

Dacus Fabricius, 1805, p. 272 (type-species: *Dacus armatus* Fabricius, 1805, p. 272, by designation of Hendel, 1927, p. 25).

Dacus group of Subgenera

Defined by Drew (1972*a*) as having sternum V of male with a slight concavity of hind margin and with posterior lobe of surstylus elongate.

Subgenus **Dacus** Fabricius

Dacus Fabricius, 1805, p. 272 (type-species: *Dacus armatus* Fabricius, 1805, p. 272, by designation of Hendel, 1927, p. 25): Drew, 1979, p. 72 (as subgenus and complete list of synonymies).

Dacus (Dacus) bellulus Drew & Hancock, sp. nov.

(Fig. 1)

Diagnosis

A small pale-coloured species, facial spots small narrow vertical lines, mesonotum red-brown, lateral and medial post-sutural vittae absent, mesopleural stripes broad (reaching anterior *npl.* bristle), humeral and notopleural calli yellow, yellow triangular marking extending onto mesonotum anterior to mesonotal suture, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells, abdomen orange-brown with no dark markings.

Type Specimens

Holotype ♂, attracted to Willison's lure, 34 km S. of Laura, north Queensland, 10.vii.1976, J. Donaldson.

Paratypes: **Queensland:** 1 ♂, 2 km N. of Laura, 10.vii.1976, J. Donaldson; 1 ♂ (attracted to cue-lure), Weipa, Mar. 1976, 1 ♂ (cue-lure), Weipa, Feb. 1976, L. Rigby; 4 ♂ (cue-lure), St Pauls, Moa (Banks) I., Torres Strait, 14–17.vii.1977, 1 ♂, same locality, 16.vii.1977, G. B. Monteith and D. Cook. **Northern Territory:** Gove (cue-lure); 2 ♂, 15.xi.1976; 29 ♂, 18.xi.1976; 1 ♂, 12.xii.1976; 5 ♂, 15.xii.1976; 1 ♂, 16.xii.1976; 1 ♂, 18.xii.1976; 5 ♂ (cue-lure), Alyangula, 19.xi.1976; 1 ♂ (Willison's lure), 12 km N. of mouth of West Alligator R., 15.x.1976; 1 ♂ (cue-lure), Groote Eylandt, 19.xi.1976; 1 ♂ (cue-lure), Milingimbi, 14.xii.1976; 1 ♂ (cue-lure), Smith Point Reserve, Cobourg Peninsula, 13.xii.1976; all coll. W. Mollah.

Holotype (reg. No. T.8214) and 5 paratypes (reg. Nos. T.8215–T.8219) in Queensland Museum, Brisbane; 5 paratypes in Australian National Insect Collection, CSIRO, Canberra; 46 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 4·5 mm, range for type series 3·9–5·0 mm, mean 4·4 mm.

Head. Generally fulvous. Vertical length: holotype 1·4 mm, range for type series 1·1–1·6 mm, mean 1·4 mm. Frons narrowing slightly posteriorly, length 1·3 times breadth; fulvous, with no dark markings; anteromedial hump indistinct, covered with short pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. Ocellar triangle dark fuscous. Vertex fulvous. Face fulvous with a pair of small, narrow, vertical spots not reaching epistoma (these spots are occasionally very pale or even absent); width of spot (0·05 mm) less than width of 3rd antennal segment, length of face 0·53 mm. Genae fulvous, subocular spot absent; red-brown bristle

present. Occiput fulvous, yellow along eye margins; occipital row with a large number of pale bristles. Antennae with 1st and 2nd segments fulvous; 3rd segment red-brown except fuscous on apex; a strong red-brown bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·11 mm; 0·23 mm; 0·67 mm.

Thorax. Mesonotum red-brown with no dark markings. Pleural areas orange-brown. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, reaching anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin strongly convex; upper hypopleural calli (posterior apices red-brown to pale fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown to pale fuscous); 2 triangular vittae extending from notopleural calli along mesonotal suture. Lateral post-sutural vittae absent. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* absent; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 2 or 3; all bristles well developed and fuscous. Legs: mid and hind coxae red-brown, all other segments fulvous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: 1st costal cell fuscous; 2nd costal cell paler fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except for a dark fuscous stigma, narrow dark fuscous costal band confluent with R_{2+3} and broadening apically to end between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga fused; pecten present on tergum III. Terga I–V orange-brown with no dark markings. A pair of shining spots on tergum V.

Comments

There are three previously known Australian species of subgenus *Dacus*, viz. *D. absonifacies* (May), *D. newmani* (Perkins) and *D. signatifrons* (May). *D. absonifacies* differs from *D. bellulus*, sp. nov., in possessing an elongate oval abdomen and a broad costal band that is confluent with vein M_{1+2}. *D. newmani* and *D. signatifrons* are similar to *D. bellulus* in general body shape and coloration. *D. newmani* differs in having a narrow mesopleural stripe and an elliptical yellow spot in centre of mesonotum. *D. signatifrons* differs in having elongate facial spots, fuscous hind tibiae and a costal band that overlaps vein R_{2+3}.

Subgenus **Pacifodacus** Drew

Pacifodacus Drew, 1972*a*, p. 12 (type-species: *Asiadacus triangularis* Drew, by original designation).

Dacus (Pacifodacus) salamander Drew & Hancock, sp. nov.

(Fig. 2)

Diagnosis

A medium-sized pale-coloured species, facial spots medium-sized and rounded, mesonotum red-brown, lateral post-sutural vittae absent, medial post-sutural vitta present, mesopleural stripes broad (reaching anterior *npl.* bristle), humeral and

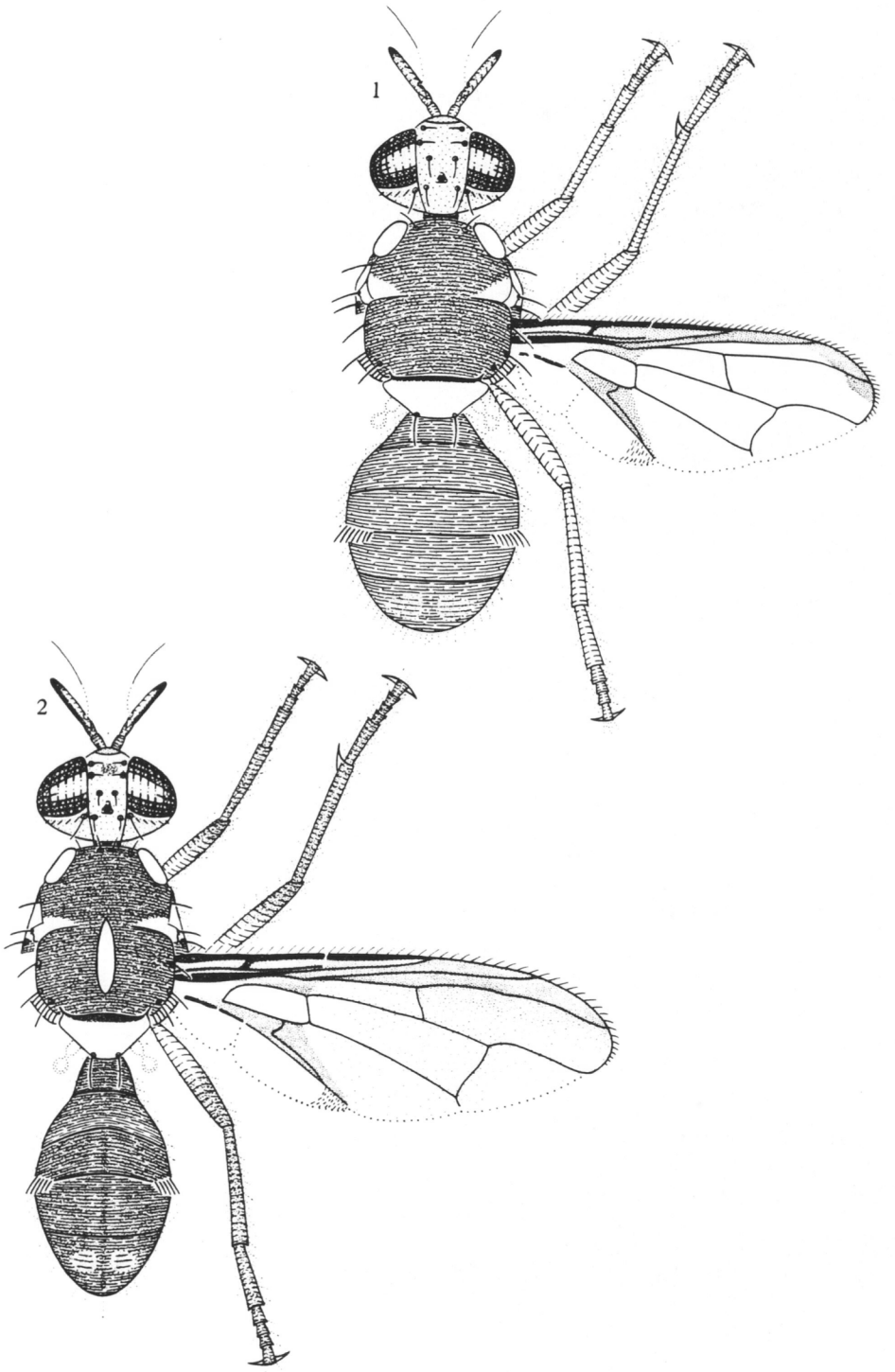


Fig. 1. *Dacus (Dacus) bellulus* Drew & Hancock, sp. nov.
Fig. 2. *Dacus (Pacifodacus) salamander* Drew & Hancock, sp. nov.

notopleural calli yellow, yellow triangular marking extending onto mesonotum anterior to mesonotal suture, scutellum yellow, wing with a fuscous tint throughout and a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells, abdominal terga III–V orange-brown with a medial longitudinal and 2 broad lateral longitudinal red-brown bands.

Type Specimens

Holotype ♂ (cue-lure), Bamaga, Cape York Peninsula, Queensland, Mar.-Apr. 1976, W. Kilpatrick. Paratype: 1 ♂ (cue-lure), Bamaga, Cape York Peninsula, Mar.-Apr. 1976, W. Kilpatrick.

Holotype (reg. No. T.8220) in Queensland Museum, Brisbane; 1 paratype in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 6·8 mm, paratype 6·0 mm.

Head. Generally fulvous. Vertical length: holotype 1·9 mm, paratype 1·5 mm. Frons of even width, length 1·67 times breadth; red-brown, with no fuscous markings; anteromedial hump distinct, covered with short brown setae; orbital bristles red-brown to black: 1 *s.or.*, 2 *i.or.*, lunule red-brown. Ocellar triangle dark red-brown. Vertex red-brown. Face fulvous with a pair of medium-sized, rounded facial spots, not reaching epistoma; width of spot (0·18 mm) less than width of 3rd antennal segment; length of face 0·5 mm. Genae red-brown, fuscous subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins, occipital row with 4–7 black bristles each side. Antennae with 1st and 2nd segments red-brown; 3rd segment red-brown with fuscous on apex and outer surface: a weak fulvous bristle on dorsal surface of second segment; arista fulvous for basal $\frac{1}{3}$ (remainder black); length of segments 0·4 mm; 0·45 mm; 1·10 mm.

Thorax. Mesonotum red-brown to dark red-brown, with no dark markings except fuscous patches at sites of muscle attachment. Pleural areas dark red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; a triangular band with base at notopleural calli and extending inwards along anterior margin of mesonotal sutures; broad mesopleural stripe, reaching anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin straight; upper hypopleural calli (posterior apices dark red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder dark red-brown); a narrow medial longitudinal vitta beginning just anterior to level of mesonotal suture and ending before level of upper *p.sa.* bristles. Postnotum dark red-brown with fuscous markings; lateral post-sutural vittae absent. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* absent; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and black. Legs: all segments red-brown except basal $\frac{1}{2}$ of each femur fulvous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cells fuscous, microtrichia covering all of 2nd costal cell and most of first cell, remainder of wings with a fuscous tint, a fuscous stigma, broad fuscous costal band confluent with R_{4+5}, broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA + 1A$. Supernumerary lobe weak.

Abdomen. Elongate oval; terga free; pecten present on tergum III. Tergum I dark red-brown; tergum II dark red-brown anteriorly and paler posteriorly; terga

III–V red-brown laterally, orange-brown centrally with a medial longitudinal red-brown stripe that extends over most of these terga. A pair of red-brown shining spots on tergum V.

Comments

Dacus (Pacifodacus) strigifinis Walker and *D. salamander*, sp. nov., are the only known species of *Pacifodacus* in Australia. They are similar in general body colour. *D. salamander* differs from *D. strigifinis* in lacking lateral post-sutural vittae and lateral yellow bands connecting humeral and notopleural calli, in possessing fuscous costal cells which are covered with microtrichia, a broad fuscous costal band confluent with R_{4+5} and legs mostly red-brown. *Dacus (Pacifodacus) aneuvittatus* Drew from New Caledonia is similar to *D. salamander* but differs from the latter in lacking a medial post-sutural vitta and in possessing fulvous legs and a broad costal band that overlaps R_{4+5} (except for an area beyond *r–m* crossvein) and which extends along *r–m* crossvein.

Bactrocera group of Subgenera

Defined by Drew (1972*a*) as the *Strumeta* group, having sternum V of male with a deep concavity of hind margin and with posterior lobe of surstylus short.

Subgenus **Bactrocera** Macquart

Bactrocera Macquart, 1835, p. 452 (type-species: *Bactrocera longicornis* Macquart, 1835, by monotypy); Hardy, 1976, pp. 245–9.

Dacus (Bactrocera) absconditus Drew & Hancock, sp. nov.

(Fig. 3)

Diagnosis

A medium-sized species, facial spots large and subquadrate, mesonotum red-brown with dark markings, lateral post-sutural vittae present, mesopleural stripes broad (reaching anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous, microtrichia in outer portion of 2nd costal cell only, abdominal terga III–V orange-brown with broad lateral and medial longitudinal dark bands over all 3 terga.

Type Specimens

Holotype ♂ (cue-lure), 11 km N. of Bamaga, Cape York Peninsula, Queensland, 19.xii.1974, D. J. Rogers.

Paratypes: **Queensland:** 6 ♂ (cue-lure), 1 km N. of Bamaga, 19.xii.1974; 4 ♂ (cue-lure), 5 km N. of Bamaga, 19.xii.1974; 6 ♂ (cue-lure), 8 km N. of Bamaga, 19.xii.1974; 5 ♂ (cue-lure), 11 km N. of Bamaga, 19.xii.1974; 5 ♂ (cue-lure), 18 km N. of Bamaga, 19.xii.1974; 5 ♂ (cue-lure), 21 km N. of Bamaga, 18.xii.1974; 6 ♂ (cue-lure), 27 km N. of Bamaga, 15.xii.1974; 1 ♂ (cue-lure), Lockerbie, Cape York Peninsula, Dec. 1974; 2 ♂ (cue-lure), 5 km E. of Lockerbie, 18.xii.1974; 1 ♂ (cue-lure), Bamaga, Dec. 1974; 1 ♂ (cue-lure), Bamaga Airport, 19.xii.1974; 5 ♂ (cue-lure), New Mapoon Settlement, near Bamaga, Dec. 1974; 4 ♂ (cue-lure), Umagico Settlement, Cape York Peninsula, Dec. 1974, all coll. D. J. Rogers. 1 ♂ (cue-lure), Running Creek, 25 km E. of Weipa, 15–20.vi.1976; 1 ♂ (cue-lure), Weipa, Nov. 1977, A. de Witte. 6 ♂ (cue-lure), Iron Range, Cape York Peninsula, 14–21.iv.1977;

1 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 7–14.iv.1977; all coll. R. I. Storey. 7 ♂ (cue-lure), Lake Boronto, Newcastle Bay, Cape York Peninsula, 2–26.ix.1974; 7 ♂ (cue-lure), 4 km E. of Lockerbie, 16–20.ix.1974; 1 ♂ (cue-lure), 4 km E. of Lockerbie, 30.i–4.ii.1975; 1 (cue-lure), 3 km E. of Lockerbie, 16–20.ix.1974; 1 ♂ (cue-lure), 3 km E. of Lockerbie, 30.i–4.ii.1975; 2 ♂ (cue-lure), Iron Range, Cape York Peninsula, 30.vi–4.vii.1977; 6 ♂ (cue-lure), Andoom, near Weipa, 5–8.ii.1975; 7 ♂ (cue-lure), West Claudie River, Iron Range, 29–30.ix.1974; all coll. G. B. Monteith. 3 ♂ (cue-lure), Eet Hill vicinity, Moa (Banks) I., Torres Strait, 9–13.vii.1977, G. B. Monteith and D. Cook. 3 ♂ (cue-lure), Thursday I., Torres Strait, 14.xii.1976, R. Paton. 10 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 9.x.1976; 9 ♂ (cue-lure), Blackwater Creek, 36 km NE. of Bamaga, 9.x.1976; 1 ♂ (cue-lure), Captain Billy Creek, 44 km E. of Heathlands, 13.x.1976; 4 ♂ (cue-lure), Blue Valley Creek, 11 km E. of Bamaga, 9.x.1976; all coll. D. Murray. 3 ♂ (cue-lure), Heathlands, Cape York Peninsula, 16–20.ix.1975, J. McNichol.

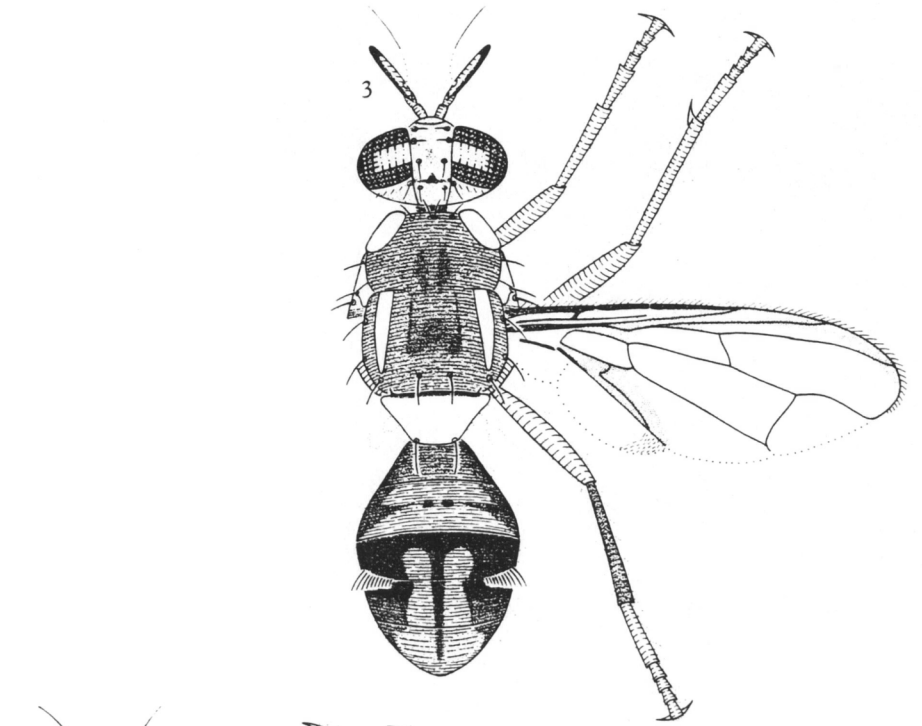
Holotype (reg. No. T.8221) and 20 paratypes (reg. Nos T.8222–T.8241) in Queensland Museum, Brisbane; 25 paratypes in Australian National Insect Collection, CSIRO, Canberra; 80 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 6·0 mm, range of type series 5·1–6·1 mm, mean 5·7 mm.

Head. Generally fulvous. Vertical length: holotype 1·7 mm, range for type series 1·4–1·7 mm, mean 1·6 mm. Frons of even width, length 1·6 times breadth; fulvous, often with pale fuscous markings on anteromedial hump and around orbital bristles; anteromedial hump distinct, covered with a small number of short pale setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. Ocellar triangle dark fuscous to black. Vertex dark fulvous to pale fuscous, red-brown posteriorly. Face fulvous, with a pair of large subquadrate facial spots, not reaching epistoma; width of spot (0·15 mm) equal to width of 3rd antennal segment; length of face 0·48 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–8 well developed dark fuscous to black bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·22 mm; 0·30 mm; 0·86 mm.

Thorax. Mesonotum red-brown with irregular fuscous markings ranging from a pair of anterior spots to a broad area covering most of the mesonotum (these fuscous areas do not reach lateral post-sutural vittae). Pleural areas dark red-brown except for a large fuscous area on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, reaching anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct transverse spot, anterior margin convex; upper hypopleural calli (posterior apices dark red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder fuscous dorsally, dark red-brown ventrally); 2 broad, lateral post-sutural vittae tapering sharply posteriorly to end before upper *p.sa.* bristle. Postnotum dark red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *npl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and dark red-brown. Legs: all segments fulvous except mid and hind coxae and hind tibiae pale fuscous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cells very pale fulvous; microtrichia in outer portion of 2nd costal



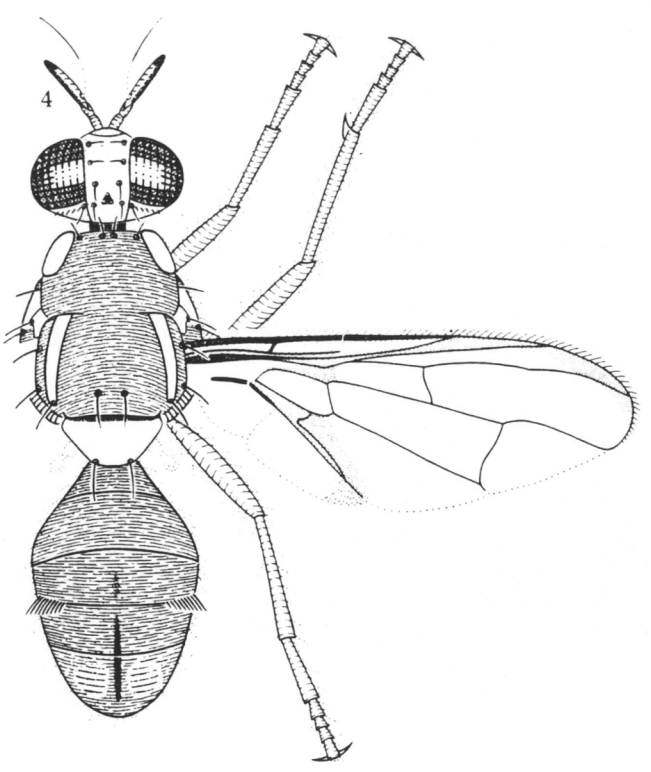


Fig. 3. *Dacus (Bactrocera) absconditus* Drew & Hancock, sp. nov.
Fig. 4. *Dacus (Bactrocera) aeroginosus* Drew & Hancock, sp. nov.

cell only; remainder of wings colourless except for a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I dark red-brown to fuscous (except for narrow orange-brown posterior margin); tergum II dark orange-brown to red-brown, posterior $\frac{1}{2}$ paler, with a fuscous marking centrally and with dark fuscous to black lateral margins; terga III–V orange-brown with a broad, dark fuscous to dull black band on anterior $\frac{1}{2}$ of tergum III and expanding over lateral margins of this tergum and anterolateral margins of tergum IV (the posterolateral corners of terga III and IV are usually dark red-brown to pale fuscous), a broad medial longitudinal dark fuscous to dull black band over all 3 terga. A pair of shining spots on tergum V, these spots usually red-brown to fuscous.

Comments

D. absconditus, sp. nov., belongs to the *silvicola* complex of species. The other species in this complex are *D. (Bactrocera) breviaculeus* Hardy, *D. rufofusculus*, sp. nov., and *D. (Bactrocera) silvicola* (May). *D. absconditus* differs from *D. breviaculeus* and *D. rufofusculus* in having the lateral post-sutural vittae ending before the upper *p.sa.* bristles and the mesopleural stripe wider (extending to the anterior *npl.* bristle dorsally). In addition it differs from *D. breviaculeus* in having the costal band overlapping R_{2+3}. It differs from *D. silvicola* in possessing fuscous markings on the mesonotum, a broader mesopleural stripe and coloured costal cells (pale fulvous).

Dacus (Bactrocera) aeroginosus Drew & Hancock, sp. nov.

(Fig. 4)

Diagnosis

A medium-sized pale-coloured species, facial spots medium-sized and rounded, mesonotum pale red-brown, lateral post-sutural vittae present, mesopleural stripes broad (reaching anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer portion of 2nd costal cell only, abdomen orange-brown with a narrow medial longitudinal dark band on part or all of terga III–V.

Type Specimens

Holotype ♂ (cue-lure), 4 km E. of Lockerbie, Cape York Peninsula, Queensland, 30.i–4.ii.1975, G. B. Monteith.

Paratypes: **Queensland:** 2 ♂ (cue-lure), 3–4 km E. of Lockerbie, Cape York Peninsula, 16–20.ix.1974; 17 ♂ (cue-lure), 3–4 km E. of Lockerbie, Cape York Peninsula, 30.i–4.ii.1975; 1 ♂ (cue-lure), Lake Boronto, Cape York Peninsula, 30.i–4.ii.1975; 1 ♂ (cue-lure), Andoom, near Weipa, Cape York Peninsula, 5–7.ii.1975; 5 ♂ (Willison's lure), Gap Creek, 4 km N. of Bloomfield River, Cape York Peninsula, 12.xi.1965; 1 ♂ (Willison's lure), Upper Mulgrave River, Cape York Peninsula, 3.xii.1975; all coll. G. B. Monteith. 2 ♂ (cue-lure), 5 km E. of Lockerbie, Cape York Peninsula, 18.xii.1976, D. J. Rogers. 1 ♂ (cue-lure), Scrubby Creek, 75 km S. of Bamaga, 10.x.1976; 1 ♂, 48 km E. of Heathlands, Cape York Peninsula, 13.x.1976; 10 ♂ (cue-lure), 31 km E. of Heathlands, 14.x.1976;

4 ♂ (cue-lure), 23 km E. of Heathlands, 14.x.1976; all coll. D. Murray. 2 ♂ (cue-lure), Heathlands, Cape York Peninsula, 19–22.ix.1975, J. McNichol. 2 ♂ (cue-lure), Heathlands, 15–20.viii.1976, A. de Witte. 1 ♂ (cue-lure), Eubenangee Swamp, near Innisfail, 17.vii.1974, D. Cook. 6 ♂ (cue-lure), Clump Point, Mission Beach, near Tully, 7.ii.1975; 3 ♂ (cue-lure), Cedar Creek, Bingil Bay Road, near Tully, 7.ii.1975, all coll. R. A. I. Drew.

Holotype (reg. No. T.8242) and 5 paratypes (reg. Nos T.8243–T.8247) in Queensland Museum, Brisbane; 5 paratypes in Australian National Insect Collection, CSIRO, Canberra; 49 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 5·7 mm, range for type series 4·5–6·5 mm, mean 5·8 mm.

Head. Generally fulvous. Vertical length: holotype 1·5 mm, range for type series 1·1–1·7 mm, mean 1·5 mm. Frons narrowing slightly posteriorly, length 1·5 times breadth; fulvous, with no fuscous markings; anteromedial hump indistinct, covered with short dark setae; bristles fulvous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of medium-sized, rounded facial spots not reaching epistoma; width of spot (0·14 mm) less than width of 3rd antennal segment; length of face 0·43 mm. Genae fulvous, dark fulvous subocular spot present; fulvous bristle present. Occiput fulvous, yellow along eye margin, occipital row with 3–6 well developed dark bristles each side. Antennae with 1st and 2nd segments fulvous, 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·17 mm; 0·28 mm; 0·76 mm.

Thorax. Mesonotum pale red-brown with no dark markings (occasionally fuscous patterns at sites of attachment of dorsoventral flight muscle). Pleural areas red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin straight; upper hypopleural callus (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural callus (remainder red-brown); 2 broad parallel-sided lateral post-sutural vittae, ending at or behind upper *p.sa.* bristle. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments fulvous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical dark fulvous spur. Wings: costal cells fulvous, 2nd cell slightly paler, microtrichia in outer portion of 2nd costal cell only; remainder of wings with a pale fulvous tint and a fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I orange-brown; tergum II orange-brown, posterior $\frac{1}{2}$ paler; terga III–V orange-brown with a narrow discontinuous medial longitudinal black band (this band is sometimes reduced to a spot on tergum V). A pair of shining spots on tergum V, generally orange-brown, occasionally darker.

Comments

D. aeroginosus, sp. nov., and *D. (Bactrocera) bidentatus* (May) are similar in general body shape and coloration and together form the *bidentatus* complex. *D. aeroginosus* differs from *D. bidentatus* in possessing lateral post-sutural vittae that extend to the upper *p.sa.* bristle, a broader mesopleural stripe (extending to the anterior *npl.* bristle dorsally) and a narrow costal band (confluent with R_{2+3}).

Dacus (Bactrocera) antigone Drew & Hancock, sp. nov.

(Fig. 5)

Diagnosis

A medium-sized species, facial spots medium-sized and rounded, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes broad (reaching anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer portion of 2nd costal cell only, abdomen orange-brown with narrow lateral longitudinal dark bands and a broad medial longitudinal dark band over terga III–V.

Type Specimens

Holotype ♂ (cue-lure), Gordon's Mine area, Iron Range, Cape York Peninsula, Queensland, 12–18.ii.1976, G. B. Monteith.

Paratypes: **Queensland:** 19 ♂ (cue-lure), Gordon's Mine area, Iron Range, Cape York Peninsula, 12–18.ii.1976; 5 ♂ (Willison's lure), Upper Mulgrave River, Cape York Peninsula, 3.xii.1965; 2 ♂ (cue-lure), Dividing Range, 15 km W. of Captain Billy Creek, Cape York Peninsula, 5–12.ii.1976; all coll. G. B. Monteith. 1 ♂ (cue-lure), Claudie R., 7 km S. of Iron Range, Cape York Peninsula, 18.x.1976; 1 ♂ (cue-lure), Claudie R., 15 km S. of Iron Range, 18.x.1976; 1 ♂ (cue-lure), Claudie R., 17 km S. of Iron Range, 18.x.1976; 4 ♂ (cue-lure), Claudie R., 48 km SW. of Cape Weymouth, 19.x.1976; 1 ♂ (cue-lure), 10 km N. of Iron Range, Cape York Peninsula, 18.x.1976; 1 ♂ (cue-lure), Yarraman R., 10 km S. of Iron Range, 18.x.1976; all coll. D. Murray. 2 ♂ (cue-lure), Iron Range, 4.xi.1975; 1 ♂ (cue-lure), Iron Range, 30.iv.1976; all coll. I. R. Bock. 1 ♂ (cue-lure), Iron Range, 12–18.vii.1977, R. Goebel. 4 ♂ (cue-lure), Iron Range, 25 km SW. of Lockhart, 14–21.iv.1977, R. I. Storey.

Holotype (reg. No. T.8248) and 5 paratypes (reg. Nos T.8249–T.8253) in Queensland Museum, Brisbane; 5 paratypes in Australian National Insect Collection, CSIRO, Canberra; 33 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 5·8 mm, range for type series 4·7–6·2 mm, mean 5·4 mm.

Head. Generally fulvous. Vertical length: holotype 1·6 mm, range for type series 1·3–1·6 mm, mean 1·5 mm. Frons of even width, length 1·7 times breadth; fulvous with no fuscous markings; anteromedial hump covered with short dark setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of medium-sized rounded facial spots, pointed anteriorly but not reaching epistoma; width of spot (0·15 mm) less than width of 3rd antennal segment; length of face 0·43 mm. Genae fulvous, dark fulvous

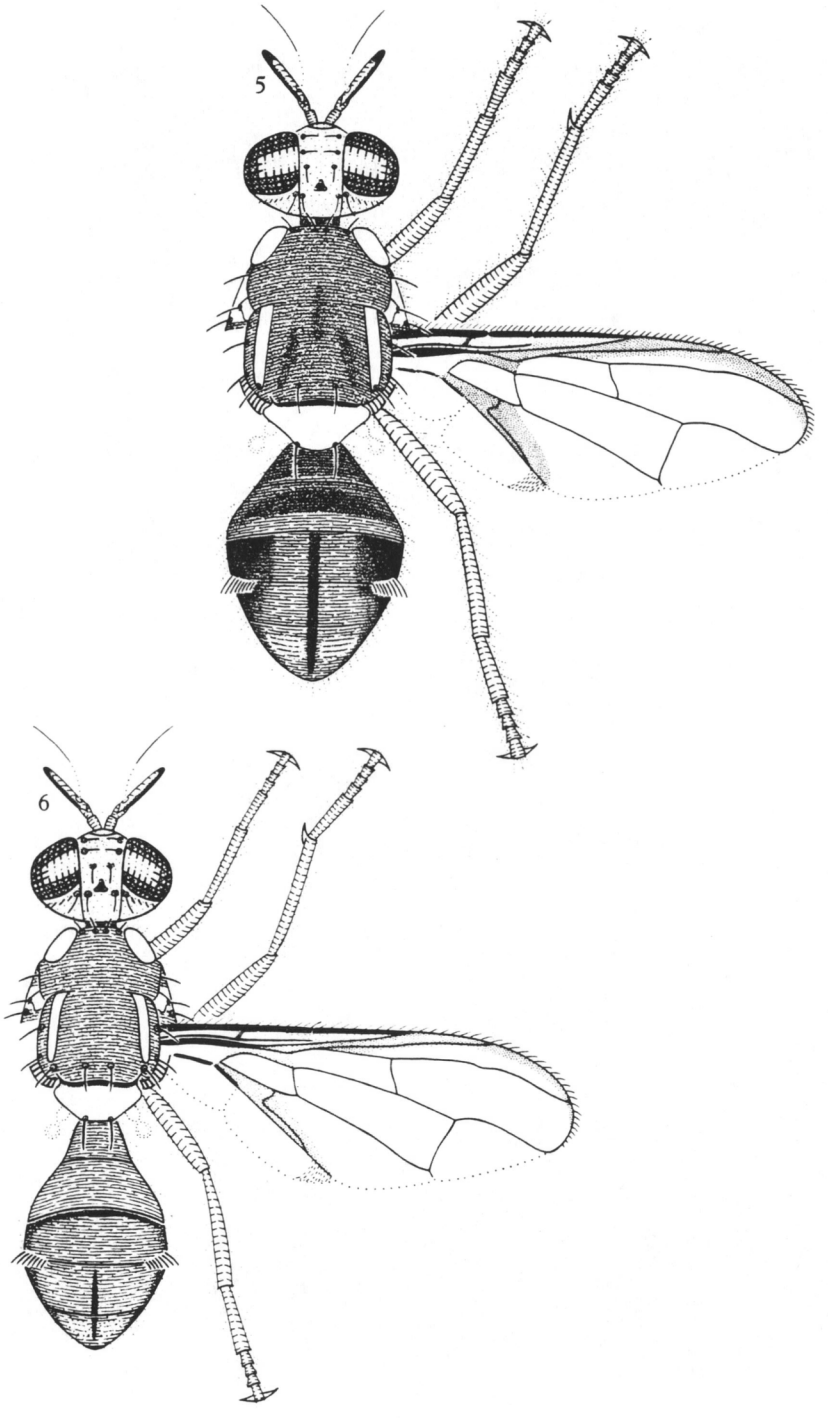


Fig. 5. *Dacus (Bactrocera) antigone* Drew & Hancock, sp. nov.
Fig. 6. *Dacus (Bactrocera) aurantiacus* Drew & Hancock, sp. nov.

subocular spot present; bristle fulvous. Occiput fulvous, yellow along eye margin, occipital row with 4–7 well developed dark bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·19 mm; 0·30 mm; 0·77 mm.

Thorax. Mesonotum red-brown with obscure fuscous to pale fuscous medial and lateral longitudinal markings. Between humeral and notopleural calli there are dark areas associated with dorsoventral flight muscles (in some specimens the dark areas are absent). Pleural areas red-brown with fuscous on sternopleuron and above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes reaching anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown); 2 broad parallel-sided lateral post-sutural vittae, ending at or behind upper *p.sa.* bristle. Postnotum dark red-brown with fuscous lateral markings. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments fulvous (extremely pale fuscous on hind tibiae of some specimens); rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical red-brown to black spur. Wings: costal cells fulvous, 2nd cell slightly paler, microtrichia in outer portion of 2nd costal cell only; remainder of wings with a pale fulvous tint and a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA + 1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I red-brown to pale fuscous; tergum II fuscous to pale fuscous anteriorly and orange-brown posteriorly; terga III–V orange-brown with narrow lateral longitudinal bands ranging from dark fuscous on anterolateral corners of tergum III to fuscous on terga IV and V; a broad medial longitudinal dark fuscous to black band on terga III–V (this band is dark fuscous on tergum III and black on terga IV and V). A pair of orange-brown to red-brown shining spots on tergum V.

Comments

D. antigone, sp. nov., belongs to the *quadratus* complex of closely related species. The other species in this complex are *D. aurantiacus*, sp. nov., *D. erubescentis*, sp. nov., *D. (Bactrocera) quadratus* (May) and *D. peninsularis*, sp. nov. These five species are similar in body shape and colour. *D. antigone* differs from the other species in the complex by possessing a broader mesopleural stripe (extending to the anterior *npl.* bristle above). It differs from *D. erubescentis* in possessing paler fulvous costal cells, a darker medial longitudinal stripe on abdominal terga III–V and in lacking a dark band along the anterior margin of tergum III. It differs from *D. quadratus* in possessing fulvous colour in the costal cells, in lacking dark fulvous on the apex of the femora and in lacking a dark band along anterior margin of tergum III. It differs from *D. aurantiacus* and *D. peninsularis* in possessing a broad dark medial longitudinal band on terga III–V and darker fuscous patterns on lateral margins of these terga (*peninsularis* usually lacks colour patterns on lateral margins of terga IV and V).

Dacus (Bactrocera) aurantiacus Drew & Hancock, sp. nov.

(Fig. 6)

Diagnosis

A medium-sized pale-coloured species, facial spots medium-sized and irregularly oval, mesonotum orange-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia in outer portion of 2nd costal cell only, abdomen orange-brown with a narrow dark band along anterior margin of tergum III and narrow lateral dark bands on terga III–V, a narrow medial longitudinal dark line on terga IV and V.

Type Specimens

Holotype ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, Queensland, 7–14.iv.1977, R. Storey.

Paratypes: **Queensland:** 9 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 7–14.iv.1977; 1 ♂ (cue-lure), 3 km E. of Lockerbie Homestead, 18.xii.1974; 1 ♂ (cue-lure), 8 km N. of Bamaga, 19.xii.1974; 1 ♂ (cue-lure), 11 km N. of Bamaga, 19.xii.1974; all coll. R. Storey. 2 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 9.x.1976; 1 ♂ (cue-lure), Blackwater Creek, 36 km NE. of Bamaga, 9.x.1976; coll. D. Murray. 1 ♂ cue-lure), Bamaga, Mar.-Apr. 1976, W. Kilpatrick. 1 ♂ (cue-lure), Thursday I., Torres Strait, 14.xii.1976, R. Paton. 6 ♂ (cue-lure), Lake Boronto, Newcastle Bay, 30.i–4.ii.1975; 2 ♂ (cue-lure), Lake Boronto, 21–26.ix.1974; 2 ♂ (cue-lure), 4 km E. of Lockerbie, 16–20.ix.1974; 1 ♂, 4 km E. of Lockerbie, 30.i–4.ii.1975; 1 ♂ (cue-lure), 3 km E. of Lockerbie, 30.i.1975; 1 ♂ (cue-lure), 3 km E. of Lockerbie, 16–20.ix.1974; all coll. G. B. Monteith.

Holotype (reg. No. T.8254) and 4 paratypes (reg. Nos T.8255–T.8258) in Queensland Museum, Brisbane; 7 paratypes in Australian National Insect Collection, CSIRO, Canberra; 20 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 5·7 mm, range for type series 4·2–5·7 mm, mean 5·3 mm.

Head. Generally fulvous. Vertical length: holotype 1·6 mm, range for type series 1·0–1·6 mm, mean 1·3 mm. Frons of even width, length 1·5 times breadth, fulvous; anteromedial hump indistinct, covered with short dark setae; orbital bristles red-brown: 1 *s.or.*, 2 *i.or.*, lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of medium-sized, irregularly oval facial spots not reaching epistoma; width of spot (0·15 mm) equal in width to 3rd antennal segment; length of face 0·43 mm. Genae pale fulvous; pale brown subocular spot present; fulvous bristle present. Occiput pale fulvous, yellow along eye margin; occipital row with 2–5 well developed pale bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·14 mm; 0·27 mm; 0·72 mm.

Thorax. Mesonotum orange-brown with or without dark markings – if present, markings are as follows: narrow lateral longitudinal pale fuscous lines, pale fuscous along inner margins of lateral post-sutural vittae, dark areas associated with attachment of dorsoventral flight muscles. Pleural areas pale red-brown, generally marked with fuscous along anterior margin of mesopleural stripes. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron as a distinct spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior $\frac{3}{4}$ lower hypopleural calli (remainder red-brown); 2 narrow parallel-sided lateral post-sutural vittae, narrowing slightly posteriorly to end before upper *p.sa.* bristles. Postnotum red-brown (fuscous laterally). Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and fulvous. Legs: all segments fulvous; fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical fulvous spur. Wings: costal cells colourless; microtrichia in outer portion of 2nd costal cell only; remainder of wings colourless except for fulvous stigma, narrow fuscous costal band marginally overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Elongate oval, terga free; pecten present on tergum III. Tergum I fulvous; tergum II fulvous except posterior $\frac{1}{4}$ paler; tergum III fulvous with a narrow anterior transverse fuscous to black band and narrow fuscous lateral margins, with or without a medial longitudinal dark band; terga IV and V fulvous with very narrow fuscous lateral margins on tergum IV and fuscous anterolaterally on tergum V and with a narrow medial longitudinal fuscous to black band on both terga. A pair of fulvous to red-brown shining spots on tergum V.

Comments

D. aurantiacus, sp. nov., is placed in the *quadratus* complex. Within this complex it differs from *D. antigone*, *D. erubescentis* and *D. peninsularis* in having a medial longitudinal dark band only on abdominal terga IV and V and from *D. quadratus* in having lateral dark margins on abdominal terga III–V and in possessing fulvous hind tibiae.

D. aurantiacus is similar to *Dacus (Bactrocera) mayi* Hardy, *D. (Bactrocera) pallidus* (Perkins and May) and *D. (Bactrocera) tenuifascia* (May) in general body shape and colour. *D. aurantiacus* is attracted to cue-lure whereas the three species listed above are attracted to methyl eugenol. In addition *D. aurantiacus* differs from *D. mayi* in lacking dark patterns on the mesonotum and in possessing a paler (general orange-brown) colour of the thorax and abdomen, in having a medial abdominal dark band only on terga IV and V, and in lacking lateral abdominal dark bands. It differs from *D. pallidus* in possessing a broader anal streak (although pale), which is entirely covered by microtrichia, and a medial abdominal dark band only on terga IV and V. It differs from *D. tenuifascia* in possessing a medial abdominal dark band only on terga IV and V, and a paler fuscous anal streak.

Dacus (Bactrocera) erubescentis Drew & Hancock, sp. nov.

(Fig. 7)

Diagnosis

A medium-sized species, facial spots medium-sized and circular to pear-shaped, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer portion of 2nd costal cell only, abdomen with terga III–V orange-brown with a narrow transverse dark band on base of tergum III, narrow dark lateral margins and a medial longitudinal dark band on all 3 terga.

Type Specimens

Holotype ♂ (cue-lure), Weipa, Cape York Peninsula, Queensland, 3.x.1977, A. de Witte.

Paratypes: **Queensland:** 3 ♂ (cue-lure), Weipa, 3.x.1977, A. de Witte; 3 ♂ (cue-lure), Gordon's Mine area, Iron Range, Cape York Peninsula, 12–18.ii.1976, G. B. Monteith; 1 ♂ (cue-lure), Chinaman's Garden, 22 km NE. of Bamaga, Cape York Peninsula, 9.x.1976, D. Murray.

Holotype (reg. No. T.8259) and 1 paratype (reg. No. T.8260) in Queensland Museum, Brisbane; 2 paratypes in Australian National Insect Collection, CSIRO, Canberra; 4 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 4·9 mm, range for type series 4·5–5·2 mm, mean 4·9 mm.

Head. Generally fulvous. Vertical length: holotype 1·4 mm, range for type series 1·2–1·6 mm, mean 1·4 mm. Frons of even width; length 1·6 times breadth; fulvous without dark markings; anteromedial hump covered with short pale setae; bristles red-brown: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium-sized circular to pear-shaped facial spots not reaching epistoma; width of spot (0·18 mm) equal in width to 3rd antennal segment; length of face 0·45 mm. Genae fulvous; subocular spot absent; bristle fulvous to red-brown. Occiput red-brown, yellow along eye margin; occipital row with 4–5 well developed red-brown bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong red-brown bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·15 mm; 0·32 mm; 0·76 mm.

Thorax. Red-brown with pale fuscous along anterior margin of mesopleural stripe and fuscous on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown to fuscous); 2 lateral post-sutural vittae of medium width and narrowing posteriorly to end at upper *p.sa.* bristle. Postnotum red-brown

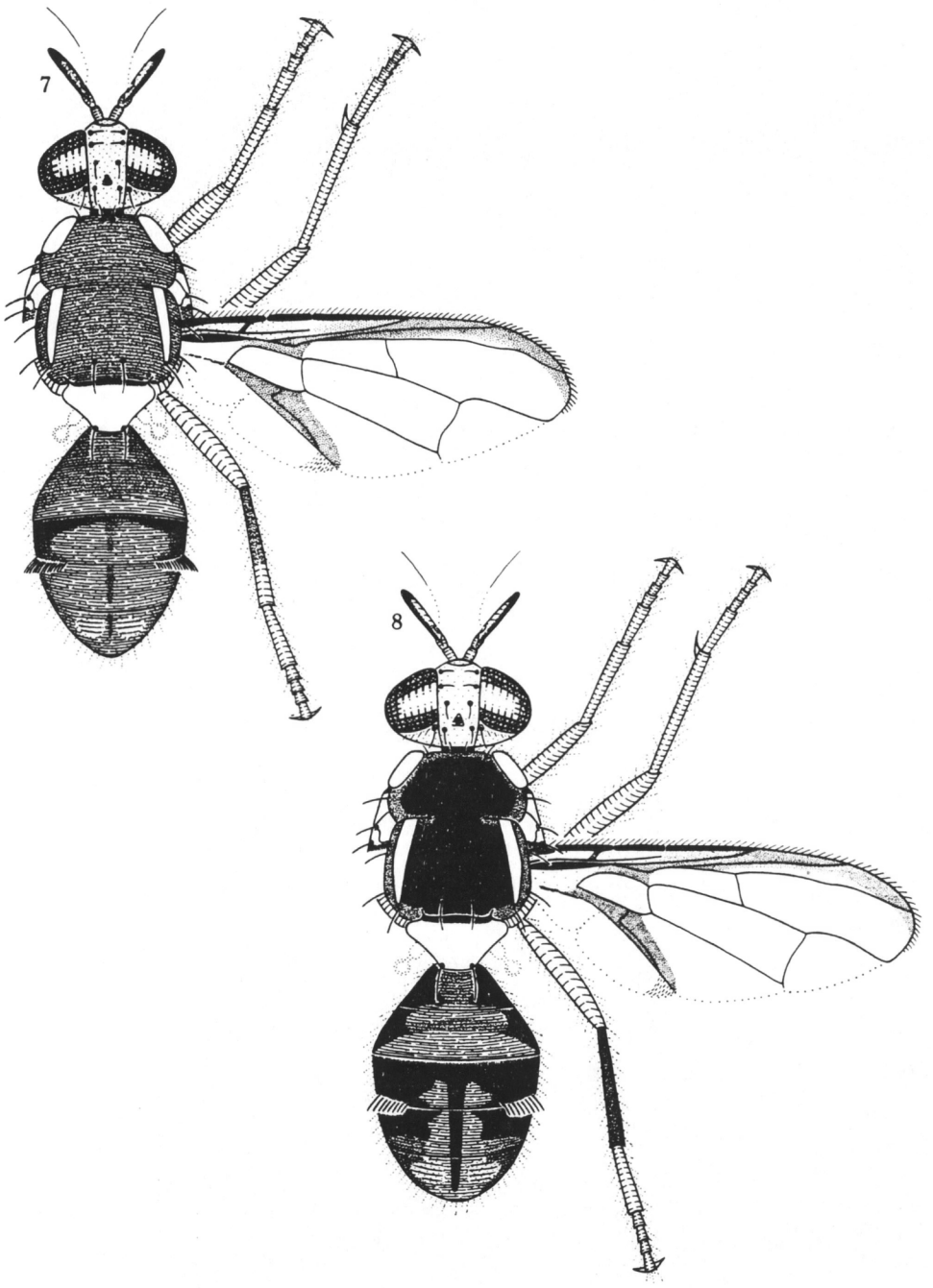


Fig. 7. *Dacus (Bactrocera) erubescentis* Drew & Hancock, sp. nov.
Fig. 8. *Dacus (Bactrocera) fuliginus* Drew & Hancock, sp. nov.

to fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments fulvous except fuscous on basal $\frac{2}{3}$ of hind tibiae; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical red-brown spur. Wings: costal cells fulvous, microtrichia in outer $\frac{1}{7}$ of 2nd costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band reaching almost to R_{1-5} and ending between extremities of R_{1-5} and M_{1-2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I red-brown centrally, pale fuscous laterally; tergum II with anterior $\frac{1}{2}$ red-brown, expanding over lateral margins (these margins sometimes pale fuscous), posterior $\frac{1}{2}$ whitish. Terga III–V orange-brown with a narrow transverse dark fuscous to dull black band on base of tergum III and expanding to cover lateral margins of this tergum, narrow fuscous markings on lateral margins of terga IV and V, an indefinite medial longitudinal narrow pale fuscous band on terga III–V which is discontinuous at intersegmental lines. A pair of shining spots on tergum V.

Comments

D. erubescentis, sp. nov., belongs to the *quadratus* complex and is similar to *D. antigone*, *D. aurantiacus*, *D. quadratus* and *D. peninsularis* in body shape and colour. It differs from *D. antigone* in possessing a narrower mesopleural stripe, a narrower medial longitudinal band on abdominal terga III–V, and a narrow dark fuscous band along anterior margin of tergum III; from *D. aurantiacus* in possessing coloured costal cells and lateral post-sutural vittae extending to upper *p.sa.* bristles. It differs from *D. quadratus* in possessing coloured costal cells, a narrower medial longitudinal band on abdominal terga III–V, and a narrower band across anterior margin of tergum III; from *D. peninsularis* in possessing a narrower mesopleural stripe, a medial longitudinal band on abdominal terga III–V, and a dark band across anterior margin of tergum III.

Dacus (Bactrocera) fuliginus Drew & Hancock, sp. nov.

(Fig. 8)

Diagnosis

A medium-sized species, facial spots small and subocular, mesonotum dull black, lateral post-sutural vittae present, mesopleural stripes broad (reaching almost to humeral callus), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous, microtrichia in outer portion of 2nd costal cell only, abdomen with terga III–V orange-brown with a broad lateral dark band across anterior of tergum III, lateral margins of terga III–V dark, a broad medial longitudinal dark band on terga III–V.

Type Specimen

Holotype ♂ (cue-lure), 4 km E. of Lockerbie, Cape York Peninsula, Queensland, 16–20.ix.1974, G. B. Monteith.

Holotype (reg. No. T.8261) in Queensland Museum, Brisbane.

Description of Male

Wing length: 5·9 mm.

Head. Generally fulvous. Vertical length 1·7 mm. Frons narrowing slightly posteriorly, length 1·6 times breadth; fulvous with no fuscous markings; anteromedial hump distinct, covered with short pale setae; bristles dark red-brown: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of large oval facial spots, not reaching epistoma; width of spot (0·19 mm) equal to width of 3rd antennal segment; length of face 0·5 mm. Genae fulvous, small dark fulvous subocular spot present; bristle red-brown. Occiput fulvous, occipital row with 5–6 well developed black bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·19 mm; 0·33 mm; 0·90 mm.

Thorax. Mesonotum dull black bounded by a narrow brown broder. Pleural areas red-brown with black markings anterior to mesopleural stripe, on sternopleuron and above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching almost to humeral callus above and continuing onto sternopleuron below as a distinct spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); 2 broad lateral post-sutural vittae, narrowing sharply posteriorly and ending before upper *p.sa.* bristle. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 2; all bristles well developed and red-brown. Legs: all segments fulvous except mid and hind coxae and hind tibiae fuscous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cells pale fulvous, microtrichia in outer portion of 2nd costal cell only; remainder of wings colourless except for a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I fuscous centrally, black laterally and with a narrow red-brown posterior margin; tergum II red-brown with a narrow transverse fuscous band and black lateral margins; terga III–V orange-brown with dark markings as follows: dull black on anterior $\frac{1}{2}$ and lateral margins of tergum III and anterolateral margins of tergum IV, pale fuscous to fuscous on posterolateral margins of tergum IV and anterolateral corners of tergum V, a broad medial longitudinal black band on terga III–V. A pair of red-brown shining spots on tergum V.

Comments

D. fuliginus, sp. nov., is similar to *Dacus (Bactrocera) endiandrae* (Perkins & May) in general body shape and colour. It differs from *D. endiandrae* in possessing larger facial spots, a broader mesopleural stripe (extending almost to humeral callus above), broader lateral post-sutural vittae, pale fulvous costal cells and darker lateral margins on abdominal terga IV and V. *D. fuliginus* is attracted to cue-lure whereas *D. endiandrae* is attracted to methyl eugenol.

Dacus (Bactrocera) humilis Drew & Hancock, sp. nov.

(Fig. 9)

Diagnosis

A small species, facial spots large and oval, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, 1st costal cell pale fulvous, 2nd costal cell fulvous, microtrichia covering costal cells, abdominal terga III–V fulvous with broad lateral longitudinal red-brown to fuscous band and indefinite medial longitudinal red-brown band.

Type Specimen

Holotype ♂ (methyl eugenol), 4 km E. of Lockerbie, Cape York Peninsula, Queensland, 30.i–4.ii.1975, G. B. Monteith.

Holotype (reg. No. T.8262) in Queensland Museum, Brisbane.

Description of Male

Wing length: 3·5 mm.

Head. Generally fulvous. Vertical length 0·8 mm. Frons narrowing slightly posteriorly; length 1·25 times breadth; fulvous with no dark markings; anteromedial hump covered with short pale setae; bristle fulvous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle dark fuscous. Vertex fulvous. Face fulvous with large, oval fuscous spots reaching almost to epistoma; width of spot (0·13 mm) less than width of 3rd antennal segment; length of face 0·25 mm. Genae fulvous without subocular spots; bristle fulvous. Occiput red-brown, occipital row with 3 pale fulvous bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·11 mm; 0·19 mm; 0·43 mm.

Thorax. Red-brown with a fuscous marking posterior to each humeral callus and inside each lateral post-sutural vitta. Pleural areas red-brown with fuscous on sternopleuron and above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a small spot, anterior margin convex; upper hypopoleural calli (posterior apices fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder fuscous); two parallel-sided lateral post-sutural vittae of medium width and ending just before upper *p.sa.* bristle. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments fulvous except hind tibiae pale fuscous; rows of long setae on dorsal surface of fore femora; middle tibiae each with an apical red-brown spur. Wings: 1st costal cell pale fulvous, 2nd costal cell fulvous; microtrichia covering all of 2nd costal cell and scattered around margins of 1st costal cell; remainder of wings with a very pale fulvous tint and a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad

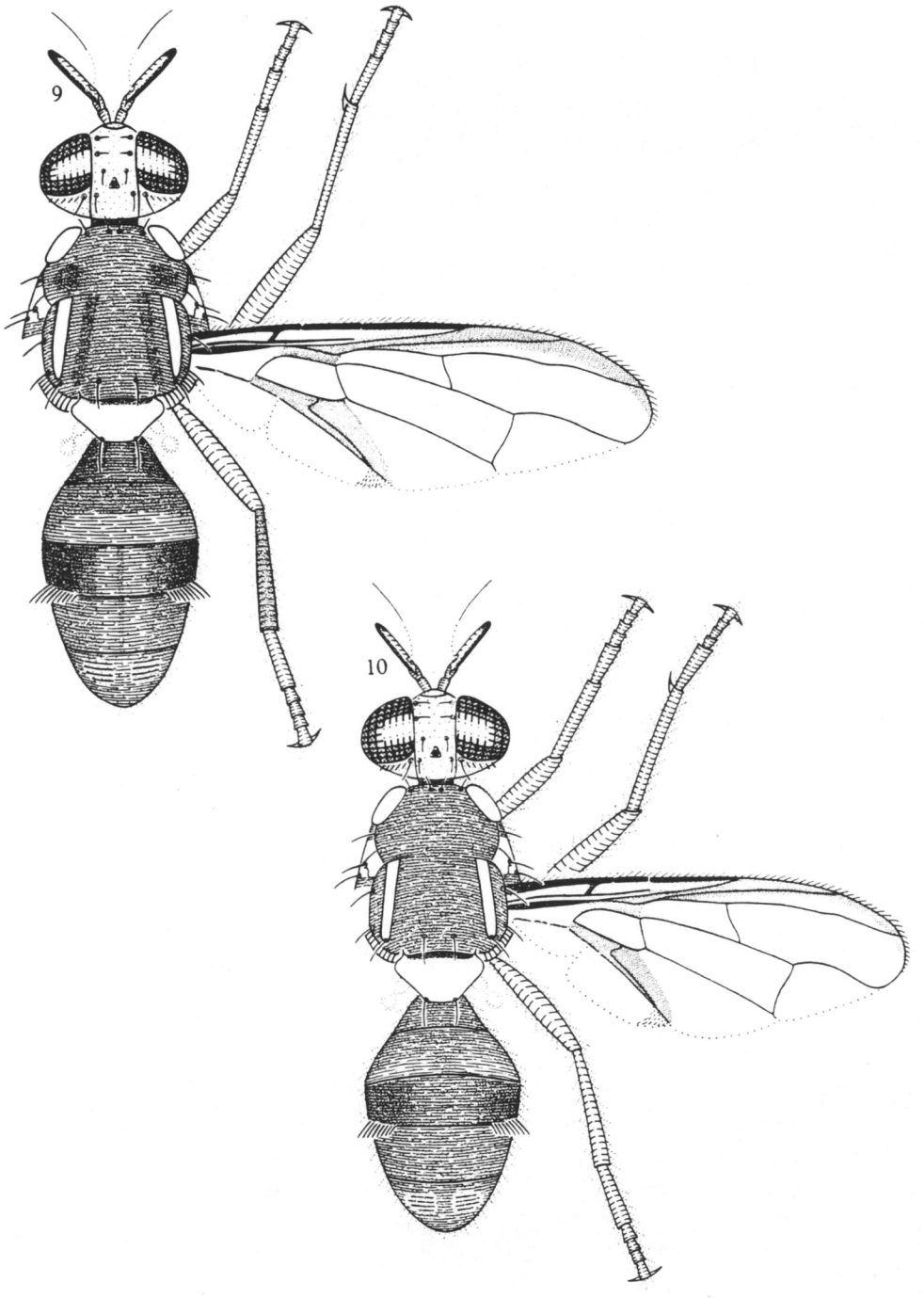


Fig. 9. *Dacus (Bactrocera) humilis* Drew & Hancock, sp. nov.
Fig. 10. *Dacus (Bactrocera) peninsularis* Drew & Hancock, sp. nov.

fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around *CuA* + 1*A*.

Abdomen. Elongate oval: terga free; pecten present on tergum III. Tergum I red-brown centrally, fuscous laterally and with a narrow red-brown posterior margin; tergum II red-brown along anterior $\frac{1}{2}$ expanding over lateral margins, posterior $\frac{1}{2}$ whitish; terga III–V fulvous with broad lateral longitudinal bands fuscous on tergum III and red-brown on terga IV and V, narrow indefinite medial longitudinal pale red-brown band on terga III and IV. A pair of red-brown shining spots on tergum V.

Comments

D. humilis, sp. nov., is a small species, distinct from all other species of *Dacus*. In the key to species it fits into the *tryoni* complex with *Dacus (Bactrocera) neohumeralis* Hardy, *D. (Bactrocera) aquilonis* (May), *D. (Bactrocera) melas* (Perkins & May) and *D. (Bactrocera) tryoni* (Froggatt), possessing microtrichia over all of the second costal cell and most of the first cell. It differs from *D. neohumeralis* in possessing yellow humeral calli, and from both *D. neohumeralis* and *D. melas* in having a paler red-brown general colour of the thorax and abdomen. It differs from *D. tryoni* and *D. aquilonis* in possessing broad lateral longituinal fuscous to red-brown bands on terga III–V. *D. humilis* is attracted to methyl eugenol, but all species of the *tryoni* complex are attracted to cue-lure.

Dacus (Bactrocera) peninsularis Drew & Hancock, sp. nov.

(Fig. 10)

Diagnosis

A medium-sized species, large subquadrate facial spots present, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (ending just posterior to anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells colourless to pale fulvous, microtrichia in outer $\frac{1}{2}$ of 2nd costal cell only, abdominal terga III–V orange-brown with red-brown to pale fuscous on lateral areas of tergum III.

Type Specimens

Holotype ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, Queensland, 7–14.iv.1977, R. I. Storey.

Paratypes: **Queensland:** 11 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 7–14.iv.1977, R. I. Storey. 1 ♂ (cue-lure), Bamaga, Dec. 1974; 1 ♂ (cue-lure), 2 km N. of Bamaga, 19.xii.1974; 1 ♂ (cue-lure), 5 km N. of Bamaga, 19.xii.1974; 1 ♂ (cue-lure), 8 km N. of Bamaga, 19.xii.1974; 2 ♂ (cue-lure), Vallack Point, Dec. 1974; 1 ♂ (cue-lure), Red Island Point, 3 km N. of Bamaga, 15.xii.1974; 1 ♂ (cue-lure), New Mapoon Settlement, near Bamaga, Dec. 1974; all coll. D. J. Rogers. 1 ♂ (cue-lure), Weipa, 13.xi.1976; 1 ♂ (cue-lure), 67 km E. of Weipa, 21.x.1976; 1 ♂ (cue-lure), Chinaman's Garden, 22 km NE. of Bamaga, 9.x.1976; 1 ♂ (cue-lure), Blue Valley Creek, 11 km E. of Bamaga, 9.x.1976; 1 ♂ (cue-lure), Scrubby Creek, 75 km S. of Bamaga, 10.x.1976; 1 ♂ (cue-lure), 23 km S. of Iron Range, 18.x.1976; 1 ♂ (cue-lure), Wenlock R., 170 km N. of Coen, 14.x.1976; 1 ♂ (cue-lure), Archer R., 67 km N. of Coen, 21.x.1976; 1 ♂ (cue-lure), Deep Creek, 37 km N. of Coen, 21.x.1976; 2 ♂ (cue-lure), Coen, 23.x.1976; 1 ♂ (cue-lure), Saltwater Creek, 142 km NW. of Laura, 23.x.1976; 1 ♂ (cue-lure), 'Silver Plains', 50 km E. of Coen, 4.x.1976; 1 ♂ (cue-lure), Station Creek, 12 km S. of Coen, 23.x.1976; 1 ♂ (cue-lure), Stewart R., 23 km S. of Coen, 23.x.1976; 1 ♂

(cue-lure), 'Bamboo', 94 km S. of Coen, 23.x.1976; all coll. D. Murray. 1 ♂ (cue-lure), Blue Valley Shed, via Lockerbie, 22-24.ix.1974; 1 ♂ (cue-lure), 3 km E. of Lockerbie, 30.i-4.ii.1975; 2 ♂ (cue-lure), 4 km E. of Lockerbie, 30.i-4.ii.1975; 2 ♂ (cue-lure), Lake Boronto, Newcastle Bay, 30.i-4.ii.1975; 1 ♂ (cue-lure), 15 km W. of Captain Billy Creek, 5-12.ii.1976; 1 ♂ (cue-lure), Road Crossing at Jardine R., 16-27.ix.1974; 1 ♂ (cue-lure), Moreton, Wenlock R., 14-29.x.1974; 1 ♂ (cue-lure), Gordon's Mine area, Iron Range, 12-18.ii.1976; 1 ♂ (cue-lure), Nichol Creek, 21 km W. of Pascoe Crossing, 29.ix-1.x.1974; 1 ♂ (cue-lure), Archer R. Crossing, 14.ix-1.x.1974; 1 ♂ (cue-lure), 5 km E. of Lakeland Downs, 2-3.x.1974; 1 ♂ (cue-lure), Higginsfield Road, near Bamaga, 23-27.ix.1974; all coll. G. B. Monteith. 1 ♂ (cue-lure), Shiptons Flat, via Helenvale, 20-27.vii.1974, G. Monteith and D. Cook. 2 ♂ (cue-lure), Bamaga, 3.xi.1975, I. Bock. 1 ♂ (cue-lure), Lankelly Creek, McIlwraith Range, near Coen, 28-31.x.1969, B. Cantrell. 1 ♂ (cue-lure), Cockatoo Creek, Heathlands area, 27-29.ix.1975, J. McNichol. 5 ♂ (cue-lure), St Pauls, Moa (Banks) I., Torres Strait, 14-17.vii.1977; 4 ♂ (cue-lure), Eet Hill vicinity, Moa (Banks) I., Torres Strait, 9-13.vii.1977; all coll. G. Monteith and D. Cook. 6 ♂ (cue-lure), Horn I., Torres Strait, 25-29.i.1975, R. Raven. 1 ♂ (Willison's lure), Prince of Wales I., Torres Strait, 17-20.vi.1977; 1 ♂ (Willison's lure), Badu I., Torres Strait, 21.vi.1977; R. Paton.

Holotype (reg. No. T.8263) and 20 paratypes (reg. Nos T.8264-T.8283) in Queensland Museum, Brisbane; 25 paratypes in Australian National Insect Collection, CSIRO, Canberra; 26 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 5·2 mm, range for type series 4·3-5·5 mm, mean 5·0 mm.

Head. Generally fulvous. Vertical length: holotype 1·4 mm, range for type series 1·1-1·4 mm, mean 1·3 mm. Frons narrowing slightly posteriorly, length 1·58 times breadth; fulvous with no fuscous markings; anteromedial hump distinct, covered with short pale setae; bristles red-brown: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of large subquadrate spots not reaching epistoma; width of spot (0·14 mm) less than width of 3rd antennal segment; length of face 0·43 mm. Genae fulvous, pale brown subocular spots present; bristle red-brown. Occiput fulvous, yellow along eye margin; occipital row with 4-5 well developed red-brown bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·18 mm; 0·25 mm; 0·71 mm.

Thorax. Mesonotum red-brown with no dark markings. Pleural areas red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown); 2 narrow parallel-sided lateral postsutural vittae, ending at or just behind upper *p.sa.* bristle. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown except *a.sa.* bristles often very weak or absent (72% of specimens have normal *a.sa.* development, 14% have reduced *a.sa.* bristles and 14% have no *a.sa.* bristles). Legs: all segments fulvous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cells colourless to very pale fulvous, microtrichia in outer $\frac{1}{2}$ of 2nd costal cell only; remainder of

wings colourless except for a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I orange-brown; tergum II orange-brown, posterior $\frac{1}{2}$ whitish; terga III–V orange-brown with red-brown to very pale fuscous areas on lateral margins of tergum III. A pair of orange-brown shining spots on tergum V. Occasionally there is a very narrow red-brown to pale fuscous medial longitudinal band on terga III–V (or part thereof) and sometimes terga III–V have pale fuscous lateral margins.

Comments

D. peninsularis, sp. nov., is placed in the *quadratus* complex and is similar to *D. antigone, D. aurantiacus, D. erubescentis* and *D. quadratus* in body shape and colour. It differs from *D. antigone* and *D. aurantiacus* in lacking a medial longitudinal dark band on abdominal terga III–V and with only fuscous to pale fuscous on lateral margins of abdominal tergum III. It differs from *D. erubescentis* in possessing a broader mesopleural stripe and in lacking both a dark band along the anterior margin of abdominal tergum III and a medial longitudinal band on terga III–V. It differs from *D. quadratus* in possessing a broader mesopleural stripe and coloured costal cells and in lacking both a dark band along the anterior margin of abdominal tergum III and a medial longitudinal dark band on terga III–V.

Dacus (Bactrocera) perkinsi Drew & Hancock, sp. nov.

(Fig. 11)

Diagnosis

A medium-sized species, medium-sized subquadrate facial spots present, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer portion of 2nd costal cell only, abdominal terga III–V red-brown with a narrow dark band along base of tergum III and with narrow medial and lateral longitudinal dark bands over all 3 terga.

Type Specimens

Holotype ♂ (cue-lure), 3 km E. of Lockerbie, Queensland, 30.i–4.ii.1975, G. Monteith.

Paratypes: **Queensland:** 5 ♂ (cue-lure), 3 km E. of Lockerbie, 30.i–4.ii.1975; 3 ♂ (cue-lure), 4 km E. of Lockerbie, 30.i–4.ii.1975; 1 ♂ (cue-lure), Lake Boronto, Newcastle Bay, 30.i–4.ii.1975; 9 ♂ (cue-lure), Iron Range, 30.i–4.vii.1977; 3 ♂ (cue-lure), Gordon's Mine area, Iron Range, 12–18.ii.1976; all coll. G. Monteith. 9 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 7–14.iv.1977; 4 ♂ (cue-lure), Iron Range, 25 km SW. of Lockhart, 14–21.iv.1977; R. Storey. 10 ♂ (cue-lure), Iron Range, 12–18.vii.1977, R. Goebel. 9 ♂ (cue-lure), Lockerbie Scrub, 25 km NE. of Bamaga, 9.x.1976; 1 ♂ (cue-lure), Blue Valley Creek, 11 km E. of Bamaga, 9.x.1976; 4 ♂ (cue-lure), Chinaman's Garden,

22 km NE. of Bamaga, 9.x.1976; all coll. D. Murray. 2 ♂ (cue-lure), Iron Range, near King Park Station, 17.v.1975, D. Smith. 4 ♂ (cue-lure), Iron Range, 4.xi.1975, I. Bock. 1 ♂ (cue-lure), 15 km W. of Captain Billy Creek, 4–9.vii.1975, D. Hancock. 3 ♂ (cue-lure), Horn I., Torres Strait, 25–29.i.1975; 1 ♂ (cue-lure), Eet Hill vicinity, Moa (Banks) I., Torres Strait, 9–13.vii.1977; G. Monteith and D. Cook.

Holotype (reg. No. T.8284) and 10 paratypes (reg. Nos T.8285–T.8294) in Queensland Museum, Brisbane; 20 paratypes in Australian National Insect Collection, CSIRO, Canberra; 39 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 7·0 mm, range for type series 5·5–7·2 mm, mean 6·4 mm.

Head. Generally fulvous. Vertical length: holotype 1·8 mm, range for type series 1·4–1·8 mm, mean 1·6 mm. Frons narrowing slightly posteriorly; length 1·5 times breadth; fulvous with or without pale fuscous markings on anteromedial hump and around orbital bristles; anteromedial hump distinct, covered with short pale setae; bristles fuscous to black: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous or pale fuscous. Face fulvous with a pair of medium-sized subquadrate spots not reaching epistoma; width of spot (0·14 mm) less than width of 3rd antennal segment; length of face 0·48 mm. Genae fulvous; brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–9 well developed black bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·17 mm; 0·34 mm; 0·85 mm.

Thorax. Mesonotum red-brown with or without fuscous markings – if present these markings represent sites of attachment of dorsoventral flight muscles. Pleural areas red-brown, occasionally with fuscous anterior to mesopoleural stripes. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown); 2 broad parallel-sided lateral post-sutural vittae ending behind upper *p.sa.* bristle. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown to black. Legs: all segments fulvous except fore and hind coxae and hind tibiae pale fuscous; fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cells fulvous; microtrichia in outer portion of 2nd costal cell only; remainder of wings colourless except for a fuscous stigma, narrow fuscous costal band extending faintly below R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I red-brown; tergum II red-brown, posterior $\frac{1}{2}$ paler; terga III–V red-brown, with a narrow dark

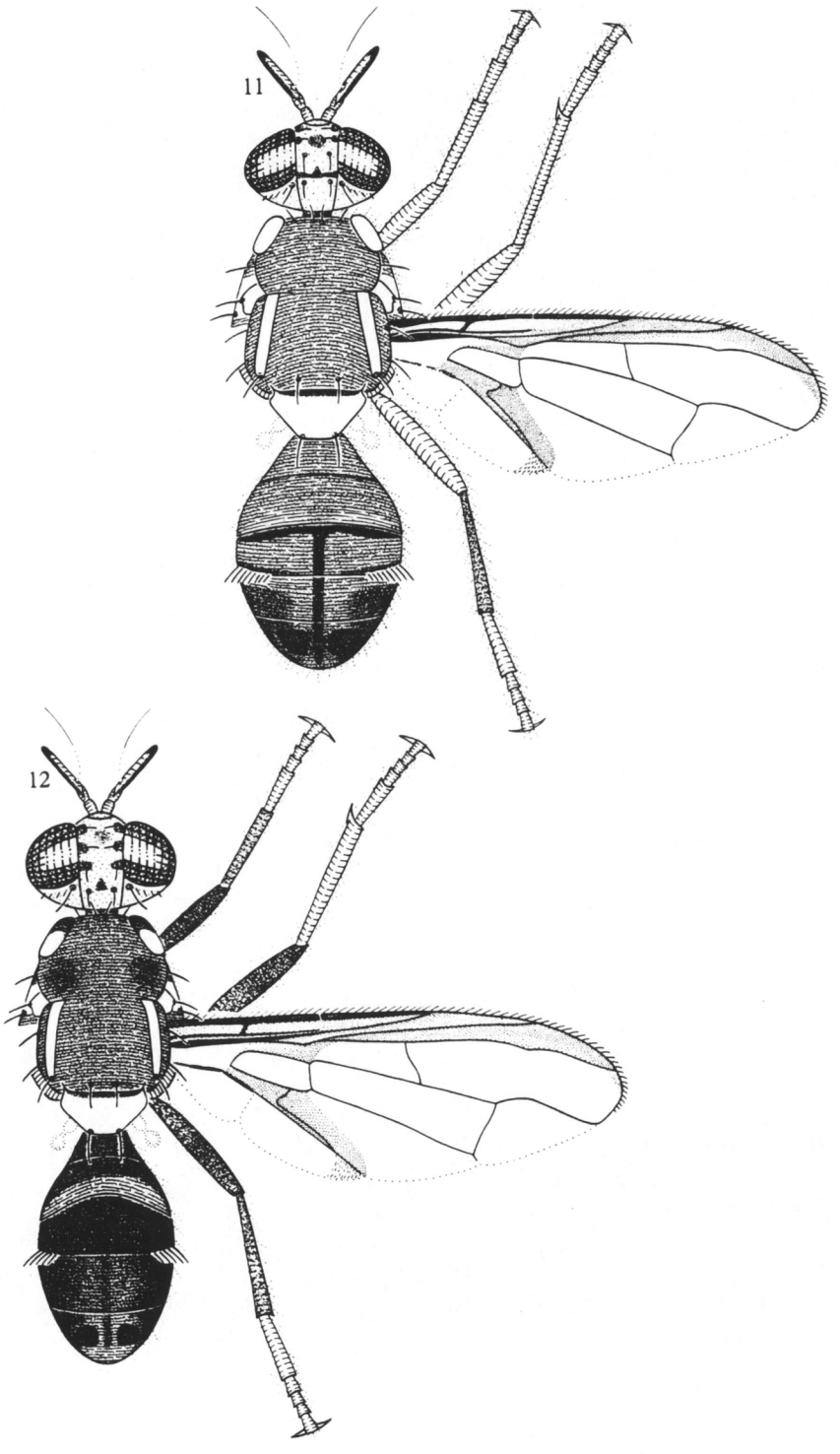


Fig. 11. *Dacus (Bactrocera) perkinsi* Drew & Hancock, sp. nov.
Fig. 12. *Dacus (Bactrocera) romigae* Drew & Hancock, sp. nov.

fuscous band along anterior margin of tergum III, a narrow medial longitudinal dark fuscous band over all 3 terga, fuscous on posterolateral margins of tergum IV and lateral margins of tergum V. A pair of dark fuscous to dull black shining spots on tergum V. (The narrow transverse band on tergum III is sometimes absent or pale fuscous and the medial longitudinal band on terga III–V is sometimes pale fuscous; occasionally there is a fuscous tint along intersegmental lines between terga III and IV and terga IV and V.)

Comments

D. perkinsi, sp. nov., is similar in general body shape and colour to *D. absconditus* and *D. silvicola* in the *silvicola* complex, to *D. aeroginosus* and *D. bidentatus* in the *bidentatus* complex, and to *D. antigone, D. aurantiacus, D. erubescentis, D. peninsularis* and *D. quadratus* in the *quadratus* complex. It differs from all these species in possessing a distinct abdominal colour pattern of dark fuscous to dull black shining spots, and fuscous on the posterolateral margins of tergum IV and lateral margins of tergum V.

This species is named after the late Mr F. A. Perkins, who pioneered much of the taxonomy of Tephritidae in Australia.

Dacus (Bactrocera) romigae Drew & Hancock, sp. nov.

(Fig. 12)

Diagnosis

A medium-sized species, facial spots large and oval, mesonotum dark red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), posterior $\frac{2}{3}$ humeral calli yellow (anterior $\frac{1}{3}$ fuscous), notopleural calli yellow, scutellum yellow, wing with a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells, abdomen elongate oval, abdominal tergum III dark fuscous, terga IV and V with broad lateral longitudinal dark fuscous bands and tergum V with a broad medial longitudinal fuscous band.

Type Specimens

Holotype ♂ (methyl eugenol), Gordon's Mine area, Iron Range, Queensland, 12–18.ii.1976, G. B. Monteith.

Paratypes: **Queensland:** 7 ♂ (methyl eugenol), Gordon's Mine area, Iron Range, 12–18.ii.1976; 3 ♂ (methyl eugenol), Iron Range, 30.vi–4.vii.1977; G. B. Monteith. 1 ♂ (methyl eugenol), Leo Creek Road (500 m), McIlwraith Range, 30 km NE. of Coen, 29.vi–4.vii.1976, G. B. and S. R. Monteith. 16 ♂ (methyl eugenol), Iron Range, 25 km SW. of Lockhart, 14–21.iv.1977, R. I. Storey. 4 ♂ (methyl eugenol), Iron Range, 12–18.vii.1977, R. Goebel. 8 ♂ (methyl eugenol), Iron Range, near King Park Station, 17.v.1975, D. Smith. 2 ♂ (methyl eugenol), Claudie R., 15 km S. of Iron Range, 18.x.1976; 1 ♂ (methyl eugenol), Claudie R., 48 km SW. of Cape Weymouth, 19.x.1976; 1 ♂ (methyl eugenol), 23 km S. of Iron Range, 18.x.1976; all coll. D. Murray.

Holotype (reg. No. T.8295) and 5 paratypes (reg. Nos T.8296–T.8300) in Queensland Museum, Brisbane; 8 paratypes in Australian National Insect Collection, CSIRO, Canberra; 30 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 6·3 mm, range for type series 5·0–6·6 mm, mean 6·1 mm.

Head. Generally fulvous. Vertical length: holotype 1·6 mm, range for type series 1·3–1·8 mm, mean 1·6 mm. Frons of even width; length 1·5 times breadth; fulvous, mostly with pale fuscous markings around orbital bristles and on anteromedial hump; latter prominent and covered with a large number of short dark setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule fulvous or fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of large oval facial spots, pointed anteriorly and not reaching epistoma; width of spot (0·22 mm) greater than width of 3rd antennal segment; length of face 0·55 mm. Genae fulvous; fuscous subocular spot present; bristle present. Occiput fulvous ventrally, tinged with fuscous dorsally, yellow along eye margin; occipital row with 5–9 well developed black bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except black on apex and outer surface; a strong fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·24 mm; 0·38 mm; 1·05 mm.

Thorax. Mesonotum dark red-brown with sites of muscle attachment showing as fuscous markings between humeral and notopleural calli and along inner margins of lateral post-sutural vittae. Pleural areas dark red-brown below humeral calli, remainder pale fuscous. Yellow markings as follows: posterior $\frac{2}{3}$ humeral calli (anterior $\frac{1}{3}$ fuscous); notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a small transverse spot, anterior margin slightly convex; upper hypopleural callus (posterior apices fuscous); anterior $\frac{2}{3}$ lower hypopleural callus (remainder fuscous); 2 narrow parallel-sided lateral post-sutural vittae ending at upper *p.sa.* bristle. Postnotum fuscous. Scutellum yellow except for narrow dark red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: coxae dark fuscous; fore femora dark fuscous, mid and hind femora dark fuscous tending fuscous to pale fuscous on basal $\frac{1}{3}$; fore and hind tibiae fuscous, mid tibiae fulvous; tarsi fulvous; dark setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cell fuscous, microtrichia covering both cells; remainder of wings with a pale fuscous tint and a dark fuscous stigma, broad dark fuscous costal band confluent with R_{4+5}, paler along R_{4+5} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Elongate oval; terga free; pecten present on tergum III. Tergum I dark fuscous; tergum II dark fuscous except posterior $\frac{1}{2}$ dark orange-brown; tergum III dark fuscous; terga IV and V with broad lateral dark fuscous bands, fuscous on centre of tergum IV and dark orange-brown to red-brown on centre of tergum V and with a broad medial longitudinal fuscous band on tergum V (this band is also on tergum IV when this tergum is paler in the central area). A pair of shining spots on tergum V, mostly fuscous to dark fuscous but occasionally dark red-brown.

Comments

D. romigae, sp. nov., is similar to *Dacus (Bactrocera) notatagena* (May) in the general colour patterns of the thorax, wings and abdomen, and together they form the *notatagena* complex. It differs from *D. notatagena* in being a larger species, in the absence of a medial black pattern on the mesonotum, in the presence of humeral calli with anterior $\frac{1}{3}$ fuscous, in the shape and size of the lateral post-sutural vittae, and in possessing a fuscous tint throughout the wing membrane, fuscous to dark fuscous femora and an elongate oval abdomen.

This species is named after Mrs M. C. Romig, who has made a major contribution to the taxonomic studies of Tephritidae through illustration work.

Dacus (Bactrocera) rufofusculus Drew & Hancock, sp. nov.

(Fig. 13)

Diagnosis

A medium-sized species, facial spots large and subquadrate, mesonotum dark red-brown, lateral post-sutural vittae present, mesopleural stripes of medium width (reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle), humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band and anal streak, costal cell colourless, microtrichia in outer portion of 2nd costal cell only, abdominal terga III–V orange-brown with a narrow transverse dark band across base of tergum III and narrow medial and broad lateral longitudinal dark bands over all 3 terga.

Type Specimens

Holotype ♂ (cue-lure), 15 km W. of Captain Billy Creek, Queensland, 4–9.vii.1975, D. L. Hancock.

Paratypes: **Queensland:** 4 ♂ (cue-lure), 15 km W. of Captain Billy Creek, 4–9.vii.1975, D. L. Hancock. 1 ♂ (cue-lure), 15 km W. of Captain Billy Creek, 5–12.ii.1976; 1 ♂ (cue-lure), Trevethan Creek, via Helenvale, 2–3.x.1974; G. B. Monteith. 1 ♂ (cue-lure), 'Heathlands', 16–19.ix.1975; 2 ♂ (cue-lure), 'Heathlands', 19–22.ix.1974; J. McNichol. 1 ♂ (cue-lure), Yarraman R., 10 km S. of Iron Range, 18.x.1976, D. Murray.

Holotype (reg. No. T.8301) and 1 paratype (reg. No. T.8302) in Queensland Museum, Brisbane; 2 paratypes in Australian National Insect Collection, CSIRO, Canberra; 7 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 5·6 mm, range for type series 5·0–5·7 mm, mean 5·3 mm.

Head. Generally fulvous. Vertical length: holotype 1·5 mm, range for type series 1·2–1·5 mm, mean 1·4 mm. Frons of even width, length 1·7 times breadth; fulvous with pale fuscous markings around orbital bristles and on anteromedial hump; latter covered with short pale setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with a pair of large subquadrate facial spots not reaching epistoma; width of spot (0·15 mm) equal to width of 3rd antennal segment; length of face 0·41 mm. Genae

fulvous, brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–7 well developed dark fuscous to black bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·17 mm; 0·28 mm; 0·74 mm.

Thorax. Mesonotum dark red-brown with a pair of fuscous bands extending from inside humeral calli to the posterior margin of mesonotum between the midline and lateral post-sutural vittae. Pleural areas fuscous except dark red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium-sized mesopleural stripes, ending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a distinct transverse spot, anterior margin straight or convex; upper hypopleural calli (posterior apices fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder fuscous); 2 narrow lateral post-sutural vittae tapering posteriorly to end behind upper *p.sa.* bristle. Postnotum dark red-brown to fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments fulvous except mid and hind coxae and hind tibiae fuscous; rows of fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. Wings: costal cell colourless; microtrichia in outer portion of 2nd costal cell only; remainder of wings colourless except for a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. Some specimens have a very pale fuscous tint in costal cells and across wings. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I dark fuscous with a narrow red-brown band along posterior margin; tergum II red-brown with a broad transverse dark fuscous band anteriorly, narrow dark fuscous lateral margins, posterior $\frac{1}{2}$ whitish; terga III–V orange-brown with a narrow medial longitudinal fuscous band over all 3 terga, a narrow transverse dark fuscous to dull black band on anterior $\frac{1}{4}$ of tergum III and broad lateral longitudinal bands on terga III–V which are dark fuscous to dull black on terga III and IV and fuscous on tergum V. A pair of fuscous shining spots on tergum V.

Comments

D. rufofusculus, sp. nov., is placed in the *silvicola* complex. The other species in the complex are *D. absconditus, D. breviaculeus* and *D. silvicola*. It differs from *D. absconditus* in possessing a narrow medial abdominal stripe on terga III–V, lateral post-sutural vittae ending at or behind upper *p.sa.* bristles, and a mesopleural stripe of medium width (reaching midway between *npl.* callus and anterior *npl.* bristle above). It differs from *D. breviaculeus* in possessing a transverse dark band across anterior margin of tergum III and colourless costal cells. It differs from *D. silvicola* in possessing a broader mesopleural stripe and lateral post-sutural vittae ending at or behind upper *p.sa.* bristles.

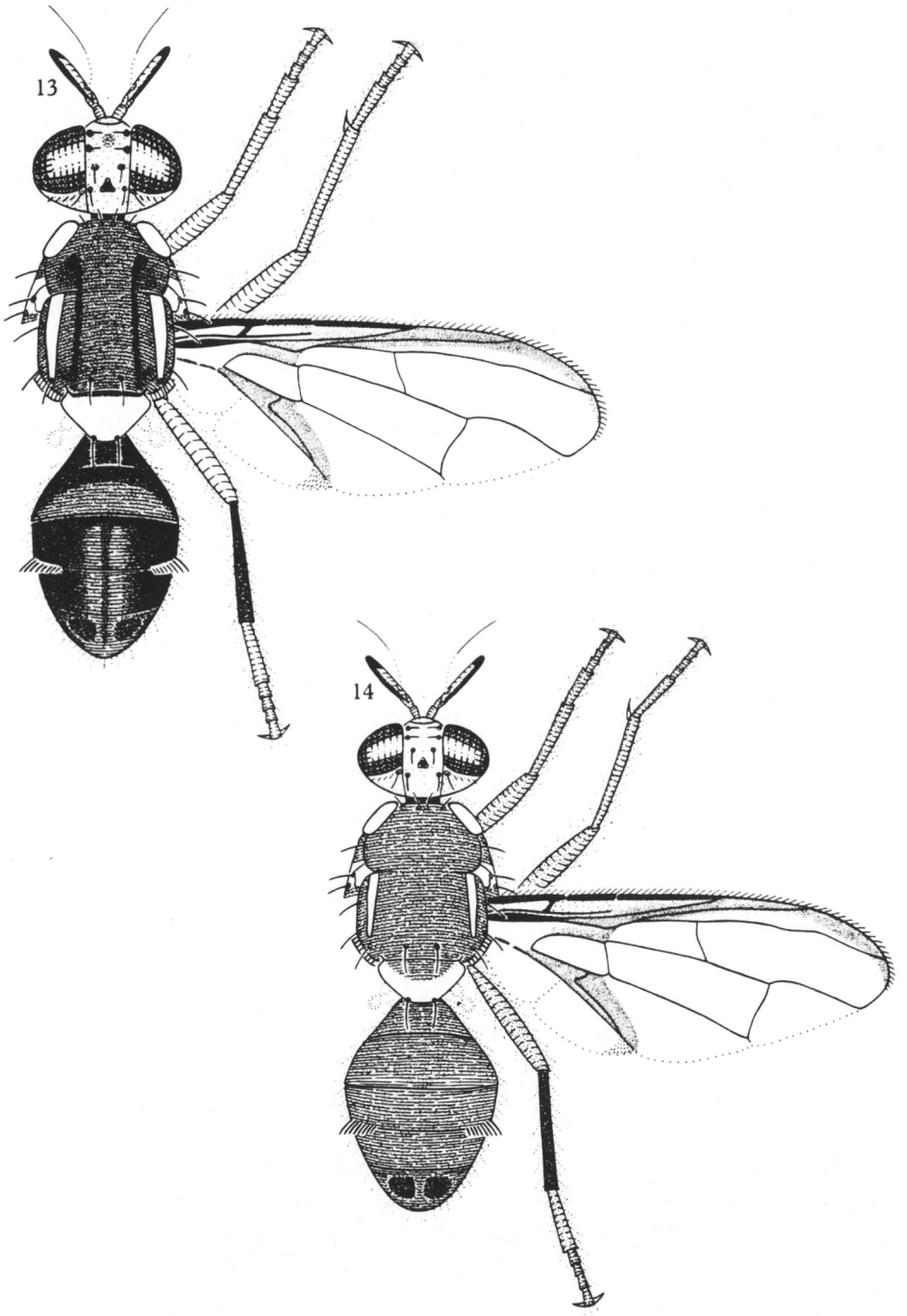


Fig. 13. *Dacus (Bactrocera) rufofusculus* Drew & Hancock, sp. nov.
Fig. 14. *Dacus (Bactrocera) russeolus* Drew & Hancock, sp. nov.

Dacus (Bactrocera) russeolus Drew & Hancock, sp. nov.

(Fig. 14)

Diagnosis

A medium-sized species, facial spots medium-sized and pointed anteriorly, mesonotum red-brown, lateral post-sutural vittae present, mesopleural stripes narrow (equal in width to notopleural callus), humeral and notopleural calli yellow, scutellum yellow with a broad red-brown basal band, wing with a pale fulvous tint and a narrow fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer portion of 2nd costal cell only, abdominal terga III–V red-brown with the shining spots on tergum V dark fuscous to black.

Type Specimens

Holotype ♂ (cue-lure), Paluma, near Mt Spec, Queensland, 8.ii.1975, R. A. I. Drew.

Paratypes: **Queensland:** 13 ♂ (cue-lure), 11 ♂ (Willison's lure), Paluma, near Mt Spec, 8.ii.1975; 2 ♂ (cue-lure), 4 ♂ (Willison's lure), The Crater, 25 km S. of Atherton, 6.ii.1975; 1 ♂ (cue-lure), Wallaman Falls area, W. of Ingham, 7.ii.1975; 1 ♂ (Willison's lure), Maiden Hair Fern Gully, Paluma–Bruce Highway Road, 8.ii.1975; all coll. R. A. I. Drew.

Holotype (reg. No. T.8303) and 5 paratypes (reg. Nos T.8304–T.8308) in Queensland Museum, Brisbane; 7 paratypes in Australian National Insect Collection, CSIRO, Canberra; 20 paratypes in Department of Primary Industries, Brisbane.

Description of Male

Wing length: holotype 6·7 mm, range for type series 5·4–6·7 mm, mean 6·3 mm.

Head. Generally fulvous. Vertical length: holotype 1·6 mm, range for type series 1·2–1·6 mm, mean 1·5 mm. Frons narrowing slightly posteriorly; length 1·6 times breadth; fulvous without fuscous markings; anteromedial hump distinct, covered with short pale setae; bristles red-brown; 1 *s.or.*, 2 *i.or.*; lunule fulvous. Ocellar triangle fuscous. Vertex red-brown. Face fulvous with a pair of medium-sized anteriorly pointed spots not reaching epistoma; width of spot (0·15 mm) less than width of 3rd antennal segment; length of face 0·5 mm. Genae fulvous; brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–7 well developed red-brown bristles each side. Antennae with 1st and 2nd segments fulvous; 3rd segment fulvous except fuscous on apex and outer surface; a fulvous bristle on dorsal surface of 2nd segment; arista black except fulvous proximally; length of segments: 0·15 mm; 0·32 mm; 0·83 mm.

Thorax. Mesonotum red-brown with or without fuscous markings – if present these markings represent sites of attachment of dorsoventral flight muscles. Pleural areas red-brown. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus above, continuing onto sternopleuron below as a narrow spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{3}{8}$ lower hypopleural calli

(remainder plus entire ventral margin, red-brown); 2 narrow lateral post-sutural vittae tapering posteriorly to end before upper *p.sa.* bristle. Postnotum red-brown. Scutellum yellow with a broad red-brown band reaching almost to centre. Bristles: *sc.* 2; *prsc.* 2; *p.sa.* 2; *a.sa.* 1; *mpl.* 1; *npl.* 2; *scp.* 4; all bristles well developed and red-brown. Legs: all segments red-brown except hind tibiae fuscous; fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical red-brown spur. Wings: costal cells fulvous; microtrichia in outer portion of 2nd costal cell only; remainder of wings with a pale fulvous tint and a fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around $CuA+1A$. Supernumerary lobe of medium development.

Abdomen. Oval; terga free; pecten present on tergum III. Tergum I red-brown; tergum II red-brown, fulvous posteriorly; terga III–V red-brown. Tergum V with a pair of dark fuscous to black shining spots.

Comments

D. russeolus, sp. nov., is placed in the *fagraea* complex and is similar to *Dacus (Bactrocera) fagraea* (Tryon), *D. (Bactrocera) halfordiae* (Tryon), *D. (Bactrocera) kraussi* Hardy and *D. (Bactrocera) rufescens* (May) in general body shape and colour. *D. russeolus* differs from *D. fagraea* in having a red-brown mesonotum (orange-brown in *fagraea*), an abdomen generally orange-brown with fuscous to black shining spots (pale orange-brown without dark shining spots in *fagraea*) and the basal band on the scutellum about half the width of the scutellum (about one-third the width of the scutellum in *fagraea*). It differs from *D. halfordiae* in possessing broader lateral post-sutural vittae and a narrower costal band, and in lacking dark coloration on the lateral margins of abdominal terga III–V; from *D. kraussi* in possessing a narrower costal band and in lacking dark fuscous to black on abdominal terga III–V; from *D. rufescens* in lacking broad dark fuscous lateral longitudinal bands on abdominal terga III–V.

Species Complexes

The Dacini are divided into two genera, *Callantra* and *Dacus*, and *Dacus* is divided into two groups of subgenera, viz. the *Dacus* group and the *Bactrocera* group [previously named the *Strumeta* group by Drew (1972*a*)]. The known Australian fruit fly fauna (78 species) consists of four species in *Callantra*, 13 species (seven subgenera) in the *Dacus* group and 61 species (five subgenera) in the *Bactrocera* group.

In the *Dacus* group of subgenera there are few known species and only one complex of closely related species. This is the *newmani* complex in subgenus *Dacus*, which consists of *D. bellulus*, sp. nov., *D. newmani* (Perkins) and *D. signatifrons* (May).

In the *Bactrocera* group of subgenera, species complexes are observable within the subgenera *Afrodacus, Hemizeugodacus* and *Bactrocera*. Within *Afrodacus, D. falvinotus* (May), *D. furvus* (May) and *D. tigrinus* (May) form a species complex. Other species currently placed in *Afrodacus* may, with the exception of *D. jarvisi* (Tryon), be aberrant forms of *Bactrocera* species. Within *Hemizuegodacus, D. aglaiae* Hardy and *D. aureus* (May) are closely related. Within the group of subgenera, however, most species (47) belong to subgenus *Bactrocera*, and it is species

complexes in this subgenus that need to be discussed and defined. In this paper, there has been no attempt to place the species in the key in 'phylogenetic' groups. However, a large number of similar species are more easily identified if placed in species complexes.

There are 31 species divided into nine species complexes in *Bactrocera*, viz. *alyxiae* complex, *bidentatus* complex, *dorsalis* complex, *fagraea* complex, *mayi* complex, *notatagena* complex, *quadratus* complex, *silvicola* complex and *tryoni* complex. In addition, there are 16 species which do not fit into species complexes. Species have been placed in these complexes on the basis of morphological similarity and attraction to the same male lures. Four complexes (*bidentatus* complex, *mayi* complex, *quadratus* complex and *silvicola* complex) are similar and most difficult to separate. They consist of species with a general red-brown colour on the thorax and abdomen, wings without infuscation other than a narrow costal band and anal streak, costal cells without microtrichia, and scutellum with a narrow red-brown basal band.

Definition of Species Complexes in Subgenus Bactrocera

alyxiae complex

Definition. *Bactrocera* species with costal band confluent with R_{4+5} and infuscation on wing in addition to costal band and anal streak, mesopleural stripe broad (attaining humeral callus dorsally), medial post-sutural vittae absent, males attracted to cue-lure.

Species. *Dacus alyxiae* (May); *D. recurrens* (Hering).

bidentatus complex

Definition. *Bactrocera* species with wing membrane lacking distinct fuscous patterns except for narrow costal band and anal streak, costal cells fulvous and without microtrichia, scutellum yellow with a narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V without dark colour patterns on lateral margins, males attracted to cue-lure.

Species. *Dacus aeroginosus*, sp. nov.; *D. bidentatus* (May).

dorsalis complex*

Definition. *Bactrocera* species with clear wing membrane except for narrow costal band and anal streak, costal cells colourless and without microtrichia, scutellum yellow with a narrow dark basal band, mesonotum black (or with a distinct black lanceolate pattern in *Dacus cacuminatus*), males attracted to methyl eugenol.

Species. *Dacus bancrofti* (Tryon); *D. cacuminatus* (Hering); *D. endiandrae* (Perkins & May); *D. musae* (Tryon).

fagraea complex

Definition. *Bactrocera* species with wing membrane lacking distinct fuscous patterns except for narrow costal band and anal streak, costal cells without micro-

* *Dacus dorsalis* does not occur in Australia but the name is used here because this is a well known complex of species.

trichia, scutellum yellow with a broad dark basal band ($\frac{1}{4}$–$\frac{1}{2}$ width of scutellum), males attracted to cue-lure.

Species. *Dacus fagraea* (Tryon); *D. halfordiae* (Tryon); *D. kraussi* Hardy; *D. rufescens* (May); *D. russeolus*, sp. nov.

mayi complex

Definition. *Bactrocera* species with clear wing membrane except for narrow costal band and anal streak, costal cells colourless and without microtrichia, scutellum yellow with a narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V without dark colour patterns on lateral margins, males attracted to methyl eugenol.

Species. *Dacus mayi* Hardy; *D. pallidus* (Perkins & May); *D. tenuifascia* (May).

notatagena complex

Definition. *Bactrocera* species with wing membrane lacking distinct fuscous patterns except for costal band and anal streak, costal cells covered with microtrichia, costal band broad (confluent with R_{4+5}), males attracted to methyl eugenol.

Species. *Dacus notatagena* (May); *D. romigae*, sp. nov.

quadratus complex

Definition. *Bactrocera* species with wing membrane lacking distinct fuscous patterns except for narrow costal band and anal streak, costal cells without microtrichia, scutellum yellow with a narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V with distinct but narrow dark colour patterns on lateral margins of some or all of these terga, males attracted to cue-lure.

Species. *Dacus antigone*, sp. nov.; *D. aurantiacus*, sp. nov.; *D. erubescentis*, sp. nov.; *D. peninsularis*, sp. nov.; *D. quadratus* (May).

silvicola complex

Definition. *Bactrocera* species with wing membrane lacking distinct fuscous patterns except for narrow costal band and anal streak, costal cells without microtrichia, scutellum yellow with a narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V with distinct broad lateral dark fuscous to black markings on all terga, males attracted to cue-lure.

Species. *Dacus absconditus*, sp. nov.; *D. breviaculeus* Hardy; *D. rufofusculus*, sp. nov.; *D. silvicola* (May).

tryoni complex

Definition. *Bactrocera* species with clear wing membrane except for narrow fuscous costal band and anal streak, costal cells covered with microtrichia, costal band narrow (not reaching R_{4+5} except at wing apex), males attracted to cue-lure.

Species. *Dacus aquilonis* (May); *D. melas* (Perkins & May); *D. neohumeralis* Hardy; *D. tryoni* (Froggatt).

Ungrouped Species

The following 16 species of *Bactrocera* cannot satisfactorily be placed in any of the preceding complexes: *Dacus allwoodi* Drew; *D. amplexiseta* (May); *D. barringtoniae* (Tryon); *D. bryoniae* (Tryon); *D. frauenfeldi* Schiner; *D. fuliginus*, sp. nov.; *D. hispidulus* (May); *D. humilis*, sp. nov.; *D. laticaudus* Hardy [= *fuscatus* (Perkins & May)]; *D. mendosus* (May); *D. mutabilis* (May); *D. perkinsi*, sp. nov.; *D. phaleriae* (May); *D. pulcher* (Tryon); *D. robiginosus* (May); *D. strigatus* (Perkins).

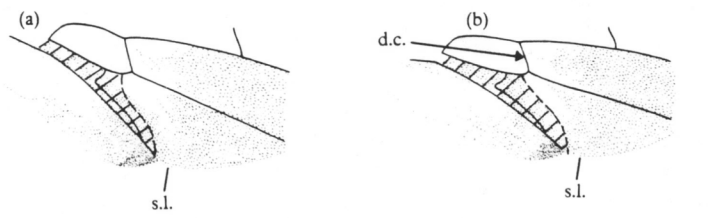


Fig. 15. Anal sections of wings showing differences in infuscation and microtrichia patterns. (*a*) *D. pallidus* (Perkins & May). (*b*) *D. tenuifascia* (May). Shading indicates microtrichia: coarse hatching, anal streak infuscation. *d.c.*, base of discoidal cell; *s.l.*, supernumerary lobe.

Key to Species of Fruit Flies Occurring in Australia

The following key is for species collected within Australia. *D. cucurbitae* (melon fly) and *D. dorsalis* (Oriental fruit fly) do not occur in Australia but are included in this key because of the economic importance of these species and because of their high risk of introduction to Australia from adjacent Pacific islands. When using this key, refer to Figs 15 and 16 for assistance in understanding the key characters.

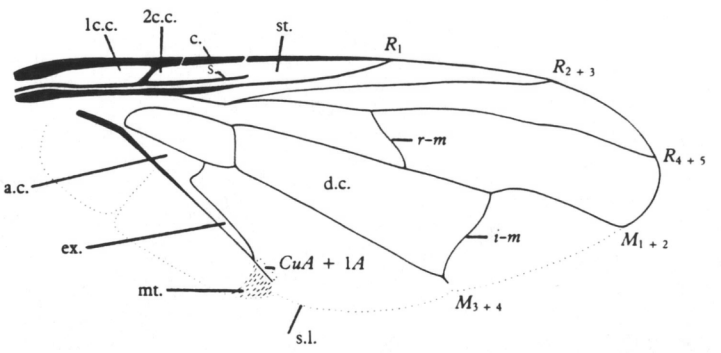


Fig. 16. Wing of fruit fly showing characters used in key to species. Abbreviations: *a.c.*, anal cell; *c.*, costa; 1 *c.c.*, first costal cell; 2 *c.c.*, second costal cell; *d.c.*, discoidal or discal cell; *ex.*, anal cell extension; *mt.*, microtrichia; *s*, subcosta; *s.l.*, supernumerary lobe; *st.*, stigma.

Species-level differences are primarily colour characters which always show some intraspecific variation and change with time in pinned dried specimens in collections. As a result closely related species will be difficult to key out.

When using couplets 13 and 43, note that even when microtrichia are confined to the apical portion of the second costal cell there is still a row of microtrichia along anterior margins of both cells.

1. Antennae elongate, 1st and 2nd segments approximately of equal length, the 2nd and 3rd segments combined generally about equal to vertical length of head, the combined lengths of all segments thus being greater than vertical length of head; abdomen elongate, strongly clavate and petiolate, segment I approximately parallel-sided or narrower at its posterior margin in dorsal view; abdomen strongly arched posteriorly and with the suture between terga III and IV strongly concave forwards in lateral view; abdomen with sterna I and II generally longer than wide (genus *Callantra* Walker).....2

Antennae comparatively short, 1st segment *c.* $\frac{1}{2}$ as long as 2nd segment, the combined lengths of all segments less than vertical length of head; abdomen elongate oval or oval, not strongly petiolate, segment I much wider across posterior margin than anterior margin in dorsal view; abdomen slightly arched centrally and with the suture between terga III and IV generally straight in lateral view; abdomen with sterna I and II wider than long (genus *Dacus* Fabricius).....5

2(1). Costal band extended well below vein R_{4+5} for its entire length.....3

Costal band confluent with vein R_{4+5} and crossing this vein only at apex of wing..... *Callantra pusilla* May

3(2). Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein ..... *Callantra aequalis* (Coquillett)

Costal band not attaining vein M_{1+2} for its entire length.....4

4(3). A row of spines present beneath fore femora; black spot on eye margin level with base of antenna; facial spot elongate; oviscape short..... *Callantra petioliforma* May

No spines beneath fore femora; no spot on eye margin level with base of antenna; facial spot pear-shaped or oval; oviscape elongate..... *Callantra smieroides* Walker

5(1). Costal band present.....6

Costal band absent..... *D. niger* Tryon (some specimens)

6(5). Costal band broken in middle, forming an isolated apical spot.....7

Costal band entire.....8

7(6). Notopleural callus brown; *r-m* crossvein infuscated..... *D. (Afrodacus) furvus* (May) (males)

Notopleural callus yellow; *r-m* crossvein not infuscated..... *D. (Afrodacus) tigrinus* (May) (males)

8(6). Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein... *D. absonifacies* (May)

Costal band not attaining vein M_{1+2}.....9

9(8). Costal band confluent with vein R_{4+5} for its entire length (in *D. visendus* and *D. calophylli* there is a small pale fuscous area distal to *r-m* crossvein), not or barely crossing this vein except at or beyond *r-m* crossvein.....10

Costal band narrow, not attaining vein R_{4+5} distal to *r-m* crossvein except on wing margin after crossing extremity of vein R_{2+3}.....20

10(9). Infuscation on wing in addition to costal band and anal streak.....11

No infuscation on wing other than costal band and anal streak.....15

11(10). Mesopleural stripe broad, attaining humeral callus dorsally.....12

Mesopleural stripe not attaining humeral callus dorsally.....14

12(11). Medial post-sutural vitta present; *a.sa.* bristles absent; *prsc.* bristles absent..... *D. (Polistomimetes) visendus* Hardy

Medial post-sutural vitta absent; *a.sa.* bristles present; *prsc.* bristles present (*alyxiae* complex).....13

13(12). Costal cells colourless; microtrichia in apical portion of second costal cell only; no medial dark stripe on abdomen..... *D. (Bactrocera) alyxiae* (May)

Costal cells coloured; microtrichia covering most of 2nd costal cell and apical portion of 1st cell; a medial black stripe present on abdomen..... *D. (Bactrocera) recurrens* (Hering)

14(11). Mesopleural stripe broad, extending to anterior *npl.* bristle dorsally; apical $\frac{1}{3}$ of wing fuscous; lateral post-sutural stripe broad, parallel-sided, ending behind upper *p.sa.* bristle..... *D. (Bactrocera) amplexiseta* (May)

Mesopleural stripe narrow, about as wide as notopleural callus; infuscation over central portion of wing only; lateral post-sutural stripe narrow and ending before upper *p.sa.* bristle..... *D. (Bactrocera) pulcher* (Tryon)

15(10). Mesonotum black; microtrichia in outer portion of 2nd costal cell only 16
Mesonotum red-brown, with or without a pattern of black markings; microtrichia covering most of both costal cells 17

16(15). No pecten of hairs on abdominal tergum III and with supernumerary lobe weak in male; facial spots linear and poorly defined; costal cells pale fulvous ..... *D. (Gymnodacus) calophylli* (Perkins & May)
Pecten of hairs present on abdominal tergum III and a definite supernumerary lobe on wing in male; facial spots distinct and oval in shape; costal cells fuscous ..... *D. (Bactrocera) bryoniae* (Tryon)

17(15). Medial yellow vitta present on mesonotum; lateral post-sutural vittae absent ..... *D. (Pacifodacus) salamander*, sp. nov.
No medial yellow vitta on mesonotum; lateral post-sutural vittae present 18

18(17). Four scutellar bristles; abdominal terga III–V red-brown except darker laterally and with a thin dark medial band ..... *D. (Paratridacus) expandens* Walker
Two scutellar bristles; abdominal terga III–V mostly fuscous (*notatagena* complex) 19

19(18). Mesonotum with a medial black pattern; humeral calli entirely yellow; legs with fore and middle femora and hind tibiae fuscous ..... *D. (Bactrocera) notatagena* (May)
Mesonotum without a medial black pattern; humeral calli with anterior $\frac{1}{3}$ fuscous; legs with all femora, fore and hind tibiae fuscous to dark fuscous ..... *D. (Bactrocera) romigae*, sp. nov.

20(9). Four scutellar bristles 21
Two scutellar bristles 29

21(20). Medial yellow vitta present on mesonotum 22
No medial yellow vitta on mesonotum 27

22(21). Infuscation on *i–m* crossvein; costal band widening at wing apex 23
No infuscation on *i–m* crossvein; no widening of costal band at wing apex 24

23(22). Costal band expanded into a distinct dark fuscous spot at apex of wing; usually with a broad dark fuscous band along *i–m* crossvein; mesonotum mostly red-brown ..... *D. (Zeugodacus) cucurbitae* Coquillett
Costal band only slightly widened at apex of wing; a narrow pale infuscation along *i–m* crossvein; mesonotum red-brown with a pattern of small fuscous markings ..... *D. (Zeugodacus) choristus* (May)

24(22). Prescutellar bristles present 25
Prescutellar bristles absent 26

25(24). *a.sa.* bristles absent; supernumerary lobe absent in wing ..... *D. (Hemizeugodacus) aglaiae* Hardy
a.sa. bristles present; supernumerary lobe very strong ..... *D. (Zeugodacus) fallacis* Drew

26(24). Medial yellow vitta on mesonotum long and narrow, with apex commencing level with posterior borders of humeral calli; facial spots large, tending oval; a medial black oval spot on abdominal tergum V; pecten present on tergum III of male abdomen; strong supernumerary lobe and dense aggregation of microtrichia at extremity of vein *CuA* + 1*A*, in male ..... *D. (Diplodacus) signatifer* Tryon
Medial yellow vitta on mesonotum broadening posteriorly and apex commencing level with mesonotal suture; facial spots small and circular; a medial black stripe present on abdominal tergum V which may extend forward on to tergum IV; no pecten on male abdomen; supernumerary lobe very weak and no microtrichia at extremity of vein *CuA* + 1*A*, in male ..... *D. (Austrodacus) cucumis* French

27(21). Small flies, entirely black on mesonotum; lateral post-sutural stripes absent .... *D. niger* Tryon
Medium to large flies, predominantly red-brown on mesonotum; lateral post-sutural stripes present 28

28(27). Scutellum yellow except for narrow, dark brown, basal band; no infuscation on wing other than costal band and anal streak; weak, brown, medial stripe on posterior $\frac{1}{3}$ of abdomen; *a.sa.* bristles present ..... *D. (Paratridacus) expandens* Walker
Scutellum yellow except for brown apical spot and narrow, dark brown, basal band; a band of infuscation on wing embracing *r–m* crossvein and outer portion of discal cell; broad, medial, fuscous band present over abdominal terga I–V; *a.sa.* bristles absent ..... *D. (Hemizeugodacus) aureus* (May)

29(20). Prescutellar bristles present 30
Prescutellar bristles absent 80

30(29). Post-sutural yellow vittae absent 31
Post-sutural yellow vittae present 32

31(30). Mesonotum black; without a yellow triangle along mesonotal suture ..... *D. (Bactrocera) allwoodi* Drew
Mesonotum red-brown; with a yellow triangle along mesonotal suture ..... *D. (Bactrocera) mendosus* (May)

32(30). A medial yellow vitta in addition to lateral post-sutural vittae on mesonotum 33
Only lateral post-sutural vittae on mesonotum 36

33(32). Costal band expanded into a distinct dark fuscous spot in apex of wing ..... *D. (Zeugodacus) cucurbitae* Coquillett
Costal band not expanded at apex 34

34(33). *r-m* crossvein infuscated; notopleural calli dark brown ..... *D. (Afrodacus) furvus* (May) (females)
No infuscation on *r-m* crossvein; notopleural calli yellow 35

35(34). Thorax entirely black (except for yellow calli and vittae); black transverse band or lateral black spots present on abdominal terga I and II.... *D. (Afrodacus) tigrinus* (May) (females)
Thorax red-brown with fuscous or black markings behind mesonotal suture; abdominal terga I and II entirely fulvous ..... *D. (Afrodacus) flavinotus* (May) (females)

36(32). Anterior supra-alar bristle present 37
Anterior supra-alar bristle absent 76

37(36). Infuscation on wing other than costal band and anal streak 38
Wings not infuscated except for costal band and anal streak 41

38(37). A transverse band across wing enclosing both the *r-m* and *i-m* crossveins 39
Only one of the crossveins infuscated 40

39(38). Humeral calli black; scutellum yellow with a black triangle; mesonotum black ..... *D. (Bactrocera) frauenfeldi* Schiner
Humeral calli yellow; scutellum entirely yellow; mesonotum red-brown ..... *D. (Bactrocera) strigatus* (Perkins)

40(38). *r-m* crossvein infuscated; distinct facial spots present; abdominal terga III and IV uniformly black, tergum V uniformly dark fuscous ..... *D. (Bactrocera) laticaudus* Hardy
i-m infuscated; facial spots absent; abdominal terga uniformly orange-brown ..... *D. (Bactrocera) hispidulus* (May)

41(37). Scutellum entirely brown or with dark markings at apex 42
Scutellum yellow on at least apical $\frac{1}{2}$ 43

42(41). Facial spots absent; scutellum uniformly pale brown; mesopleural stripe broad, almost reaching humeral callus dorsally ..... *D. (Bactrocera) phaleriae* (May)
Facial spots present; scutellum dark brown or black on apical $\frac{1}{3}$; mesopleural stripe narrow, about as wide as notopleural callus ..... *D. (Bactrocera) bancrofti* (Tryon)

43(41). Microtrichia covering most of second costal cell and a portion of first cell 44
Microtrichia confined to apical portion of second costal cell only 49

44(43). Facial spots absent; abdomen uniformly yellow-brown; lateral post-sutural stripe narrow, parallel-sided for part of its length and tapering to end just before the upper *p.sa.* bristle. ..... *D. (Bactrocera) mutabilis* (May)
Large oval facial spots present; abdomen fuscous or reddish-brown with fuscous markings; lateral post-sutural stripe broad, triangular and ending before upper *p.sa.* bristle or parallel-sided and reaching to *p.sa.* bristle (*tryoni* complex) 45

45(44). Humeral callus brown or dark brown ..... *D. (Bactrocera) neohumeralis* Hardy
Humeral callus yellow 46

46(45). Mesonotum and abdomen chiefly fuscous with a pattern of darker fuscous to black markings; apical $\frac{1}{2}$ of mid and hind femora fuscous ..... *D. (Bactrocera) melas* (Perkins & May)
Mesonotum and abdomen chiefly red-brown or fulvous, often with fuscous markings; all femora entirely fulvous 47

47(46). Mesonotum and abdomen red-brown with a pattern of fuscous markings 48
Mesonotum pale red-brown and abdomen fulvous, without fuscous markings ..... *D. (Bactrocera) aquilonis* (May)

48(47). Costal cells fuscous; abdominal terga III–V with broad lateral longitudinal fuscous to dark fuscous bands ..... *D. (Bactrocera) tryoni* (Froggatt)
Costal cells fulvous; abdominal terga III–V with broad lateral longitudinal fuscous to red-brown bands; a small species ..... *D. (Bactrocera) humilis*, sp. nov.

49(43). Mesonotum mostly black (*dorsalis* complex) 50
Mesonotum red-brown, with a distinctive black pattern consisting of a broad medial longitudinal band narrowing to a point anteriorly and with 2 similar but shorter lateral bands, all arising out of a broad black area on posterior region of mesonotum ..... *D. (Bactrocera) cacuminatus* (Hering)
Mesonotum orange-brown or red-brown, with or without a pattern of fuscous markings 54

50(49). Abdomen with a pronounced broad medial black vitta on terga III–V 51
Abdomen without a broad medial black vitta on terga III–V (occasionally a faint narrow fuscous line) 53

51(50). Lateral post-sutural stripe not broad, narrowing posteriorly and ending before upper *p.sa.* bristle 52
Lateral post-sutural stripe broad, parallel-sided and ending at or beyond upper *p.sa.* bristle ..... *D. (Bactrocera) dorsalis* Hendel

52(51). Mesopleural stripe broad, reaching almost to humeral callus ..... *D. (Bactrocera) fuliginus*, sp. nov.
Mesopleural stripe narrow, reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle ..... *D. (Bactrocera) endiandrae* (Perkins & May)

53(50). Abdomen uniformly orange-brown, especially on terga III–V; brown spot on apex of scutellum; costal band narrower than stigma beyond extremity of vein R_{2+3}; mesopleural stripe about as wide as notopleural callus and with anterior margin straight ..... *D. (Bactrocera) bancrofti* (Tryon)
Abdomen orange-brown or reddish brown except tending fuscous on anterior portion of tergum III; without brown spot on apex of scutellum; costal band at least as broad as stigma beyond extremity of vein R_{2+3}; mesopleural stripe slightly wider than notopleural callus and convex on anterior margin ..... *D. (Bactrocera) musae* (Tryon)

54(49). Scutellum with broad basal brown band, $\frac{1}{4}$–$\frac{1}{2}$ width of scutellum (*fagraea* complex) 55
Scutellum with narrow basal band 59

55(54). Abdomen with a well defined medial black vitta on terga III–V ..... *D. (Bactrocera) rufescens* (May)
Abdomen without a medial black vitta 56

56(55). Abdominal terga III and IV with lateral fuscous markings 57
Abdominal terga III and IV uniformly coloured, without fuscous markings 58

57(56). Mesonotum and abdomen uniformly red-brown; rarely with narrow longitudinal fuscous bands on mesonotum; fuscous areas on extreme lateral margins of abdominal terga III and IV only; mesopleural stripe not wider than notopleural callus; lateral post-sutural stripe not broad and narrowing posteriorly ..... *D. (Bactrocera) halfordiae* (Tryon)
Mesonotum red-brown with or without a pattern of fuscous markings; abdomen usually fuscous over most of terga III and IV and laterally on tergum V; mesopleural stripe $1\frac{1}{2}$ times width of notopleural callus; lateral post-sutural stripe parallel-sided for most of its length ..... *D. (Bactrocera) kraussi* Hardy

58(56). Abdominal tergum V with a pair of dark shining spots; mesonotum red-brown; basal band of scutellum *c.* $\frac{1}{2}$ width of scutellum ..... *D. (Bactrocera) russeolus*, sp. nov.
Abdominal tergum V without dark shining spots; mesonotum orange-brown; basal band of scutellum *c.* $\frac{1}{3}$ width of scutellum ..... *D. (Bactrocera) fagraea* (Tryon)

59(54). A well defined or indistinct medial dark vitta on abdomen, either as a band on terga III–V or as an elongated spot on one or two of these terga 61
No medial dark vitta on abdomen 60

60(59). Abdominal tergum III with red-brown to very pale fuscous areas on lateral margins ..... *D. (Bactrocera) peninsularis*, sp. nov. (some specimens)
Abdomen with broad lateral longitudinal dark fuscous bands on terga III–V ..... *D. (Bactrocera) barringtoniae* (Tryon)

61(59). Abdominal terga III–V with broad lateral longitudinal dark band (e.g. Fig. 3) (*silvicola* complex) 62
Abdominal terga III–V with narrow, pale lateral longitudinal dark bands (e.g. Figs 5–7) or without dark lateral margins (e.g. Fig. 4) 65

62(61). Costal cells colourless 63
Costal cells fulvous or lightly infuscated ..... *D. (Bactrocera) absconditus*, sp. nov.

63(62). Lateral post-sutural vittae ending before upper *p.sa.* bristles; abdominal terga III–V with a broad, well defined medial black stripe ..... *D. (Bactrocera) silvicola* (May)
Lateral post-sutural vittae ending at or behind upper *p.sa.* bristles; abdominal terga III–V with a narrow or indistinct medial fuscous stripe 64

64(63). Abdominal tergum V with a pair of fuscous shining spots; costal band of wing extends below R_{2+3} over its entire length; abdominal terga III–V with medial fuscous stripe connected to lateral fuscous bands along anterior margin of tergum III ..... *D. (Bactrocera) rufofusculus*, sp. nov.
Abdominal tergum V without dark shining spots; costal band of wing narrow, not extending below R_{2+3} except at wing apex; abdominal terga III–V with medial fuscous stripe indistinct and separate from lateral fuscous bands at anterior margin of tergum III ..... *D. (Bactrocera) breviaculeus* Hardy

65(61). Abdominal terga III–V with distinct, narrow lateral dark colour patterns on at least some terga 66
Abdominal terga III–V without distinct lateral dark colour patterns 71

66(65). Abdominal tergum V with a pair of fuscous to black shining spots ..... *D. (Bactrocera) perkinsi*, sp. nov.
Abdominal tergum V without dark shining spots (*quadratus* complex) 67

67(66). Abdominal terga III–V with more or less distinct medial fuscous stripe 68
Abdominal terga IV and V only with distinct medial fuscous stripe 70

68(67). Abdominal terga III–V with broad lateral fuscous patches; medial stripe well defined ..... *D. (Bactrocera) antigone*, sp. nov.
Abdominal tergum III with broad lateral fuscous patches, terga IV and V with patches narrow or absent; medial stripe not well defined 69

69(68). Lateral post-sutural vittae broad, parallel-sided; costal band of wing barely overlaps vein R_{2+3}; hind tibiae fulvous ..... *D. (Bactrocera) peninsularis*, sp. nov. (some specimens)
Lateral post-sutural vittae tapered posteriorly; costal band of wing almost reaches vein R_{4+5}; hind tibiae fuscous on basal $\frac{2}{3}$ ..... *D. (Bastrocera) erubescentis*, sp. nov.

70(67). Mesonotum orange-brown; abdominal terga III–V with a very narrow lateral fuscous margin; hind tibiae fulvous; femora fulvous ..... *D. (Bactrocera) aurantiacus*, sp. nov.
Mesonotum red-brown; abdominal tergum III with lateral fuscous patches, remaining terga dark fulvous; hind tibiae fuscous; femora fuscous at apex ..... *D. (Bactrocera) quadratus* (May)

71(65). Costal cells colourless; abdominal terga III–V with a distinct medial longitudinal fuscous band (*mayi* complex) 72
Costal cells pale fulvous; abdomen with distinct medial longitudinal fuscous band over terga IV and V only, a trace may be present on tergum III 74

72(71). Anal streak narrow, approximating width of anal cell (or much paler if extending towards base of discoidal cell), with microtrichia never extending over the entire coloured streak (Fig. 15*a*); mesonotum pale red-brown; abdomen pale orange-brown ..... *D. (Bactrocera) pallidus* (Perkins & May)
Anal streak broad, reaching almost to base of discoidal cell and covered with microtrichia for entire width (Fig. 15*b*); mesonotum and abdomen red-brown or dark red-brown 73

73(72). Lateral post-sutural stripe broad, almost parallel-sided for part of its length; mesonotum and abdomen red-brown; mesonotum seldom marked with fuscous and then only laterally before mesonotal suture and along inner margins of lateral post-sutural stripe ..... *D. (Bactrocera) tenuifascia* (May)
Lateral post-sutural stripe not broad, narrowing sharply posteriorly; mesonotum and abdomen dark red-brown; mesonotum usually with a pair of longitudinal parallel black bands centrally ..... *D. (Bactrocera) mayi* Hardy

74(71). Mesonotum with a pair of longitudinal parallel fuscous stripes; abdominal tergum V with a pair of fuscous to black shining spots ..... *D. (Bactrocera) robiginosus* (May)
Mesonotum uniformly reddish brown; abdominal tergum V without fuscous to black shining spots (*bidentatus* complex) 75

75(74). Lateral post-sutural vittae broad, parallel-sided, ending at upper *p.sa.* bristle; hind tibiae fulvous; costal band confluent with R_{2+3} ..... *D. (Bactrocera) aeroginosus*, sp. nov.
Lateral post-sutural vittae narrow, tapered sharply posteriorly and ending before upper *p.sa.* bristle; hind tibiae brown; costal band overlapping R_{2-3} ..... *D. (Bactrocera) bidentatus* (May)

76(35). *r-m* crossvein infuscated; mesopleural stripe L-shaped and reaching humeral callus dorsally ..... *D. (Afrodacus) brunneus* (Perkins & May)
No infuscation on *r-m* crossvein; mesopleural stripe not attaining humeral callus dorsally . 77

77(76). Humeral and notopleural calli joined by a broad yellow band... *D. (Afrodacus) jarvisi* (Tryon)
Humeral and notopleural calli not joined by a broad yellow band 78

78(77). Costal cells brown; microtrichia covering most of 2nd costal cell and a portion of 1st cell; facial spots absent ..... *D. (Bactrocera) mutabilis* (May) (some specimens)
Costal cells pale fulvous or colourless; microtrichia in outer portion of 2nd costal cell only; facial spots present 79

79(78). Mesonotum black; abdomen with a narrow fuscous band along anterior margin of tergum III and a fuscous to black medial longitudinal band on terga III-V ..... *D. (Afrodacus) mesoniger* (May)
Mesonotun red-brown with a pattern of black markings; abdomen with an elongate black spot on tergum V which extends onto tergum IV in some specimens ..... *D. (Afrodacus) aberrans* Hardy

80(29). Post-sutural yellow vittae on mesonotum present 81
Post-sutural yellow vittae on mesonotum absent (except an elliptical yellow spot in centre of mesonotum in *D. newmani*) 85

81(80). Medial post-sutural yellow marking on mesonotum absent 82
Medial post-sutural yellow marking on mesonotum present 83

82(81). Abdomen fulvous with a transverse dark fuscous to dull black band across base of tergum III, narrow fuscous markings on lateral margins of terga III-V, a broad medial longitudinal black band on terga III-V ..... *D. (Polistomimetes) murrayi* (Perkins)
Abdomen red-brown with a transverse dull black band across base of tergum III, dark lateral markings on terga IV and V usually absent, a narrow medial longitudinal dark band on terga III-V which is interrupted at the intersegmental lines and very pale on tergum III.... *D. (Polistomimetes) decurtans* (May)

83(81). Lateral post-sutural vittae present 84
Lateral post-sutural vittae absent; medial vitta very broad ..... *D. (Didacus) hardyi* Drew

84(83). Humeral and notopleural calli connected by a yellow band; infuscation on *i-m* crossvein ..... *D. (Pacifodacus) strigifinis* Walker
Humeral and notopleural calli not connected by a yellow band; no infuscation on *i-m* crossvein ..... *D. (Diplodacus) signatifer* Tryon (some specimens)

85(80). *r-m* crossvein infuscated; broad mesopleural stripe attaining humeral callus dorsally; abdomen fulvous with fuscous markings on first 4 terga ..... *D. exiguus* (May)
r-m crossvein not infuscated; mesopleural stripe not attaining humeral callus dorsally; abdomen uniformly coloured on first 4 terga 86

86(85). Elongate facial spots present; mesopleural stripe broad and attaining anterior notopleural bristle dorsally; mesonotum uniformly red-brown or dark brown 87
No facial spots; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle; mesonotum rich chocolate brown with a central elliptical yellow spot posterior to mesonotal suture ..... *D. (Dacus) newmani* (Perkins)

87(86). Facial spots small, narrow (occasionally absent); hind tibiae fulvous; costal band not overlapping vein R_{2-3} ..... *D. (Dacus) bellulus*, sp. nov.
Facial spots distinct and elongate; hind tibiae fuscous; costal band overlapping vein R_{2+3} ..... *D. (Dacus) signatifrons* (May)

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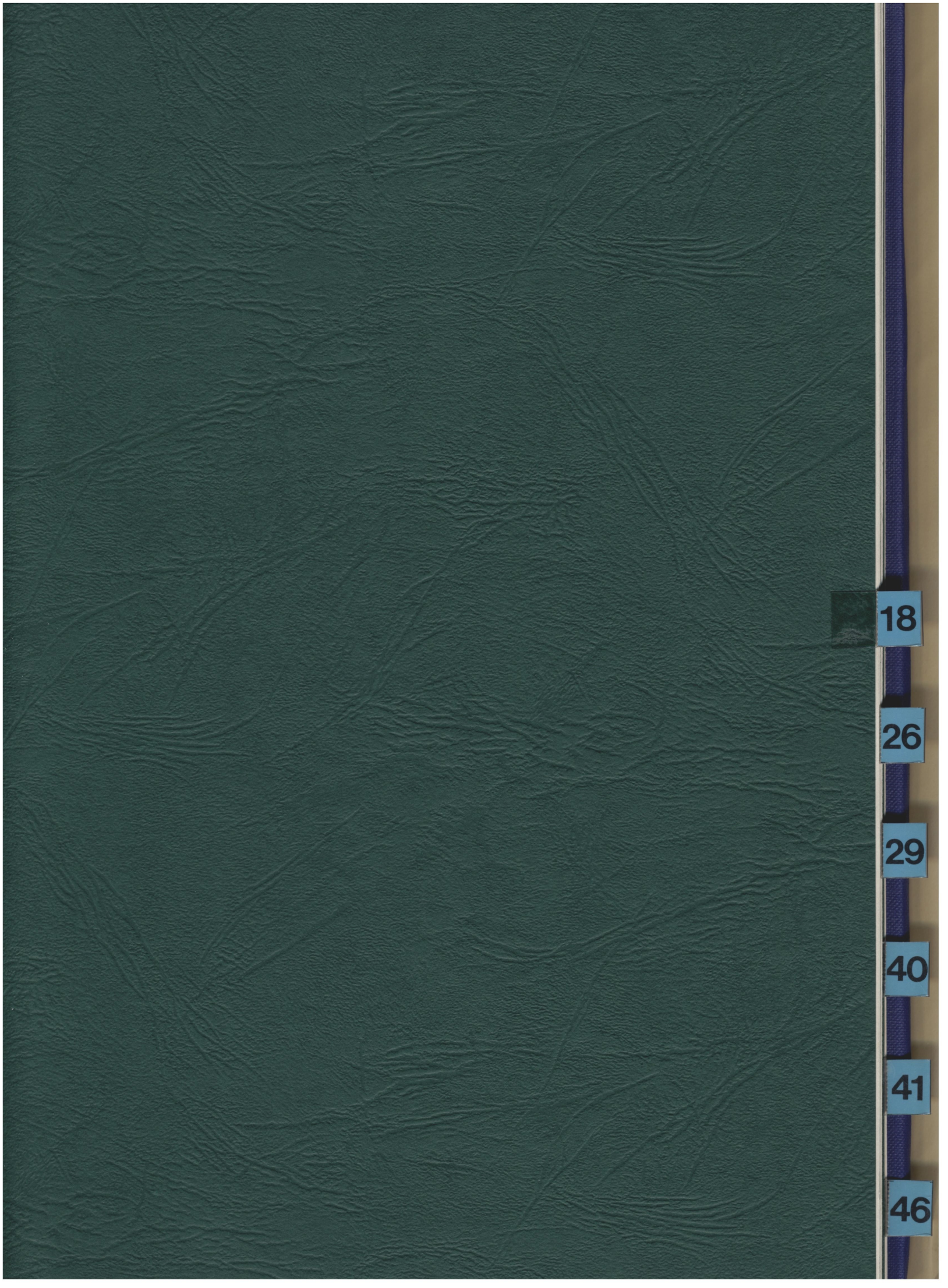
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DACUS (BACTROCERA) OPILIAE, A NEW SIBLING SPECIES OF THE DORSALIS COMPLEX OF FRUIT FLIES FROM NORTHERN AUSTRALIA (DIPTERA: TEPHRITIDAE)

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Abstract

A new species within the dorsalis complex, *Dacus (Bactrocera) opiliae*, is described. It is based on cytological, electrophoretic and minor morphological characters, supported by data on geographic distribution, ecology, pheromones and male stridulation.

Introduction

The dorsalis complex comprises *Dacus cognatus* Hardy and Adachi, *D. dorsalis* Hendel, *D. dorsaloides* Hardy and Adachi, *D. muiri* Hardy and Adachi, *D. occipitalis* (Bezzi), *D. pedestris* (Bezzi) and *D. propinquus* Hardy and Adachi from the Oriental Region; *D. abdolonginquus* Drew, *D. indecorus* Drew, *D. nigrescens* Drew, *D. trivialis* Drew and *D. vulgaris* Drew from Papua New Guinea; *D. bancroftii* (Tryon), *D. cacuminatus* (Hering), *D. endiandrae* (Perkins and May) and *D. musae* (Tryon) from Australia. It is difficult to separate these species on morphological characters and in some cases impossible unless the characters of the ovipositor can be compared.

Additional undescribed species occur in Papua New Guinea and Indonesia but a major study is needed to unravel status and relationships within the complex.

D. dorsalis (Oriental fruit fly) is one of the most destructive fruit flies of the world and, when flies indistinguishable from it were collected in methyl eugenol traps on Melville Island, Northern Territory, in August 1975, it was cause for alarm. Intensive field surveys showed that the fly was distributed over *ca* 358,000 km^2 of the northern half of the Northern Territory and the northern corner of Western Australia. Subsequent checks of collections in museums revealed that this species was apparently first collected at Humpty Doo, 80 km SE of Darwin, in December 1969 but had been misidentified as *D. endiandrae*. Fourteen specimens were also found which had been bred from mango collected by A. Allwood on 3 occasions during November and December 1969 at Nightcliff, a suburb of Darwin.

The north Australian population was initially identified as *D. dorsalis* (see Drew 1976, Anon. 1976) but, after ecological, physiological and genetic studies (M. A. Bateman, G. P. Fitt and A. Ohta pers. comm.) had demonstrated substantial differences from that species, more critical morphological studies revealed differentiating characters. There seem to be no structural differences between the 2 species which can be seen under the light microscope and the colour differences which we use to separate them show some variation and overlap over a large series and between specimens of varying tenerality. Since colour differences alone would not normally be considered definitive characters, taxonomists could not separate these taxa clearly before ecological and genetic data were available. However, in the case of closely related (sibling) species, colour differences may be the only differentiating features and, in practice, are usually reliable for fully hardened (sexually mature) adults.

Dacus (Bactrocera) opiliae sp. n. (Figs 1, 3, 5, 7, 9, 11-15)

Types.—NORTHERN TERRITORY: *holotype* ♀, 19 *paratype* ♀♀, iv.1979, coll. G. Fitt, ex laboratory culture, CSIRO, Darwin; 19 *paratype* ♂♂ (methyl eugenol), i.1976, coll. A. Allwood, Melville Island; 9 *paratype* ♂♂ (methyl eugenol), 2.ii.1976, coll. A. Allwood, Darwin; 5 *paratype* ♂♂ (methyl eugenol), ii.1976, coll. A. Allwood, Pine Creek, Stuart Highway; 6 *paratype* ♂♂ (methyl eugenol), 13.x.1976, coll. A. Smith, Gunn Pt; 1 *paratype* ♀, bred ex *Opilia amentacea* Roxb. (Opiliaceae), xi.1976, coll. T. Angeles, Melville Island; 1 *paratype* ♂, bred ex *O. amentacea*, xi.1976, coll. A. Smith, Melville Island; 1♀ and 1♂ *paratype*, bred ex *O. amentacea*, xi.1976, coll. A. Smith, Scotch Creek; 1 *paratype* ♀, 13.xii.1976, coll. A. Smith, Melville Island; 1 paratype ♀, bred ex *O. amentacea*, 20.xii.1976, coll. A. Smith, Melville Island. WESTERN AUSTRALIA: 1 *paratype* ♂ (methyl eugenol), 7.i.1977, Kimberley Research Station; 1 *paratype* ♂, 17.i.1977, coll. M. Whiting, Kununurra.

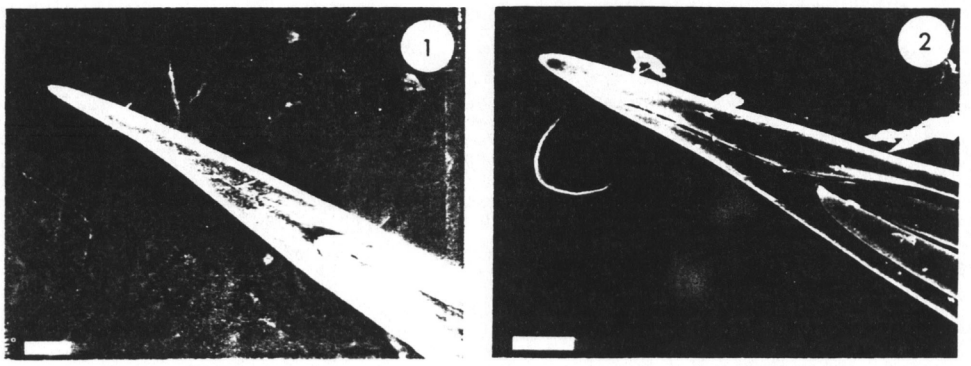
Holotype (Reg. No. T.8427) and 5 paratypes (Reg. Nos T.8428-8432) in Queensland Museum, Bris-

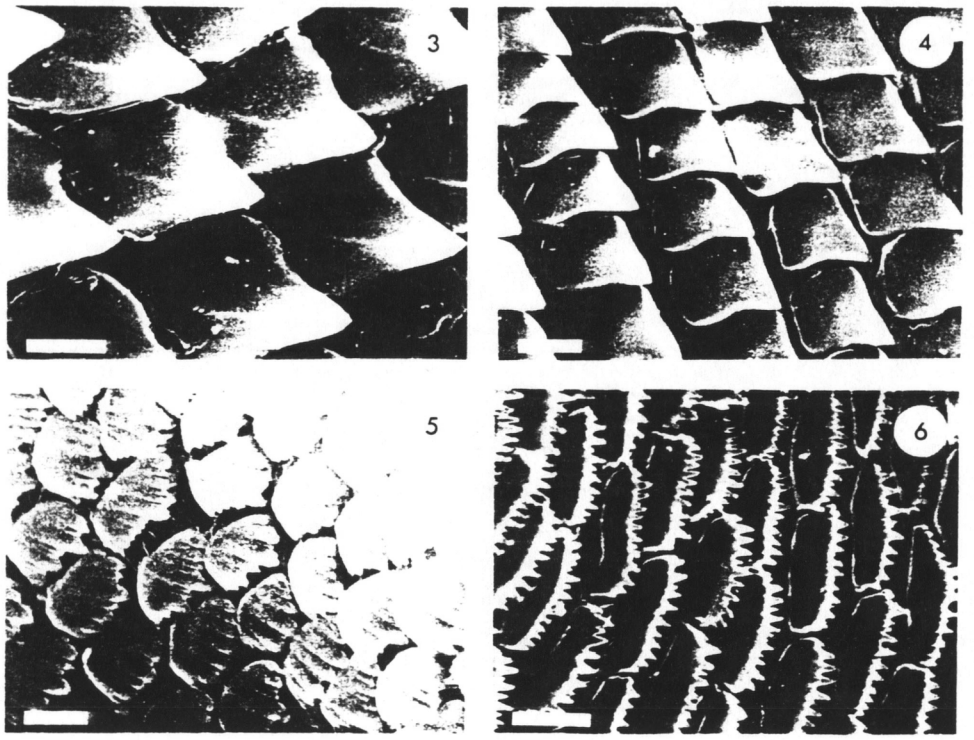
bane; 10 paratypes in Australian National Insect Collection, CSIRO, Canberra; 15 paratypes in Department of Entomology, University of Hawaii, Honolulu; 36 paratypes in Department of Primary Industries, Brisbane.

Morphology

D. opiliae sharing general morphological characteristics of *D. dorsalis* (see Hardy 1969, Drew 1978) but differentiated by having thorax less extensively marked with black; black marking on mesonotum typically extending anteriorly as a median vitta between inner scapular bristles; anterior areas between outer scapulars red brown tinged with fuscous; area surrounding each humeral callus red brown; red brown between humeral and notopleural calli and along inner margin of each lateral postsutural yellow vitta; (mesonotum entirely black in about 20% of specimens); pleural areas red brown with fuscous to black confined to sternopleuron and mesopleuron, a small amount of fuscous ventrally in front of mesopleural stripe; abdominal sterna red brown.

D. dorsalis typically with mesonotum entirely black with a red brown perimeter; sternopleuron black

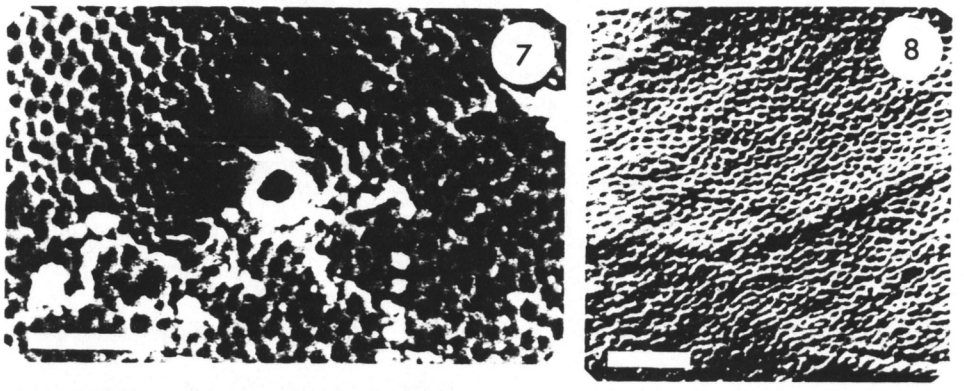


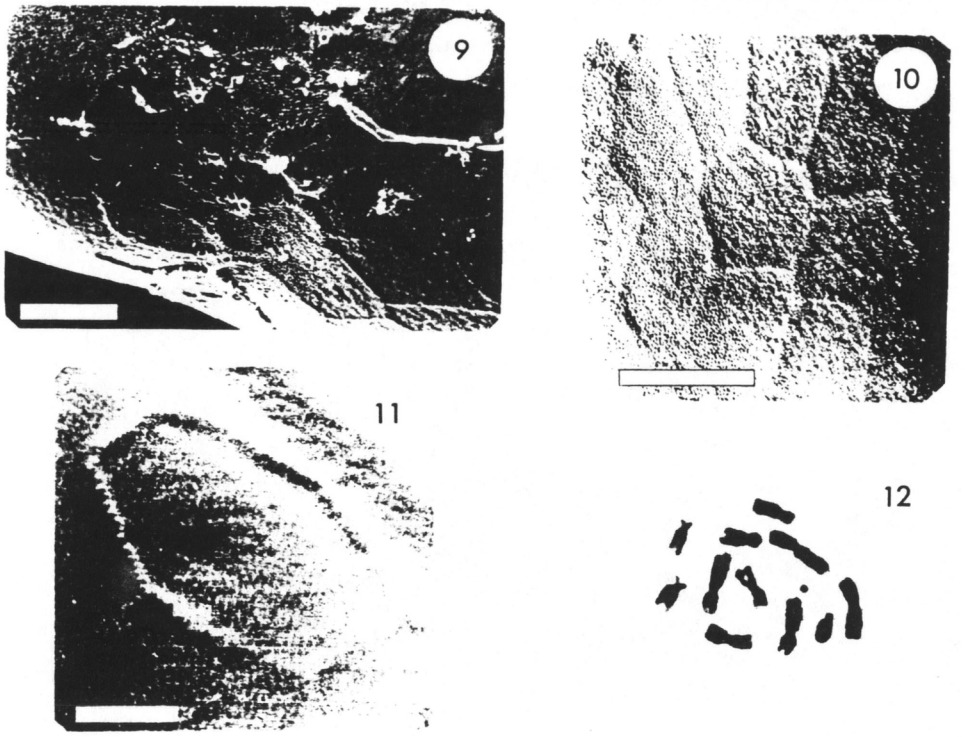


FIGS **1-6**—*Dacus* spp.: **(1-2)** apex of piercer of ovipositor: **(1)** *D. opiliae* sp. n.; **(2)** *D. dorsalis* Hendel (scale 0.05 mm); **(3-4)** spicules on proximal end of middle segment of ovipositor: **(3)** *D. opiliae* sp. n.; **(4)** *D. dorsalis* Hendel (scale 0.01 mm); **(5-6)** spicules on distal end of middle segment of ovipositor: **(5)** *D. opiliae* sp. n.; **(6)** *D. dorsalis* Hendel (scale 0.005 mm).

(except for yellow spot at ventral end of mesopleural stripe); black anterior to mesopleural stripe continuous with black marking on mesonotum; pleurotergite and hypopleura predominantly black; abdominal sterna fuscous to black.

Ovipositor (ovipositors and eggs of *D. opiliae* and *D. dorsalis* were dehydrated in ethyl alcohol and processed in critical point dryer before study under scanning electron microscope).—Gross details of the ovipositor are visible with a compound microscope, but the scanning electron microscope revealing good diagnostic characters. Apex of piercer of *D. opiliae* much more slender and more gradually attenuated than in *D. dorsalis*, apical portion measured from gonopore to apex being about 12.5 times longer than wide (Fig. 1) (width as measured at preapical sensory setae); in *D. dorsalis* apical portion thicker by comparison, about 7 times longer than wide (Fig. 2); all Dacinae possessing scales or spicules on middle segment of ovipositor (abdominal segment VIII) serving to strengthen (or support) segment wall while still allowing segment to telescope when ovipositor is extended or retracted, these spicules differing strikingly in the 2 species: pointed apically and smooth-sided (Figs 3-4) at proximal end of spiculated area on segment VIII in





FIGS 7-12—*Dacus* spp.: **(7-8)** pore pattern on egg surface: **(7)** *D. opiliae* sp. n.; **(8)** *D. dorsalis* Hendel (scale 0.005 mm); **(9-10)** ridges on egg surface: **(9)** *D. opiliae* sp. n.; **(10)** *D. dorsalis* Hendel (scale 0.02 mm); **(11)** ridges on egg surface of *D. opiliae* sp. n. showing beaded pattern (scale 0.01 mm); **(12)** metaphase chromosomes from larva produced by holotype ♀ of *D. opiliae* sp. n.

both species; about 1.2 times as wide as long with 6 to 11 dentations of varying size along apical margin (Fig. 5) at distal end of spiculated area in *D. opiliae*, but about 2.2 times as wide as long with 11-16 fine dentations along apical margin (Fig. 6) at distal end in *D. dorsalis*.

Eggs.—Scanning electron microscopy revealing only minor differences. Basic pattern of fine pores on chorion surface similar in both species (Figs 7-8). Pattern of ridges on chorion surface (presumably resulting from imprint of cells in ovariole wall) varying within each species and thus not a good comparative character, but ridges in *D. opiliae* are lower than in *D. dorsalis* and absent on some areas on each egg studied (Figs 9-10). Ridges in *D. opiliae* also possessing a slightly beaded pattern (Fig. 11) and in *D. dorsalis* containing the fine pores that are visible on chorion surface (Fig. 8).

Genetics

Metaphase chromosome preparations were made from larvae produced by the holotype ♀ and 19 paratype ♀♀ ex laboratory culture, CSIRO, Darwin, by G. P. Fitt. Fig. 12 shows the metaphase plate from a larva produced by the holotype. Studies at the Queensland Department of Primary Industries, Brisbane, showed distinct cytological differences in the metaphase plates between the 2 species. The X chromosome in males of *D. opiliae* is acrocentric but metacentric in *D. dorsalis*.

Starch gel electrophoresis showed similarity coefficients between the 2 species ranging from 0.78 to 0.801 based on 19 loci from 15 enzymes. In the starch gel electrophoresis only 19 loci produced results suitable for analysis; the other loci were unreadable. A system of isoelectric focusing was therefore introduced; this showed fixed differences between the 2 species in the enzymes aldehyde oxidase (aldox) and hydroxybutyrate dehydrogenase (Figs 13-14).

Ecology

Data gained from intensive field and laboratory studies since 1975 provide ample evidence to support the conclusion that the north Australian population is a species distinct from *D. dorsalis*. It is confined to the northern half of the Northern Territory and the northern corner of Western Australia (Fig. 15), the native fruit *O. amentacea* apparently being its sole field host. Although it was initially bred from mango in 1969 no further record has been obtained from fruits of potential economic importance (Allwood and Angeles 1979). A single record from *Terminalia ferdinandiana* Exell. (Combretaceae) in 1978 could not be substantiated in 1979 despite collection of 11,978 fruits from 15 different sites (G. P. Fitt pers. comm.). Only *Dacus aquilonis* (May) and *Dacus jarvisi* (Tryon) have been found infesting cultivated fruits such as mango and guava in the Darwin area. These fruits are favourite hosts of the generalist *D. dorsalis* throughout its range.

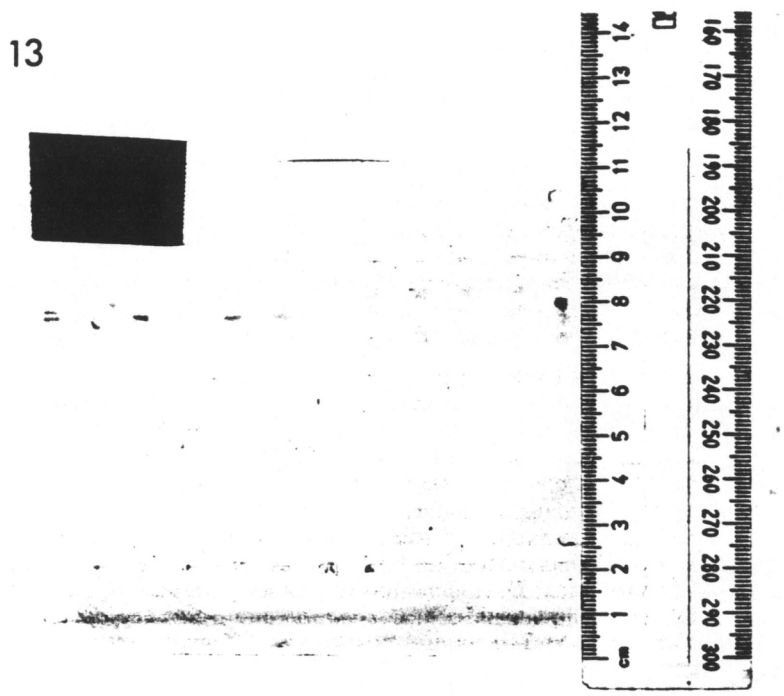
Studies by G. P. Fitt (pers. comm.) revealed that *D. opiliae* shows marked seasonal fluctuations in numbers correlated with changes in moisture availability. During the dry season (June-July) numbers caught in traps typically decline to 0 or very low levels and increase with the coming of the rains in September-October. The peak population occurs in November followed by a decline and then another peak in mid-January. Pupae of *D. opiliae* are physiologically more susceptible to drying out of the soil during dry seasons than are those of *D. jarvisi* and *D. tenuifascia* (May). This effectively limits the species to wet season production.

Pheromone studies

Chemical analyses of the pheromones were made by Dr T. Bellas (CSIRO, Canberra). Ether extracts of the pheromone glands of specimens of *D. opiliae* and *D. dorsalis* (the latter from Hawaii) were analysed using gas chromatography. Comparing the presence or absence of components suggested that the 2 are different species, but further investigations are required to interpret correctly the meaning of the presence and relative amounts of the various chemical components in the pheromones of *Dacus* F. (T. Bellas pers. comm.).

Male stridulation

A sonographic analysis of male stridulation in *D. opiliae* and *D. dorsalis* (the latter from Hawaii) was made by Dr D. L. Chambers (U.S. Department of Agriculture,



FIGS **13-14**—Isoelectric focusing gels: **(13)** aldox, from left to right, positions 1-6 *D. opiliae* sp. n., positions 7-12 *D. dorsalis* Hendel; **(14)** hydroxybutyrate dehydrogenase, positions 1-6 *D. opiliae* sp. n., positions 7-12 *D. dorsalis* Hendel.

Gainesville). The pulse-train duration and interval were longer in *D. opiliae*, but a similar comparison between 2 strains of *Dacus cucurbitae* Coquillett revealed differences of similar magnitude in the same parameters. Further studies are needed to determine the significance of such differences in defining species (D. L. Chambers pers. comm.).

Comments

Morphological differences shown in scanning electron micrographs of the ovipositors and eggs, the major chromosome difference in the metaphase plates and the fixed differences in isoelectric focusing gels of aldox and hydroxybutyrate dehydrogenase indicate that *D. opiliae* is a good species distinct from *D. dorsalis*. The ecology, pheromone and male stridulation studies support this.

Other species in the dorsalis complex can be separated from *D. opiliae* as follows: *D. bancroftii* and *D. musae* have an orange brown abdomen without dark patterns; *D. cacuminatus* has a lanceolate black pattern on the mesonotum, broad lateral longitudinal dark bands on abdominal terga III to V and the costal band not overlapping R_{2+3}; *D. endiandrae* has lateral postsutural vittae narrowing and ending before the upper *p.sa.* bristles; *D. indecorus* and *D. nigrescens* lack *prsc.* bristles; *D. abdolonginquus* has an elongate-oval abdomen with lateral longitudinal dark bands on terga III to V; *D. trivialis* has most of tergum III and broad lateral margins of terga IV and V dark fuscous to black; *D. vulgaris* has lateral longitudinal dark bands on terga III to V and colour in the first costal cell; *D. cognatus* and *D. dorsaloides* have the costal band confluent with R_{2+3} and the lateral postsutural vittae tapering to end before the upper *p.sa.* bristle; *D. muiri* has a characteristic broad ovipositor which is abruptly tapered at the apex of the piercer; *D. propinquus* has a trilobed apex on the piercer; *D. occipitalis* has a broader costal band, overlapping R_{2+3} and almost confluent with R_{4+5} (this character was observed on the lectotype ♂ of *D. occipitalis*); *D. pedestris* has all tibiae and the apices of all femora dark fuscous to black (as observed in the type series).

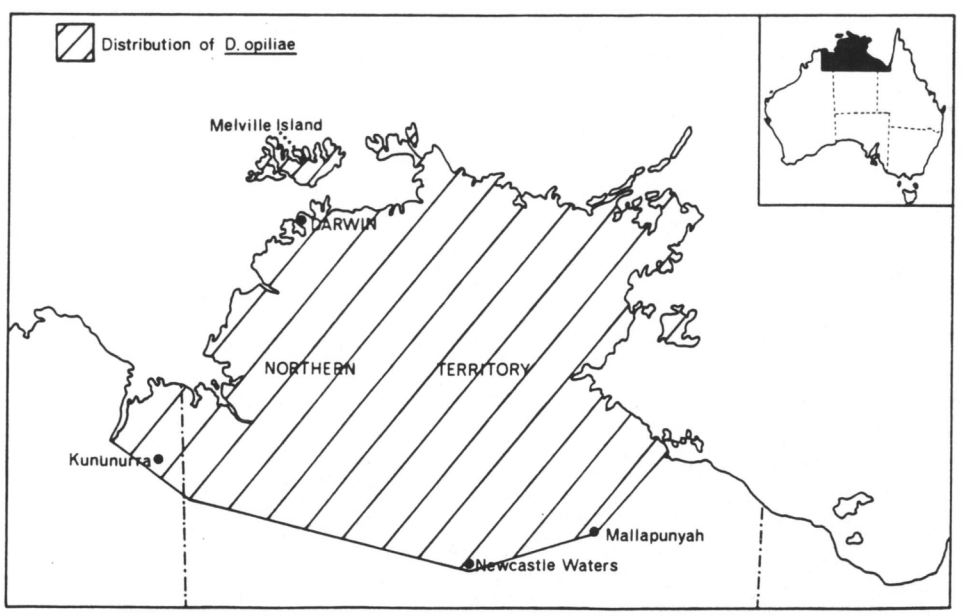


FIG. 15—Map showing distribution of *D. opiliae* sp. n. in northern Australia.

Acknowledgments

Miss J. Grimshaw (Queensland Department of Primary Industries) and Mr J. Hardy (University of Queensland) assisted in preparing scanning electron micrographs. Mr G. Fitt (CSIRO) provided metaphase

plate chromosome preparations. Type specimens of *D. occipitalis* and *D. pedestris* were loaned by Museo Civico di Storia Naturale, Milan. Frozen specimens of *D. dorsalis* for electrophoresis and eggs of that species for scanning electron microscopy were received from the U.S.D.A. Fruit Fly Laboratory, Honolulu. Funds were provided by the Australian Department of Health (Plant Quarantine). We thank them all.

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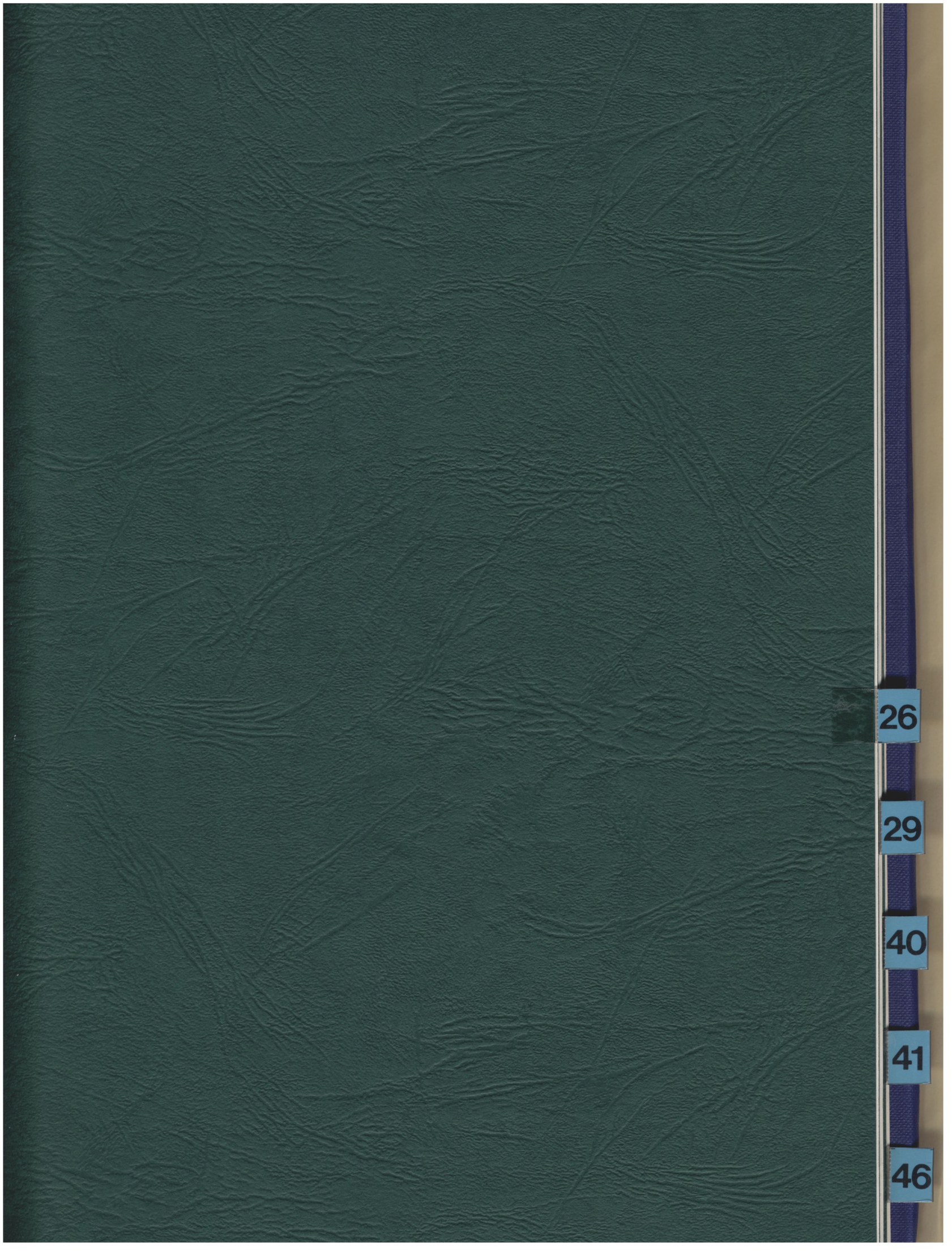
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Systematic Entomology (1985) **10**, 129–134

A new family of Strepsiptera parasitizing fruit flies (Tephritidae) in Australia

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ABSTRACT. A new family of Strepsiptera (Dipterophagidae) from Australia containing a new genus and species (*Dipterophagus daci*) is described and figured. This is the first species of Strepsiptera to be described as a parasite of Diptera. *D.daci* is recorded from ten fruit fly species, viz *Dacus aquilonis* (May), *D.bellulus* Drew, *D.cacuminatus* (Hering), *D.decurtans* (May), *D.mayi* Hardy, *D.neohumeralis* Hardy, *D.peninsularis* Drew, *D.tenuifascia* (May), *D.tryoni* (Froggatt) and *Dacus* sp.n. (near *musae*). Gregarious parasitism (two to six adult parasites per fly) is common.

Introduction

Although more than ninety species of Strepsiptera are known to occur in Australia, only nine have been described (Riek, 1970). About 300 species have been described from all parts of the world and they are most frequently found parasitizing Hymenoptera and Hemiptera (Bohart, 1941). No species has previously been recorded as a parasite of Diptera except for one undescribed species on platystomatid flies in Papua New Guinea (Riek, 1970).

Kinzelbach (1971, 1978) divided the Order Strepsiptera into nine families, based on a thorough morphological study of the group. His classification is used in this paper.

Materials and Methods

Large numbers of male fruit fly specimens were collected throughout northern and north-eastern Australia using synthetic male lures (cue lure and methyl eugenol) and some female flies in protein hydrolysate traps. The flies were preserved dry, identified and examined for presence of strepsipteran parasites. Some fly specimens were collected live and, when parasitized, frozen in liquid nitrogen.

Female parasites and triungulinid larvae were dissected from the frozen flies. As some of the taxonomic characters of the female are lost after preservation in alcohol, the adult females and the triungulinid larvae were observed and illustrated before preservation in 80% alcohol.

When mature male parasites were present in their pupal cases, within the abdomens of the dry flies, they were dissected, softened in 5% potassium hydroxide, washed in water and preserved in a solution of 9 parts 80% alcohol and 1 part glycerol.

Results

The preservation of live parasitized flies in liquid nitrogen proved to be excellent for

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subsequent taxonomic study of the female parasites as all characters could be observed before preservation in alcohol. Another advantage was that the first stage triungulinid larvae were able to be dissected from the frozen female parasites.

The mature male parasites dissected from the dry host specimens were in excellent condition and were as good as field collected male Strepsiptera of other species that we have observed. Because adult male Strepsiptera do not feed and usually live only for a few hours (Kirkpatrick, 1937; Lea, 1910), the field collected males are no more developed than are mature males dissected from pupal cases in the host. This dissection technique allowed the valuable host records to be obtained.

Taxonomy

DIPTEROPHAGIDAE, **fam.nov.**

Male with six segmented antennae; all tarsi with three segments, terminal tarsi triangular and without terminal claws; strong cone-shaped mandibles which do not overlap in centre of face; maxillary palp equal in length to base; subalare not present. Females endoparasitic; no complex eye present; head less than half length of cephalothorax, cephalothorax bell-shaped with dorsal surface sclerotized; one pair of functional metathoracic spiracles present; brood passage opening broad and sub-apical; abdomen with three genital openings on segments III–V; first larvae with all tarsi setiform.

DIPTEROPHAGUS **gen.nov.**

Male with third antennal segment laterally flabellate; mandibles conical in shape with apex slightly curved; maxillary palps short and stout; wing with two detached veins between radius and media, radius unbroken, MA and CuA of equal length, CuP shorter; tarsal segments of approximately equal size and shape; aedeagus narrowing to a point with a subapical recurved spine. Female with three genital tubes; cephalothorax with one pair of functional spiracles; thoracic segments not well defined, width of cephalothorax at base of mandibles approximately one-third the width at spiracles, width at base of head slightly greater than width at spiracles. Last abdominal segment of first stage larva with a pair of medial stylets and a pair of lateral cerci of approximately equal length, abdominal terga VII–IX of larva with single postero-lateral bristles each side.

DIPTEROPHAGUS DACI **sp.nov.**

(Figs. 1–10)

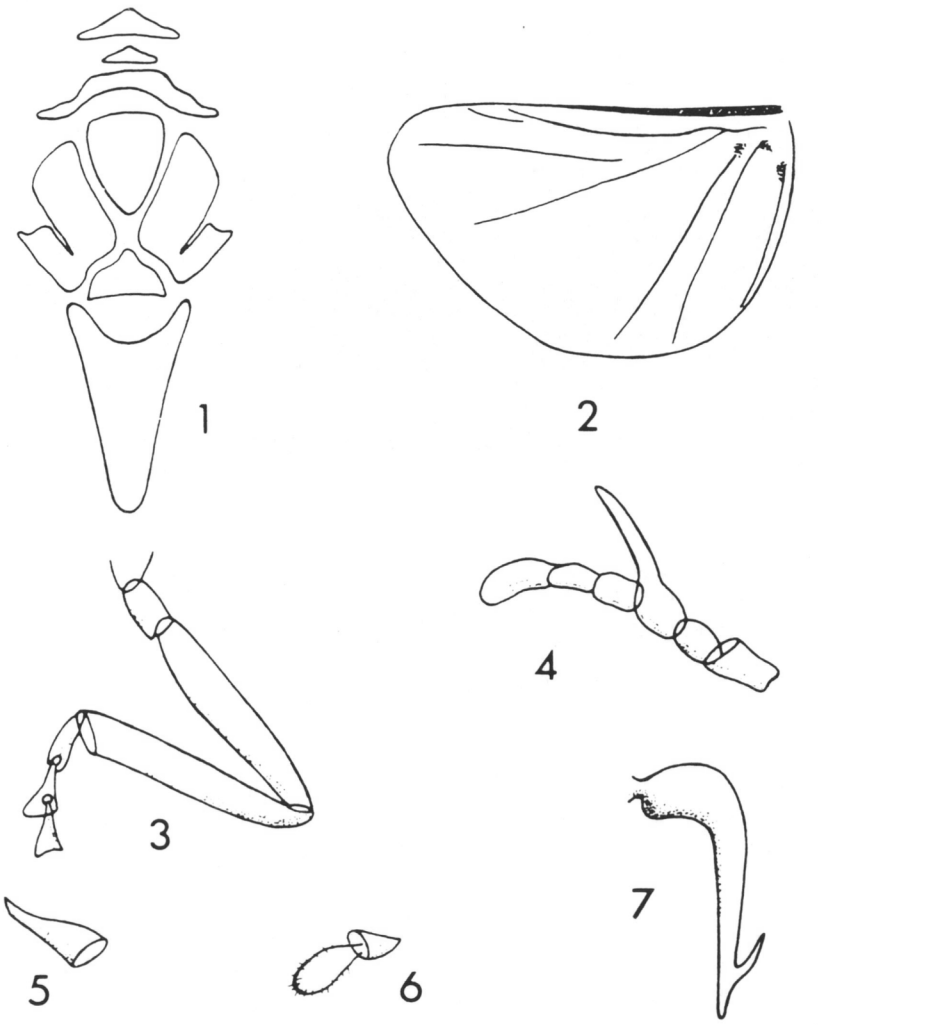
MALE

Body length 1.7–2.1 mm (holotype 2.1 mm); wing length 1.3–1.5 mm (holotype 1.4 mm).

Head. Generally red-brown; length 0.19–2.0 mm (holotype 0.2 mm), width 0.55–0.7 mm (holotype 0.7 mm); anterior margin flat between antennae; mandibles cone-shaped, sharply pointed and slightly curved at apex in lateral view (Fig. 5) and not overlapping in centre of face; maxillary palpae two-segmented, the segments being of approximately equal length (Fig. 6); antennae six-segmented, the second segment slightly smaller than first, the third segment expanded laterally into a flabellum which has an inner cavity into which the fourth segment fits, the sixth segment is larger than the fourth and fifth which are of equal length (Fig. 4).

Thorax. Generally red-brown; pronotum a separate narrow transverse band not sunken into head; acrotergite between pronotum and mesonotum which is a larger transverse band; metanotum large and divided into sclerites as follows: *pre-scutum* – a large triangular plate, *scutum* – two sclerites, one each side of pre-scutum and with a deep indentation on anterior margin, *scutellum* – a large triangular sclerite centrally placed behind scutum with apex pointing anteriorly, *postnotum* – a large elongated sclerite centrally placed and extending posteriorly over abdomen (Fig. 1); no subalare present: *legs*: fore and mid coxae very large, hind coxae small, all segments pale yellow-brown, all tarsi three-segmented, triangular in shape and without apical tarsal claws (Fig. 3); *wings*: pale, venation reduced, R_2 and R_3 as two small detached veins between R_1 and R_4, R_1 and R_4 unbroken and arising from a common junction, MA and CuA of approximately equal length, CuP shorter (Fig. 2).

Abdomen. Yellow-brown; comprised of ten segments, aedeagus inflated and rounded at



FIGS. 1–7. *Dipterophagus daci* adult male: 1, pronotum, mesonotum and metanotal sclerites; 2, wing showing venation; 3, leg showing number and shape of tarsi; 4, antenna showing number and shape of segments; 5, mandible; 6, maxillary palp; 7, aedeagus.

base, narrowing to a point at apex, with a single sub-apical recurved spine which forms an acute angle with the main axis (Fig. 7).

FEMALE

Cephalothorax with dorsal surface heavily sclerotized, dark red-brown to black, broadly rounded anteriorly, no complex eyes present, length of head less than half length of cephalothorax; mandibles reduced and rounded in shape (Fig. 10); width of cephalothorax at spiracles 0.41–0.44 mm; width between mandibles 0.14–0.16 mm; width at base of head 0.47–0.52 mm; width at base of cephalothorax 0.77–0.83 mm; length from centre of brood passage opening to anterior margin of head 0.27–0.29 mm; length from base of cephalothorax to anterior margin of head 0.61–0.65 mm; brood passage opening large and ventrally placed, width 0.24–0.26 mm (half width of head), length 0.12–0.13 mm; one pair of functional metathoracic spiracles present; without hook-like projections behind spiracles; thoracic segments not well defined; abdominal sterna rectangular and whitish; three genital tube openings postero-centrally on segments III, IV and V (Fig. 9).

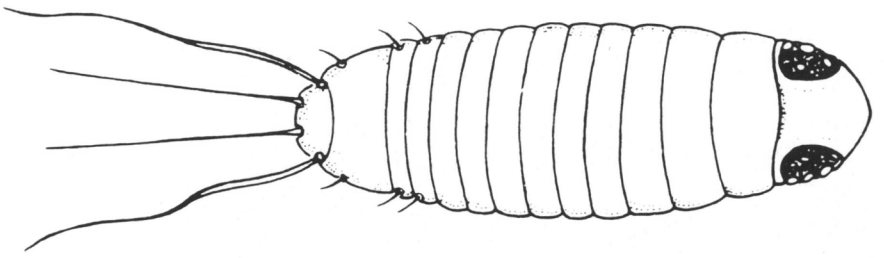


FIG. 8. *Dipterophagus daci* first stage triungulinid larva.

FIRST LARVA

Consisting of a head, three thoracic and ten abdominal segments; length of body (excluding stylets), 0.21–0.24 mm; a pair of medial stylets and a pair of lateral cerci (length 0.09 mm) which are slightly longer than the stylets protruding posteriorly from last abdominal segment; width of head 0.05 mm; all tarsi setiform; abdominal sterna not dentate, abdominal sternum IX with four bristles evenly spaced along posterior margin (length of bristles over half length of sternum), abdominal sternum IX without lateral spine bearing tubercles, abdominal terga VII–IX each with a postero-lateral bristle which is slightly longer than each respective tergum; no sub-lateral bristles on remaining terga, no minute hairs fringing abdominal terga (Fig. 8).

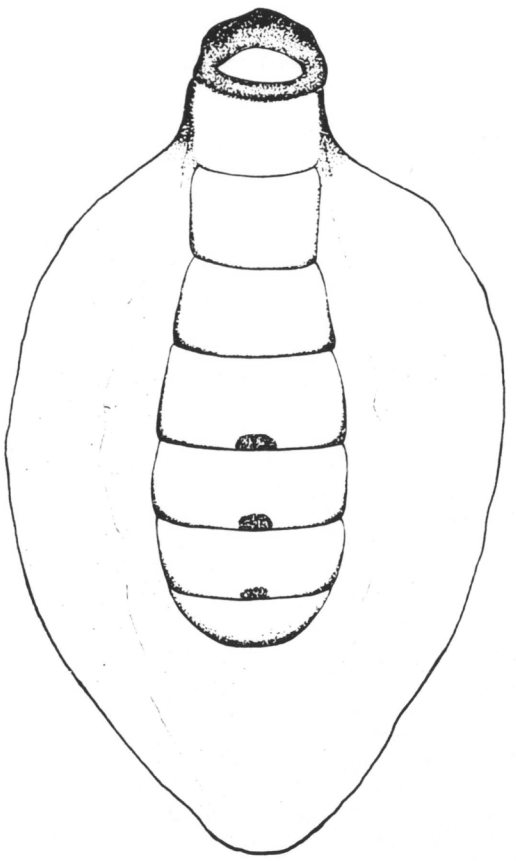


FIG. 9. *Dipterophagus daci* adult female showing brood passage opening in cephalothorax and three genital tube openings.

MATERIAL STUDIED

Holotype, ♂, AUSTRALIA – Northern Territory: Melville Island, dissected from *Dacus aquilonis* (May), 9.xi.1977 (*Allwood*), (Reg. No. T.9209 in Queensland Museum, Brisbane).

Paratypes, AUSTRALIA – Northern Territory: 5♂, same data as holotype; 1♂, Yirrkala Mission, Gove Peninsula, dissected from *Dacus bellulus* Drew, 20.iv.1982 (*Allwood*);

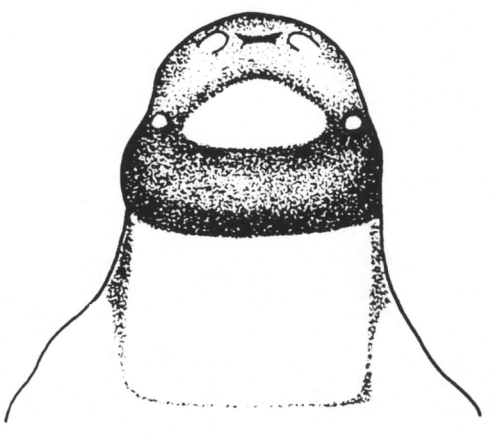


FIG. 10. *Dipterophagus daci*: ventral aspect of cephalothorax of adult female, showing mandibles, brood passage opening and spiracles.

5♂, Gove, dissected from *Dacus decurtans* (May), ix–x.1977 (*Allwood*); 6♂, Melville Island, dissected from *Dacus tenuifascia* (May), x.1977–i.1978 (*Allwood*) (all in Australian National Insect Collection, Canberra); 1♀, Darwin River Dam, dissected from *Dacus aquilonis* (May), i.1978 (*McCulloch*) (Reg. No. T.9210 in Queensland Museum, Brisbane). Queensland: 2♂, Julatten, dissected from *Dacus cacuminatus* (Hering), vi.1980 (*Storey*); 1♂, Bamaga, dissected from *Dacus mayi* Hardy, 8.ix.1981 (*Storey*); 1♂, Bamaga, dissected from *Dacus peninsularis* Drew, 8.vi.1982 (*Hemsley*); 2 first stage triungulinid larvae, Bamaga, dissected from *Dacus peninsularis* Drew, 19.viii.1982 (*Hemsley*) (Reg. Nos. T.9211–T.9216 in Queensland Museum, Brisbane).

Non-type material, AUSTRALIA – Queensland: 1♂, Cow Bay, N of Daintree, parasite in *Dacus neohumeralis* Hardy, viii–ix.1983 (*Storey* and *Cunningham*); 4♀, Mt Glorious, parasite in *Dacus tryoni* (Froggatt), 6.ix.1982 and 27.ix.1982 (*Courtice*); 1♂, Bamaga, parasite in *Dacus* sp.n. (near *musae*), 8.v.1981 (*Currey*) (all in Queensland Department of Primary Industries, Brisbane).

Comments

Based on the classification of Kinzelbach (1978), this new family is similar to the families Halictophagidae, Elenchidae and Myrmecolacidae in that the males lack tarsal claws, possess strong well-developed mandibles, have the maxillary palp greater than one-sixth length of the maxillary base, lack a subalare in the metathorax, and in that the females lack complex eyes. Further it is similar to the Elenchidae and Myrmecolacidae in that the females possess a bell-shaped cephalothorax in which the head is less than half the length of the cephalothorax and have a large brood passage opening. The Dipterophagidae is clearly different from the Halictophagidae in that the males possess six-segmented antennae and the female has the head less than half the length of the cephalothorax. It differs from the Elenchidae and Myrmecolacidae in that males possess cone-shaped mandibles, three-segmented tarsi and six-segmented antennae with a lateral flabellum on the third segment and in that the females have a pair of functional metathoracic spiracles, the dorsal surface of the cephalothorax heavily sclerotized and single median genital openings on each of abdominal sterna III–V.

The wing venation in the Dipterophagidae is not as reduced as in the known species of Elenchidae, but is similar to that found in the Halictophagidae.

The classification of Riek (1970) defines the Elenchinae in Australia as a subfamily of Halictophagidae. The extensive studies of Kinzelbach (1971, 1978) show that it is more correct to have a separate family Elenchidae.

Male fruit flies collected in male lure traps are all sexually mature. They reach this stage at about 2 weeks old. No flies reared from fruit have been found parasitized and so it is presumed that the triungulinid larvae enter the host at the teneral adult stage (when the abdominal membranes are soft) and not the larval or pupal stage. The male Strepsiptera had emerged from 75% of all flies that contained male strepsipteran pupal cases. It seems that the male parasite completes its development and emerges from the host within 2 weeks whereas the endoparasitic female remains in the host for the duration of the host's life.

Gregarious parasitism is common with from two to six adult parasites developing to full maturity in one fly abdomen, in differing combinations of males and females. The parasites always extrude through the membranous wall on the ventral surface of the abdomen and there is little visible distortion of the host. The bodies of the parasites usually fill most of the abdominal cavity of the host. Examination of the testes of male fruit flies revealed no differences in size and colour between parasitized and non-parasitized flies.

Acknowledgments

Mrs S. Sands, Queensland Department of Primary Industries, prepared the illustrations. The study was supported by a grant from the Australian Biological Resources Study. The fruit fly specimens were collected in the Plant Quarantine northern Australian surveillance programme. This support is gratefully acknowledged.

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On the Specific Status of *Dacus* (*Bactrocera*) *aquilonis* and *D.* (*Bactrocera*) *tryoni* (Diptera: Tephritidae)

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Ann. Entomol. Soc. Am. 79: 870–878 (1986)

ABSTRACT Two closely related allopatric species in the tryoni complex, *Dacus* (*Bactrocera*) *aquilonis* (May) and *D.* (*Bactrocera*) *tryoni* (Froggatt), are compared on the basis of morphology, cytology, electrophoresis of enzymes, mating and sterility tests, and chemical analyses of male pheromones, and are shown to be valid species. The species were found to be closely related, showing only small morphological differences in body color, male surstyli, ovipositors, and egg surfaces. Differences were found in isoelectric focusing of esterase and glutamate dehydrogenase enzymes. A Nei's similarity coefficient of 0.95 was calculated based on 30 loci in cellulose acetate gel electrophoresis. Small differences were found in minor components of male pheromones, but no differences were found in metaphase chromosomes and asymmetric isolation in mate-recognition and sterility tests. Validity of mate-recognition tests in the laboratory is discussed in view of elimination of components of the specific mate-recognition systems that are known to exist in field populations of Dacinae.

KEY WORDS *Dacus aquilonis*, *Dacus tryoni*, status, morphology, mate recognition, cytology

THE TRYONI COMPLEX consists of the following known species: *Dacus aquilonis* (May), *D. melas* (Perkins and May), *D. neohumeralis* Hardy, and *D. tryoni* (Froggatt) (Drew et al. 1981). In addition, there are two undescribed species in Papua New Guinea that show close similarities to *D. tryoni* and *D. neohumeralis*. *D. aquilonis* occurs only in northwestern Australia and is geographically separated from *D. melas*, *D. neohumeralis*, and *D. tryoni*, which occur in eastern Australia. An understanding of the genetic relationships among these species (including those in Papua New Guinea) may assist in understanding speciation in the tropical fruit flies (subfamily Dacinae), which are thought to have undergone extensive speciation in Southeast Asia and Papua New Guinea.

D. aquilonis and *D. tryoni* are very similar morphologically. This resulted in the first specimens collected at Darwin in 1961 being identified as *D. tryoni* (May 1963) and later regarded as a separate species and described as *D. aquilonis* (May 1965). Characters of *D. aquilonis* used by May to separate it from *D. tryoni* are as follows: the paler coloration of the head, thorax, and abdomen; lack of definite orbital spots on the frons; lateral postsutural stripe reaching upper *p. sa.* bristle; a wider costal band on the wing; a different shape and size of the male genitalia. The head and frons colors are not considered adequate species-level differences within the Dacinae; the lateral postsutural stripe varies and is the same as in *D. tryoni* for some specimens of *D. aquilonis*; the variation in the width of the costal band is not evident in most specimens of *D. aquilonis;* the differences in shape and size of male genitalia are due to differences in age of specimens studied (Drew 1969). This leaves the only satisfactory morphological characters used by May as the paler coloration of the thorax and abdomen in *D. aquilonis*, and even in these the differences are so slight as to be of questionable value for species-level differentiation.

Scanning electron microscopy of eggs and female ovipositors revealed structural differences of value in differentiating between two cryptic species of *Dacus* (Drew & Hardy 1981).

D. tryoni infests all commercial fruit crops (except pineapple and strawberries) and many vegetable crops. It has been recorded from many wild host plants within rainforest and open forest in eastern Australia (Drew 1978). *D. aquilonis* has been recorded from *Citrus* spp., peach, and guava and 13 species (nine genera) of wild hosts in the Northern Territory (Allwood & Angeles 1979). *D. tryoni* has been reared from the same commercial hosts but not from any of the 13 species of wild hosts of *D. aquilonis*. *D. tryoni* has been reared from plants belonging to two of the nine genera containing hosts of *D. aquilonis*. Both species respond to cue-lure attractant. Mate-recognition and sterility experiments, which have been used to separate species of *Drosophila*, have not been used in previous studies on the taxonomy of Tephritidae. These studies were undertaken to decide whether or not the two allopatric populations should be considered as separate species.

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Materials and Methods

Morphology. For comparative morphology studies, specimens of both *D. aquilonis* and *D. tryoni* were reared from hosts and collected at the male attractant cue-lure. *D. aquilonis* specimens were collected at localities representing a large area of its distribution in the Northern Territory and *D. tryoni* specimens were collected at localities throughout the eastern coastal areas and in some inland regions of Queensland. Ovipositors and eggs for scanning electron microscopy were dehydrated by passing them through ethyl alcohol solutions of increasing concentration and then processing them in a critical point dryer. Male surstyli and claspers were mounted from dry specimens without treatment in the critical point dryer.

Electrophoresis Studies. *D. aquilonis* and *D. tryoni* were studied using standard electrophoresis. Five specimens each of *D. aquilonis*, *D. tryoni*, and *D. aquilonis* × *D. tryoni* hybrids were electrophorised on cellogel (cellulose acetate) using the method of Richardson et al. (1986). Thirty enzymes providing 30 genetic loci were studied, gene frequency data were recorded, and Nei's genetic similarity coefficient (Nei 1972) was estimated. In addition, 80 specimens of each species were analyzed by isoelectric focusing in which the samples were run for 2 h at 4°C on a polyacrylamide gel with a pH gradient from 3.5 at the anode to 9.5 at the cathode. Isoelectric focusing data were not used to calculate genetic similarity but to assess the presence of fixed differences at loci. Fifteen enzymes were studied, as follows: alcohol dehydrogenase, aldehyde oxidase, esterase, glutamate dehydrogenase, glutamate oxaloacetate transaminase, hydroxy butyric dehydrogenase, hexokinase dehydrogenase, hexokinase, leucine aminopeptidase, malic enzyme, malate dehydrogenase, phosphoglucose isomerase, phosphoglucomutase, α-glycerophosphate dehydrogenase, and glucose-6-phosphate dehydrogenase.

Cytology. Metaphase chromosomes were prepared from the ganglion of final stage (third instar) larvae of *D. aquilonis* and *D. tryoni* using a G-banding technique modified by Guest & Hsu (1973).

Mate Recognition and Sterility Experiments. *D. aquilonis* stock colonies did not reach egg production stage as early as *D. tryoni*. As a result, an experiment was designed to deterimine the laboratory age at which each species began to copulate. Results of this experiment were important in setting up the *choice* experiments.

Single puparia of each species were held in glass tubes with cotton wool stoppers. When the flies emerged, they were separated by sex and all females were grouped in a separate cage for each species and likewise with males. After 22 days, five cages containing protein, sugar, and water were set up and five virgin male and five virgin female *D. aquilonis* were placed in each. Another set of five cages was set up for a similar experiment on *D. tryoni*. The females were dissected in Eide & Reinecke's (1970) saline, and spermathecae were extracted and squashed on a microscope slide in the same saline and examined for presence of motile sperm. For each species, five females from one cage were dissected when 26 days old, and then at 28 days, 30 days, 33 days, and 35 days. The number of females that had mated was recorded, and notes were made on the stage of development of the ovaries.

Hybridizations among stocks of both species were completed to determine the degree of sterility. When 7 days old, 50 virgin female *D. tryoni* and 50 virgin male *D. aquilonis* were placed together in a cage and allowed to mature and produce eggs. The reciprocal cross was also made using the same number of adults. The F_1 hybrid progeny was used to produce an F_2; then F_2 was used to produce an F_3. For each cross, 100 eggs were sampled from the females of the parent species, F_1, F_2, and F_3 hybrids. The eggs were placed on moist black filter paper in glass petri dishes and held for 72 h at 25°C. After hatching was complete, the percent egg fertility was estimated for each sample.

Divergence in mate recognition among stocks of both species was assayed in *male-choice* experiments. Each experimental unit consisted of three flies, a male and a female of the same species and a female from the other species. Each experiment consisted of 24 units plus 24 units of the reciprocals. This experiment was carried out in triplicate for the male *D. aquilonis* and duplicate for the male *D. tryoni*. In the three experiments with *D. aquilonis* males, all flies were 29 days, 34 days, and 36 days old, respectively, when set up and in the two experiments with *D. tryoni* males, all flies were 29 days and 34 days old, respectively. In each experiment the females were dissected after 24 h and the spermathecae were examined in saline (Eide & Reinecke 1970), as described in the maturity test, for presence of motile sperm. Both species in this study mate once at dusk, so dissection after 24 h would allow for only one mating by any particular female. The number of females of each species that mated with males of a particular species was recorded for each experiment. The data were analyzed using the Charles–Stalker isolation index (I) (Stalker 1942) in which

$$I = \frac{\%\text{ homogamic matings} - \%\text{ heterogamic matings}}{\%\text{ homogamic matings} + \%\text{ heterogamic matings}}.$$

In this analysis, only matings in which one female was inseminated were used. A test of proportions (C) was calculated for each I value that tested the null hypothesis that the two species were mating at random; the null hypothesis was accepted if $-1.96 < C < +1.96$. C was calculated using the

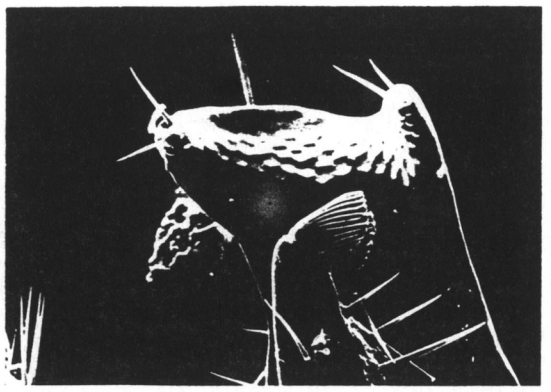

Fig. 1. *D. aquilonis*, inner surface of surstylus and clasper of male.

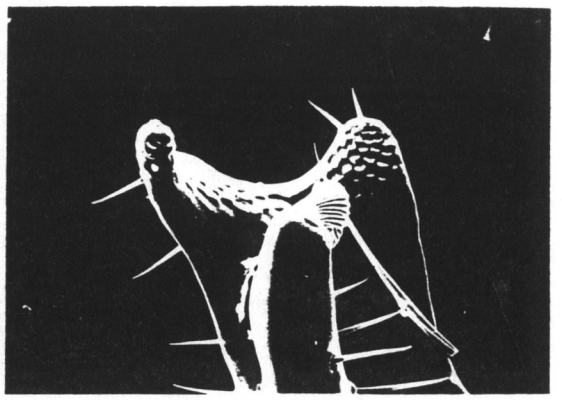

Fig. 2. *D. tryoni*, inner surface of surstylus and clasper of male.

formula $2\sqrt{n}\,(p - 0.5)$ where n = number of successful trios and p = percentage of homogamic matings.

Divergence in mate recognition among stocks of both species was also assayed in *female-choice* experiments. Each experimental unit consisted of three flies, a male and a female of the same species and a male from the other species. Each experiment consisted of 30 such units plus 30 units of the reciprocals. This experiment was carried out in duplicate. In the first experiment, the *D. aquilonis* were 29 days old and the *D. tryoni* 27 days old, and in the second experiment the *D. aquilonis* were 36 days old and the *D. tryoni* 34 days old. In each experiment the flies were observed at dusk and identified in each mating pair. The number of males of each species that mated with females of a particular species was recorded for each experiment. *I* and *C* for each *I* value were calculated.

Male Pheromone Analyses. The pheromone gland and reservoir were removed from a large number of sexually mature adult male *D. aquilonis* and *D. tryoni* and placed in acetone into which the contents were dissolved. The resulting solution was then analyzed in a Gas Chromatograph–Mass Spectrometer.

Results

Morphology. Complete illustrated description and distributions of *D. aquilonis* and *D. tryoni* are given by Drew (1978). The pale form of *D. tryoni* illustrated in that description is reasonably common and even paler forms are collected throughout the geographic range.

A comparative study has shown that *D. aquilonis* is very similar to *D. tryoni* and possesses the following differences.

Head. Vertex fulvous. May (1965) recorded *D. aquilonis* as differing from *D. tryoni* in lacking definite orbital spots on the frons; however, in a large series of specimens, it has been found that many do possess fuscous orbital spots on the frons and a fuscous anteromedial hump.

Thorax. Mesonotum fulvous or pale red-brown with fuscous patterns absent on posterior region and in some specimens smaller or absent on anterior regions (this gives the general impression of a paler thorax than that of *D. tryoni*). May (1965) recorded *D. aquilonis* as differing from *D. tryoni* in possessing a fulvous thorax without fuscous markings on the pleura and mesonotum, a lateral postsutural stripe that attains the upper *p. sa.* bristle and a wider costal band on the wing. In the material studied, all specimens possessed fuscous markings on the pleura and most had some fuscous patterns on the mesonotum; some specimens had tapering lateral postsutural vittae that did not reach the upper *p. sa.* bristle (as for *D. tryoni*); all specimens possessed a costal band the same width as that of *D. tryoni*.

Abdomen. Terga III–V fulvous with pale to very pale fuscous across anterior margin of tergum III and a narrow pale fuscous medial longitudinal band from tergum III to center of tergum V (this band is absent in some specimens). May (1965)

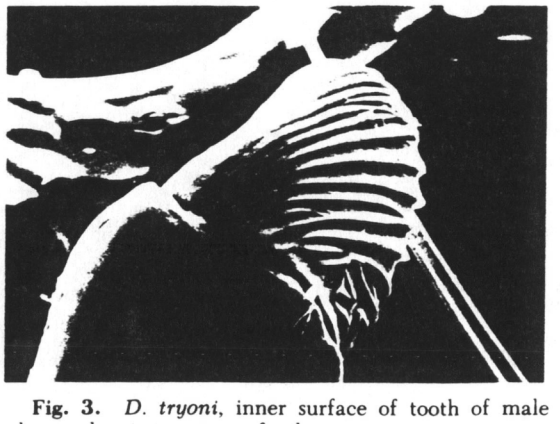

Fig. 3. *D. tryoni*, inner surface of tooth of male clasper showing pattern of ridges.

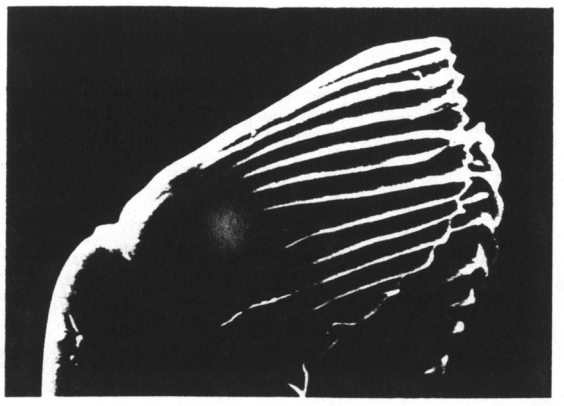

Fig. 4. *D. aquilonis*, inner surface of tooth of male clasper showing pattern of ridges.

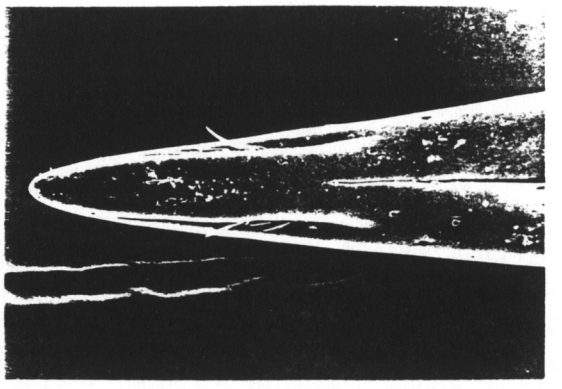

Fig. 6. *D. tryoni*, apex of piercer of ovipositor.

recorded *D. aquilonis* as differing from *D. tryoni* in possesssing uniform fulvous coloration on terga III–V. However, in the present study, most specimens of *D. aquilonis* terga III–V possessed pale fuscous patterns and some *D. tryoni* terga III–V possessed a uniform red-brown coloration without dark markings.

Male Surstyli and Claspers. The ridged pattern on the inner surfaces of the surstyli of *D. aquilonis* (Fig. 1) and *D. tryoni* (Fig. 2) show no significant differences. On the clasper there is a deep indentation between the apical tooth and the stem, and the surface ridges on the tooth are further apart with shallow alternating furrows in *D. tryoni* (Fig. 3), whereas in *D. aquilonis* there is only a shallow indentation between the tooth and the stem, and the surface ridges are closer together with deeper alternating furrows (Fig. 4).

Ovipositor. The apex of the piercer is needle-shaped in both species but more slender and pointed at the tip in *D. aquilonis* (Fig. 5 and 6). The apical portion measured from the gonopore to the apex is ca. 6.0-fold longer than wide (width as measured at the preapical sensory setae) in *D. aquilonis* and 4.6-fold longer than wide in *D. tryoni*. The preapical sensory setae vary intraspecifically and, therefore, do not provide consistent differences between species. The scales or spicules on the middle segment of the ovipositor show differences between the species when compared adjacent to the intersegmental line between this segment and the piercer, but are similar as the scales change shape along the segment, where they become large smooth-sided triangular scales at the proximal end. Adjacent to the intersegmental line in *D. tryoni* the scales have a row of 7–10 small teeth of reasonably uniform size (Fig. 7), whereas in *D. aquilonis* the teeth are more irregular in size and often larger (Fig. 8).

Eggs. Small differences exist between *D. aquilonis* and *D. tryoni* on the chorion surface of the eggs. The ridges in *D. aquilonis* contain fine pores that are visible on the chorion surface (Fig. 9), while in *D. tryoni* they consist of a beaded pattern (Fig. 10).

Electrophoresis. No fixed differences were observed between the two species in electrophoresis on cellulose acetate gel, but there were a number of gene frequency differences. Allele frequencies are presented in Table 1 for 30 loci (1 from each of 30 enzymes) from which Nei's genetic similarity coefficient was estimated as 0.95.

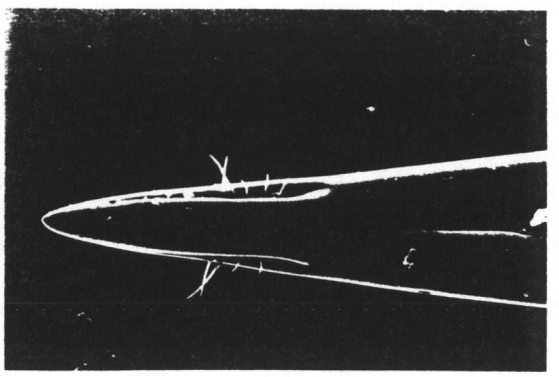

Fig. 5. *D. aquilonis*, apex of piercer of ovipositor.

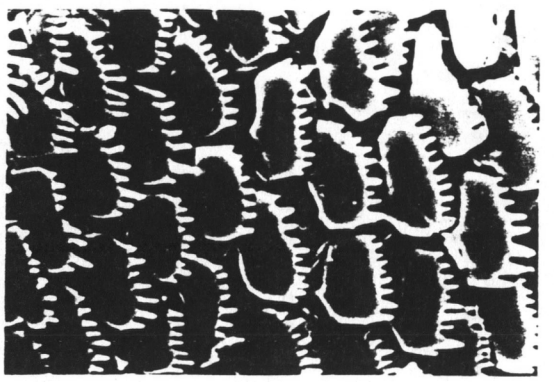

Fig. 7. *D. tryoni*, dentate scales on distal end of middle segment of ovipositor.



Fig. 8. *D. aquilonis*, dentate scales on distal end of middle segment of ovipositor.

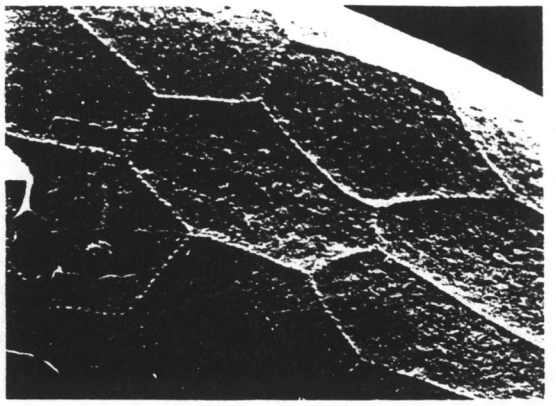

Fig. 10. *D. tryoni*, ridges on surface of egg chorion showing beaded pattern.

Isoelectric focusing showed a fixed difference between the two species at one nonspecific esterase locus. In males, the locus closest to the anode present in *D. aquilonis* (from left to right, positions 1–12) was absent in *D. tryoni* (from left to right, positions 13–24) (Fig. 11). In females this locus was present in all *D. aquilonis* specimens and 50% of *D. tryoni;* however, when present in the latter it consisted of slower alleles. A fixed difference was also observed between males of the two species for a glutamate dehydrogenase locus (Fig. 12, from left to right, *D. tryoni* positions 5 and 6; *D. aquilonis* positions 7 and 8).

Cytology. No differences were observed in the metaphase plate chromosomes between the two species. In the males, each plate consists of three pairs of metacentric chromosomes, two pairs of acrocentric and a metacentric X chromosome in the sex pair.

Mate Recognition and Sterility Experiments

Maturity Test. Of the 26-day-old *D. aquilonis* females, 60% had mature ovaries with well-developed eggs and the remainder had ovaries that had

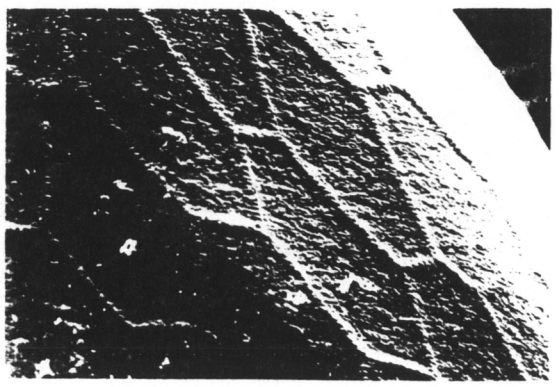

Fig. 9. *D. aquilonis*, ridges containing pores on surface of egg chorion.

Table 1. Allele frequencies for 30 loci, 1 from each of 30 enzymes for *D. aquilonis* and *D. tryoni*, using cellulose acetate gel electrophoresis

Enzyme	Allele	Allele frequency	
		D. tryoni	*D. aquilonis*
Glutamate oxaloacetate transaminase (c)	c	0.25	0
	b	0.75	1.00
Glutamate oxaloacetate transaminase (m)	c	1.00	0.833
	a	0	0.167
Hydroxybutyrate dehydrogenase	a	1.00	1.00
Superoxide dismutase (c)	b	1.00	1.00
Superoxide dismutase (m)	a	1.00	1.00
Aldehyde oxidase	b	1.00	1.00
Alcohol dehydrogenase 1	b	1.00	1.00
Alcohol dehydrogenase 3	c	1.00	1.00
Peptidase A	b	1.00	1.00
Peptidase B	a	0.125	0
	c	0.5	1.00
	d	0.375	0
Peptidase D	b	1.00	1.00
Adenylate kinase 1	b	1.00	1.00
Adenylate kinase 2	b	1.00	1.00
Glucose-phosphate isomerase	a	1.00	1.00
α-glycerophosphate dehydrogenase	d	1.00	1.00
Glyceraldehyde-3-phosphate dehydrogenase	b	1.00	1.00
Phosphoglucomutase	b	0.125	0.875
	c	0.875	0.125
Malate dehydrogenase (c)	c	1.00	1.00
Malate dehydrogenase (m)	b	1.00	1.00
Glucose-6-phosphate dehydrogenase	b	1.00	1.00
6-phosphogluconate dehydrogenase	d	0.125	0.3335
	e	0.875	0.5
	g	0	0.1665
Isocitrate dehydrogenase	c	1.00	1.00
Malic enzyme	c	1.00	1.00
Hexokinase	d	1.00	1.00
Esterase 1	e	1.00	1.00
Esterase 2	c	0.5	1.00
	d	0.5	0
Phosphoglycerate kinase	b	1.00	1.00
Sorbitol dehydrogenase	b	1.00	1.00
Aconitase (c)	a	0	0.3335
	c	1.00	0.6665
Aconitase (m)	b	1.00	1.00

c, cytoplasmic; m, mitochondrial.

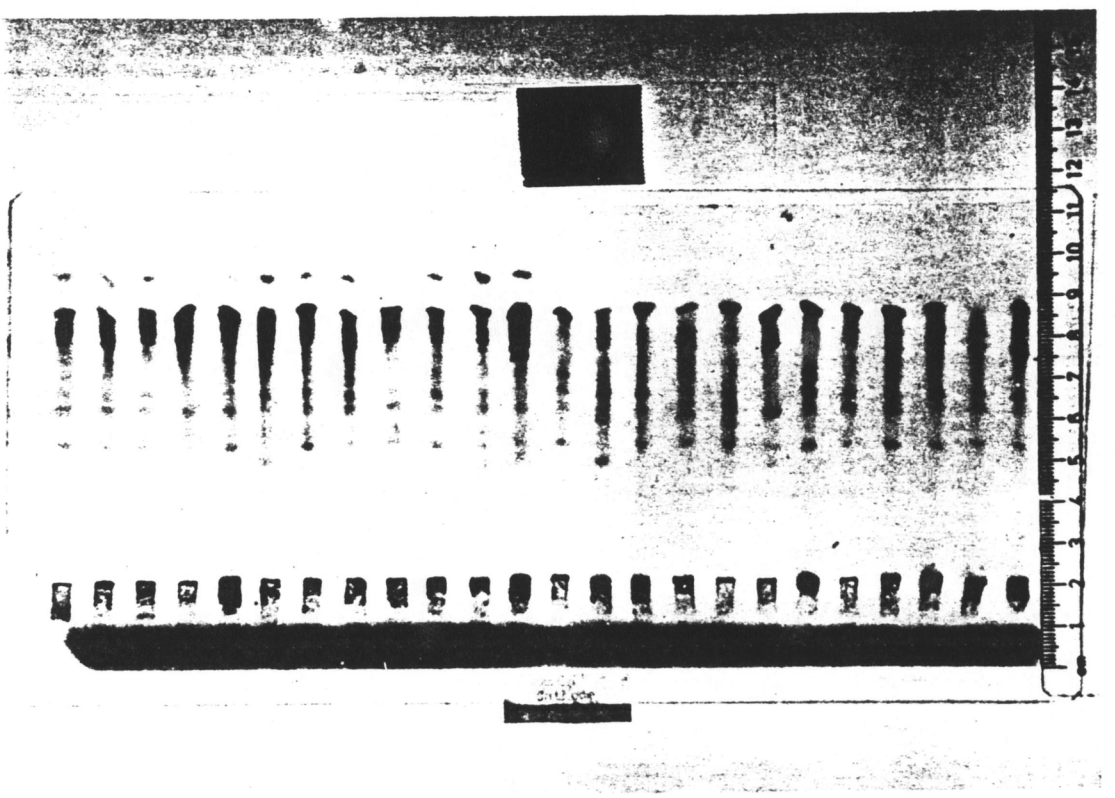

Fig. 11. Esterase enzyme pattern on isoelectric focusing gel. From left to right: *D. aquilonis*, positions 1–12; *D. tryoni*, positions 13–24.

not reached full maturity. Sixty percent of these females had also copulated. Females 28–35 days old all had mature ovaries and all had copulated. Similarly, *D. tryoni* females reached full maturity and had copulated at 21 days old. As a result, it was decided that the male-choice and female-choice experiments should be conducted with flies of both species that were at least 29 days old.

Hybridization Experiment. The percent hatch of eggs produced by crossing *D. tryoni* females with *D. aquilonis* males, the reciprocal crosses *D. aquilonis* females with *D. tryoni* males, and from the subsequent hybrid crosses is given in Table 2.

In both crosses there was no sterility and no significant hybrid breakdown in the F_1, F_2, and F_3 generations.

Male-choice Experiments. These experiments have been termed male-choice; however, this name may be misleading. The actual choice of whether or not to copulate is made by the female and not the male. In *Dacus* species, the males tend to court indiscriminately, moving from fly to fly (male or female) attempting to copulate. It is often the female that rejects the male to terminate courtship.

Table 3 reports the results of the male-choice experiments. In the first experiment set up with 29-day-old virgin flies, all females placed with *D. tryoni* males were dissected after 24 h. Half the females of both species, which were placed with *D. aquilonis* males, were dissected after 24 h and the remainder were dissected after 48 h. In the second male-choice experiment set up with 34-day-old virgin flies, all females were dissected after 24 h. In the third male-choice experiment set up with 36-day-old virgin flies, only trios with *D. aquilonis* males were used and all females were dissected after 24 h.

I has a maximum value of $+1$, meaning total divergence (or all homogamic matings), and a minimum value of -1, meaning all heterogamic matings. A value of zero means that no divergence exists and that the male is equally acceptable to both females.

Female-choice Experiments. These experiments were conducted because the female plays a major role in the choice of a mate during courtship. Table 4 reports the results of both female-choice experiments set up with virgin flies. In the first experiment, *D. aquilonis* was 29 days old and *D. tryoni* 27 days old and in the second experiment, *D. aquilonis* was 36 days old and *D. tryoni* 34 days old.

Male Pheromone Analyses. The major components of the pheromone gland secretions in both species were found to be a group of relatively simple amides. Both species were similar in the major

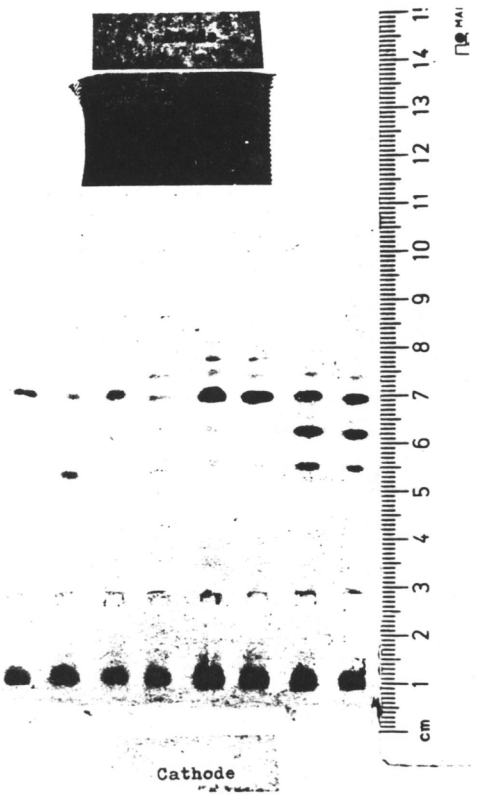

Fig. 12. Glutamate dehydrogenase enzyme pattern on isoelectric focusing gel. From left to right: *D. tryoni*, positions 5 and 6; *D. aquilonis*, positions 7 and 8.

amide component but showed differences in the minor amide and nonamide components.

Discussion

The only external morphological characters of *D. aquilonis* that indicated that it could be a separate species from *D. tryoni* were the postsutural vittae reaching the upper *p. sa.* bristle and abdominal terga fulvous without darker markings on lateral areas of terga IV and V. With these two characters, there was some overlap between the two populations: some *D. aquilonis* had the postsutural vittae ending before the upper *p. sa.* bristle as for *D. tryoni*, and some *D. tryoni* possessed pale abdomens as for *D. aquilonis*. However, *D. tryoni* never had the postsutural vittae reaching the upper *p. sa.* bristle and *D. aquilonis* never possessed the dark abdominal color patterns typical of *D. tryoni*.

Table 2. Percent hatch of eggs produced from *D. tryoni* females (*t*♀) crossed with *D. aquilonis* males (*a*♂), from the reciprocal crosses (*a*♀ × *t*♂), and from hybrid crosses

Cross	Eggs sampled (*n*)	Hatch (%)
t♀ × *a*♂	200	69
F_1♀ × F_1♂	100	93
F_2♀ × F_2♂	100	66
F_3♀ × F_3♂	100	93
a♀ × *t*♂	200	74
F_1♀ × F_1♂	100	97
F_2♀ × F_2♂	100	86
F_3♀ × F_3♂	100	97

Differences in shape of the apex of the piercer of the ovipositor and in the shape and number of dentations on the spicules of the middle segment of the ovipositor were used as good diagnostic characters between two cryptic species in the *dorsalis* complex (Drew & Hardy 1981). The differences between *D. aquilonis* and *D. tryoni* in the shape of the piercer apex, the shape of the dentations on the spicules on the middle segment of the ovipositor, the shape of the apical tooth, and the ridges on the surface of this tooth on the male surstylus indicated that they were different species. Similarly, the differences in patterns on the egg chorion indicated that the two were different species.

Morphologically, the two species were very similar, showing only minor differences in color patterns, ovipositor structure, and egg chorion texture.

The similarity in the metaphase chromosomes may indicate that *D. aquilonis* and *D. tryoni* are closely related; however, our studies have shown that species such as *D. jarvisi* (Tryon) and *D. tryoni*, which belong to different subgenera, also possess the same metaphase plate chromosome composition (unpublished data).

The close similarities in chemical composition of pheromone gland secretions indicated that the

Table 3. Male-choice experiment between *D. aquilonis* and *D. tryoni*

Expt.	Time of dissection	♀♀ mated with *D. aquilonis* ♂♂		*I*	*C*	♀♀ mated with *D. tryoni* ♂♂		*I*	*C*
		D. aquilonis ♀♀	*D. tryoni* ♀♀			*D. aquilonis* ♀♀	*D. tryoni* ♀♀		
i	24 h	10	30	−0.50	[a]	17	71	0.62	2.84
	48 h	8	69	−0.80	−3.1	—	—		
ii		20.8	62.5	−0.50	−2.24	4.4	82.6	0.90	4.03
iii		0	95.8	−1.0	−4.8				

i, 29-day-old; ii, 34-day-old; and iii, 36-day-old virgin flies.
[a] Number of successful trios too small to calculate *C*.

Table 4. Female-choice experiment between virgin *D. aquilonis* and *D. tryoni*

Expt.	♂♂ mated with *D. aquilonis* ♀♀ (%)		*I*	*C*	♂♂ mated with *D. tryoni* ♀♀ (%)		*I*	*C*
	D. aquilonis ♂♂	*D. tryoni* ♂♂			*D. aquilonis* ♂♂	*D. tryoni* ♂♂		
a	0	13	−1.0	−2.0	17	83	0.66	3.61
b	0	10	−1.0	−1.73	27	63	0.40	1.35

two species were closely related. Similar comparative chemical analyses on other more taxonomically distinct species (W. Kitching, unpublished data) have shown major differences in the composition of pheromone gland secretions.

The Nei's similarity coefficient of 0.95 indicated that *D. aquilonis* and *D. tryoni* were genetically very similar. Some divergence was illustrated, however, from the isoelectric focusing of esterase and glutamate dehydrogenase loci. This did not argue directly for the specific status of the forms, since various degrees of genetic similarity can be associated with various taxonomic ranks (Lambert & Paterson 1982).

In the hybridization experiments, no detectable postmating effects were observed. However, in the male-choice experiments asymmetrical mating patterns were observed. When *D. aquilonis* males were used, significant mating with *D. tryoni* females was obtained, while in the reciprocal direction, when *D. tryoni* males were used, significant mating also occurred with *D. tryoni* females (Table 3). Thus, *D. aquilonis* males are accepted by both *D. aquilonis* and *D. tryoni* females (Table 3), while *D. tryoni* males are strongly rejected by *D. aquilonis* females. Similarly, with the female-choice experiments, asymmetrical mating patterns were observed. When *D. aquilonis* females were used, all matings were heterogamic; when *D. tryoni* females were used, there was a strong trend toward homogamic matings (Table 4). Such asymmetrical mating patterns have been described for a number of *Drosophila* species (Kaneshiro 1976, 1980, 1983), and yet their specific status has not been questioned. Closely related species of the subfamily Dacinae, such as *D. neohumeralis* and *D. tryoni*, also hybridize readily in the laboratory and produce fertile progeny (Birch & Vogt 1970). Fruit fly mating in host trees and its significance have been studied. This laboratory hybridization may be explained since recent studies on bacteria feeding by adults and the attraction of dacine species to bacterial odor (Drew et al. 1983; R.A.I.D., unpublished data) have shown that specific chemicals are probably important mate-recognition factors, bringing the sexes together in host plants for mating. The recognition concept of species (Paterson 1985) provides a sound basis for understanding these results. In laboratory studies, such as mating and sterility tests, specific mate-recognition systems would be eliminated, and this throws doubt on the validity of such experiments. It is most likely that intensive chemical studies on the odors emitted by the endemic host plants of Dacinae will provide a better understanding of the species complexes by defining specific mate-recognition systems.

Northeastern Australia (the endemic habitat of *D. tryoni*) and northwestern Australia (endemic habitat of *D. aquilonis*) are zoogeographically separated with respect to fruit flies by a semiarid extension of the Simpson Desert, which reaches to the Gulf of Carpentaria. *D. aquilonis* and *D. tryoni* are an excellent example of speciation between these two regions and the taxonomic status of both populations is best understood in light of this separation.

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Chapter 1.1 Taxonomic Characters used in Identifying Tephritidae

R.A.I. DREW

1 INTRODUCTION

The Tephritidae, particularly the subfamily Dacinae, are one of the most difficult groups of insects to study taxonomically. It has been hard to find sound taxonomic characters and this has led to major problems. The most common errors are synonyms, homonyms, misidentifications and establishment of supra-specific groups based on questionable characters. Prolific speciation within the Tephritidae has resulted in large numbers of species (Hardy (1977) reports some 3700 species are known worldwide) and almost certainly many sibling species. Only now can some of these be recognised with the aid of recently developed taxonomic techniques.

It is not possible to discuss all characters that have been used, consequently this chapter will be confined to a discussion of those that are thought to be most important. The characters used in the subfamily Dacinae have been illustrated by Drew (1982). There will always be some difference of opinion in the definitions of supra-specific groups due to the varying degrees of importance that workers place on the different characters.

2 FAMILY LEVEL CHARACTERS

The characters most commonly used to define the Tephritidae are as follows:

Head. Ptilinal fissure present; incurved *i.or.* bristles present; vibrissae absent.

Thorax. Costal vein broken at two positions bordering second costal cell; subcosta complete and separate from R_1; R_1 setulose above; R_{4+5} unbranched; CuA short and joining 1A well back from wing margin, if anal cell long and acute then CuA is angulate or indented; cell M closed; mesonotal suture broadly interrupted medially; scutellum present; scutellar bristles not at apices of long spines; no setulae on lower margin of metathoracic spiracle; legs not elongate, tibiae without preapical dorsal bristles.

Abdomen. Abdomen not elongate; females with a well developed ovipositor; males with well developed surstyli and claspers. Hennig (1973) used (a) abdominal segment VII of female with tergum and sternum fused into a tube; (b) male with a small asymmetrical post-abdomen retracted beneath segment V; (c) male with a tubular shaped aedeagus spiralled and lying beneath the post-abdomen.

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3 SUBFAMILY LEVEL CHARACTERS

3.1 Subfamily Dacinae

The characters most commonly used to define this subfamily are:

Head. Antennal segment 3 elongate, three or more times longer than wide; lacking ocellar and post-ocellar bristles.

Thorax. Reduction in bristles, lacking dorsocentral, presutural, sternopleural and usually humeral; cell M in wing two times wider than cell Cu, cell M approximately two times longer than wide, cell Cu with an elongate apical lobe, dense pattern of microtrichia in wing of male at distal end of anal lobe; wings generally hyaline except for a dark costal margin and anal streak.

Abdomen. Abdomen often short and broad; mostly with a pair of shining spots on tergum V of male above tergal glands; usually with a pecten of cilia on posterolateral margins of tergum III of male; female with two spermathecae composed of tightly set coils.

3.2 Subfamily Tephritinae

The characters most commonly used to define this subfamily are:

Head. Antennal segment 3 short, less than three times longer than wide; chaetotaxy not reduced; occipital row consisting of setae that are stubby, thick, flat and scale-like, usually white or yellow-white.

Thorax. Chaetotaxy not reduced; dorsocentral bristles before or near the supra-alar bristles; cell M narrow equal in width to cell Cu and over 4 times longer than wide, apical lobe of cell Cu short, no dense pattern of microtrichia in wing of male between anal cell and wing margin; wings usually with a spotted colour pattern; mesonotum tomentose and covered with flat recumbent scale-like white setae; vertical suture of mesopleuron absent or rudimentary.

Abdomen. Generally more slender and straight sided than in the Dacinae; no shining spots on tergum V and no pecten of cilia on tergum III; abdominal tergum VI in female equal to or longer than V; females with 2 to 3 spermathecae but never formed of tight set coils.

3.3 Subfamily Trypetinae

The main diagnostic characters of this subfamily are similar to those for the Tephritinae except as follows:

Head. Occipital row setae thin, pointed and dark coloured; in the Adramini antennal segment 3 is similar to that in the Dacinae.

Thorax. Dorsocentral bristles usually behind the supra-alar bristles; mesonotum rarely tomentose and never with scale-like white setae; wings rarely spotted and usually covered with elaborate colour patterns; vertical suture of mesopleuron well developed.

Abdomen. Tergum VI of female shorter than tergum V. In the Adramini the chaetotaxy of the head and thorax is reduced and similar to that in the Dacinae.

3.4 Subfamily Schistopterinae

This subfamily is represented by one genus (*Rhabdochaeta* de Meijere). It is similar to the Tephritinae and Trypetinae except that it possesses a deep cleft in the costa at the extremity of the subcosta, two developed bristles on the anterior margin of this cleft and distinctive wing colour patterns consisting of a large dark formation over centre of wing with radiating arms to wing margin.

4 GENERIC/SUBGENERIC LEVEL CHARACTERS

4.1 Subfamilies Tephritinae and Trypetinae

These subfamilies are generally divided into distinct genera without significant disagreement between workers. Subgenera are not used. The main characters used to define genera are:

Head. Shape of proboscis; ratio of width to height of head; number of *i.or.* and *s.or.* bristles; antennal segment 3 pointed or rounded at apex, size of arista and whether or not the arista is pubescent, plumose or bare.

Thorax. Position of dorsocentral bristles in relation to mesonotal suture; number of scutellar bristles; presence or absence of prescutellar bristles; whether or not the humeral, dorsocentral, mesopleural or sternopleural bristles are absent, present, weak or well developed; general wing shape and some wing colour patterns; the shape of some wing veins; ratio of length of subcostal cell to costal cell; whether or not R_1, R_{4+5}, CuA_1 and CuA_2 are bare or setose; cell Cu pointed or truncate at distal end; shape of apex of female ovipositor; occasionally some scutellum and mesonotum colour patterns; presence or absence of spines or bristles on ventral surfaces of femora; presence or absence of 1 or 2 spurs on apex of mid-tibiae.

4.2 Subfamily Dacinae

It has been extremely difficult to establish enough reliable characters at the generic/subgeneric level for this subfamily. As a result there has been a great deal of conjecture over whether most supra-specific groups should be given generic or subgeneric status. Also there has been considerable shifting of species between supra-specific groups. The early taxonomists such as Fabricius (1805) and Walker (1857, 1865) used one genus (*Dacus* Fabricius). Tryon (1927) also used genera (without subgenera) while Malloch included species in four subgenera of *Dacus*. Perkins (1937, 1939) and May (1963) insisted on using genera but Hardy (1951, 1955) and Drew (1972) used two genera and a series of subgenera of *Dacus*. Perkins and May did not present sound taxonomic arguments for rejecting the subgeneric concept. The only reason given by Perkins (1937) was that 'the Dacinae contained so many species, is so widely distributed and is so important that it should be divided into clearly defined genera'. The argument of May (1963) was equally vague, stating that the subfamily was naturally divided into two groups on the basis of fusion or non-fusion of abdominal terga. Hardy (1951) presented reasons of more taxonomic significance stating that it was not sound practice to establish genera on some of the available characters such as single chaetotaxic characters which vary within species and secondary sexual characters (e.g. pecten of cilia on abdominal tergum III of male).

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Munro (1984) has added considerable confusion to the group by dividing a comparatively small African fauna of 175 species into 45 genera many of which are based on characters that have little or no significance at the species level e.g. face colour and facial spots, presence or absence of anal stripe in wing, width of costal band in wing, presence or absence of post-sutural yellow vittae, presence or absence of yellow on hypopleural calli, presence or absence of microtrichia in cell M and leg colour patterns. This classification of Munro cannot be applied to the much larger South-East Asian and South Pacific fauna. It is clear that a great deal of study remains to be done if a worldwide classification is going to be achieved.

The characters most commonly used at the generic/subgeneric level are as follows:

Head. The sum of lengths of antennal segments compared with vertical length of head.

Thorax. Presence or absence of scutellar, prescutellar, supra-alar and humeral bristles.

Abdomen. Abdominal terga fused or free; abdominal shape i.e. strongly petiolate with length of tergum I equal to or greater than width, to elongate oval and oval with the length of tergum I less than width; presence or absence of a pecten of cilia on posterolateral corners of abdominal tergum III; length of posterior lobe of surstylus on male genital segment; size of concavity on posterior margin of abdominal sternum V of male.

5 SPECIES LEVEL CHARACTERS

In all subgenera the characters most commonly used to define species are colour patterns. In the Tephritinae, Trypetinae and Schistopterinae most species have distinctive colour patterns across the wing. These remarkable patterns are significant in courtship and mating behaviour and are the primary characters used to identify species. Other characters used are colour patterns on the face, antennae, mesonotum, legs and abdominal terga. In the Dacinae where most species do not possess elaborate wing colour patterns the following characters are used:

Head. Face colour including presence or absence of facial spots.

Thorax. Width of coloured costal band on wing, presence or absence of other dark colour patterns on wing, colour of costal cells and presence or absence of dense microtrichia in these cells; colour of mesonotum; presence or absence, shape and size of the yellow longitudinal vittae on the mesonotum; size of the mesopleural stripe; presence or absence of a yellow band connecting the humeral and notopleural calli; colour of the humeral and notopleural calli; colour of the scutellum; colour of legs.

Abdomen. Colour patterns on abdomen particularly terga III to V; shape of the tip of the apical segment of the ovipositor and shape of spicules (scales) at the distal end of the second segment of the ovipositor, as seen under the scanning electron microscope; pattern of teeth and ridges on the male surstyli and claspers under the scanning electron microscope.

6 DISCUSSION

The taxonomic characters presently used in the Tephritidae are a mixture of reliable and less reliable ones. Further investigation is required into the generic/subgeneric character states in the Dacinae with the aim of developing an acceptable classification of the entire world fauna. It is becoming increasingly evident that we are now faced with a very large number of species and many sibling (or cryptic) species. The definition of these cryptic species is going to require intensive research into the genetic characters e.g. cytology and tissue enzyme (isozyme) patterns, biological characters e.g. mate recognition and sterility experiments, gathering biological information such as host records, the chemistry of male pheromones particularly in the Dacinae, scanning electron microscopy of significant body structures such as the female ovipositors and male surstyli and claspers. This approach was recently applied to the study of two cryptic species of the *Dacus tryoni* complex in Australia (Drew and Lambert, 1986).

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Chapter 1.2 The Taxonomy and Distribution of Tropical and Subtropical Dacinae (Diptera: Tephritidae)

R.A.I. DREW

1 INTRODUCTION

The Dacinae are distributed throughout the tropical and subtropical regions of the world and, except for the African and American continents, they are endemic to the tropical and subtropical rainforests. These forests contain a very diverse flora comprised of thousands of species. Webb and Tracey (1981) listed 545 plant genera in Australian rainforests and 750 in Papua New Guinea lowland and lower montane rainforests, 400 of which are not recorded in Australia. It is in association with this very diverse habitat that the Dacinae have speciated, utilising the soft fleshy fruits for larval food.

Considering the known fauna and taxonomic work presently being undertaken the Dacinae probably contains at least 800 species (Africa 200, Asia/South East Asia 300, South Pacific region 300). Papua New Guinea with some 200 species probably has more than any other single land mass and appears to be in the centre of origin of the group.

The first species of Dacinae to be described were *Musca ferruginea* Fabricius (1784), *Musca oleae* Gmelin (1790) and *Dacus armatus* Fabricius (1805). From these early studies a large number of entomologists have been involved in describing species and developing supraspecific groupings. Francis Walker (1857, 1859, 1860, 1861, 1862, 1864, 1865) described species from material collected on the voyages of Alfred Russel Wallace but he had confused generic and family concepts (Hardy, 1959).

In recent times large sections of the fauna have been described and revised by Hardy (1973, 1974, 1977) for South East Asia, Drew (1971, 1972a, 1972b, 1973, 1974) for the South Pacific Region and Munro (1984) for the African continent.

In this chapter the present status of our knowledge of the taxonomy of Dacinae will be reviewed.

2 SUBFAMILY CLASSIFICATION

The definition of the subfamily is based primarily on antennal segment 3 elongate, reduced chaetotaxy on the head and thorax, an elongate apical lobe extension on cell Cu, dense microtrichia at end of this lobe in males, a pair of shining spots on tergum V, usually with a pecten of cilia on posterolateral margins of tergum III in males and females with two coiled spermathecae (Hardy, 1973, 1974). This definition has been widely accepted by most dipterists and, except for the occasional borderline species, it delineates a distinct group and is clearly workable. In contrast, Munro (1984) elevated the group to family status and redefined it as having five terga in the dorsum of the abdomen,

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tergum and sternum VI in the female forming a separate collar around the ovipositor, a pair of shining spots on tergum V, a pair of glands on anterior corners of sternum II, wing vein R_{2+3} close to costa, cell M wide and hyaline, anal cell extended into a lobe, subcosta ending bluntly with a short darkened streak directed towards costa, females with two spermathecae. Munro also gave supplementary characters as genal bristle present, 1 *s.or.* and 2 *i.or.* bristles present, reduced chaetotaxy of head and thorax, antennae 3-segmented and with an arista, yellow markings on thorax well developed, anterolateral knobs on tergum I each with a gland, aedeagus characteristic. This is a departure from the standard family level characters in Diptera which are mainly major differences in wing venation. Munro also does not make clear how this new family definition relates to those for the other close dipteran families. The major problem in raising the Dacinae to family level is that it weakens the generic definitions by reducing the generic level characters to those that are even questionable at species level. It is doubtful if the classification of Munro will be widely accepted particularly as family and subfamily definitions are generally required to cater for the worldwide fauna and not for that of one continent.

3 GENERIC/SUBGENERIC CLASSIFICATION

It is at this level that taxonomists have had greatest difficulty in developing a widely accepted classification that would encompass most of the worldwide fauna. A very large number of genera and subgenera have been defined but the basic problem of an inadequate number of valuable characters still persists.

Although the very first two dacine species described were placed in genus *Musca*, the commonly used and longest standing generic name has been *Dacus* Fabricius. At the beginning this genus was used to pool a conglomeration of species now belonging to various families e.g. Tephritidae, Otitidae, Platystomatidae. As more and more species were described it was necessary to define more supraspecific groups. Some workers insisted on making all such groups genera (e.g. Perkins, 1937; May, 1963), while others used two genera with most supraspecific groups being subgenera of *Dacus* (Hardy, 1951, 1955; Drew, 1972a). The classification most widely used at present is a division of the subfamily into two genera viz. *Callantra* Walker and *Dacus* and then the subsequent division of *Dacus* into subgenera. The finding of valuable characters on the male genitalia and abdominal sternum V (Drew 1972a) has assisted in defining more stable subgenera but this has still not overcome the problems raised by Hardy (1951, 1955) that we use characters based on one sex and also single chaetotaxic characters. The latter are a problem especially the supra-alar bristles which can be present or absent in the one species. This particular chaetotaxic character is used to separate subgenus *Afrodacus* Bezzi (*sa.* bristle absent) from subgenus *Bactrocera* Macquart (*sa.* present). It is most likely that some species presently placed in *Afrodacus* are just aberrant *Bactrocera*.

In taking an overview of the Dacinae, some interesting facts are now coming to hand that are leading to a new classification. An examination of the distribution of numbers of species indicates that the centre of origin and prolific speciation is in the Papua New Guinea region. The South East Asian and South Pacific fauna (some 450 known species) is unique in having free abdominal terga (except for approximately 50 species) while the African fauna is equally unique in having 175 known species, all of which have fused abdominal terga (except for 5 species). The known endemic plant hosts of the African species belong primarily to two families viz., Asclepiadaceae and Cucurbitaceae. The

known endemic plant hosts of the South East Asian and South Pacific species with fused abdominal terga are Asclepiadaceae and Cucurbitaceae which generally grow away from the rainforests which contain most of the hosts of the South Pacific Dacinae. Consequently the initial division of the subfamily based on fusion and non-fusion of abdominal terga appears to be much more significant geographically and biologically than that presently used to divide the group into *Callantra* and *Dacus*. This will also overcome another problem in that we now have enough 'Callantra' like species with so much variation in abdominal shape and antennal length that it is difficult to maintain this as a well defined group warranting generic status. Consequently in a monograph presently being prepared on the South Pacific Dacinae in which almost 300 species are being treated (Drew unpub. data) a new classification is used based on the division of the subfamily into two genera:

(a) *Dacus* — species with fused abdominal terga, mostly African, primarily infesting endemic Asclepiadaceae and Cucurbitaceae.
(b) *Bactrocera* — species with free abdominal terga, mostly South East Asian and South Pacific, primarily infesting endemic tropical and subtropical rainforest fruits.

In this classification, the difficult 'Callantra' types will be placed in subgenera of *Dacus* based on characters not befitting of generic status. *Callantra* will be one subgenus. This new classification will mean that our major Asian and Pacific pest species will now be placed in genus *Bactrocera* and not *Dacus* which will be a problem in our economic entomology 'world'. However we cannot ignore the mounting taxonomic, geographic and biological evidence that comes through the collection and knowledge of increasing numbers of species. This is an advantage that earlier taxonomists did not have.

The new generic classification of Munro (1984) is not relevant to the South East Asian and South Pacific fauna which contains the bulk of the species. 6 of the 12 characters upon which it is based are only applicable at the species level and another two are of no value at that level in the Asian and Pacific fauna. If indeed the African species can be classified on the characters proposed by Munro then it proves that that fauna is very unique and distinct from the rest of the world fauna.

From the information explained above, it is most likely that the Dacinae originated in the Papua New Guinea area and speciated prolifically. An ancestral form with fused abdominal terga from the South East Asian/Pacific region was probably the precursor of the African fauna.

4 SPECIES LEVEL STUDIES

Good progress has been made at this level. Following on the long line of workers and species descriptions started by Fabricius in 1784, Hardy (1951, 1954, 1955, 1970, 1973, 1974, 1977) and Hardy and Adachi (1954) have described many species and produced an excellent catalogue of the South East Asian fauna. Drew (1968a, 1968b, 1971, 1972a, 1972b, 1979), Drew and Hancock (1981) and Drew and Hardy (1981) have described a large number of South Pacific species. The known South Pacific fauna will be increased by more than 100 species when the current monograph presently being prepared is published (Drew, unpublished data).

The major difficulties presently being encountered at this level are in the identification of sibling (or cryptic) species. It is now evident that there are large numbers of such species not separable on the standard external mor-

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phological characters. We are now encountering, for example, species very close or identical on external morphological characters but which occupy different host plants and/or different geographic regions. We must now address this problem and make definite progress towards defining these species. Examples of these are *Dacus opiliae* Drew and Hardy (a sibling species of the dorsalis complex), *Dacus tryoni* (Froggatt) and *Dacus aquilonis* (May) (two very closely related species in the tryoni complex). The latter two species have been the subject of an intensive study using genetic and scanning electron microscope techniques (Drew and Lambert, 1986). Such studies in the Dacinae are now essential in order to further define the species and relate them taxonomically to the different biological characteristics now being observed.

The value of polytene chromosomes to taxonomy has been well illustrated in the Drosophilidae. The first successful attempt at preparing these chromosomes in Tephritidae was in *Ceratitis capitata* (Bedo, 1986). In this work, polytene chromosome preparations were made from trichogen cells at the bases of the lower pair of superior orbital bristles in males and from thoracic trichogen cells in both sexes. Further development of these techniques will be of great value in taxonomic studies on sibling species.

The value of biological and ecological studies to taxonomy at the species level cannot be underestimated. Two areas of investigation will eventually make great contributions to our understanding of the dacine species, viz., larval and adult feeding. As we research and understand more the host fruit records, the bacterial diets of the larvae and adults, the complex chemical attractants produced by the bacteria in the host plants and the influence of these odours on mating and oviposition behaviour, then we will develop a clearer understanding of the speciation processes that continue within the populations and a better understanding of the species themselves. Conversely it is clear that a sound knowledge of the taxonomy of the group will assist in ecological research and in understanding the ecology of the species.

In contrast to the temperate subfamilies, the Dacinae are restricted to an area of the world which includes a large number of developing countries. There is major crop loss in some areas and restriction on trade in others. The socio-economic impact of fruit flies on these countries is enormous and demands that increasing resources be expended in fruit fly research. There is still a major need for more taxonomic research to define the species that are major pests and in most countries there is a complete lack of reference collections for identification purposes. Without such research and facilities, Plant Quarantine and fruit fly control programmes will be severely hindered.

For such research efforts, people well trained in taxonomy are required. In the history of dacine taxonomy it is very clear that because fruit flies caused major economic impacts on society, there was a rush to identify the species involved by the economic entomologists of the day. These worked tirelessly but left a legacy of taxonomic problems and misidentifications. Large amounts of funding and applied research were based on much of this work. This problem is particularly evident in Australia where Froggatt, Tryon,Perkins and May were confronted with evolving and increasing fruit fly problems in developing horticulture industries. If we learn from this historical review we must ensure that trained taxonomists are made available to undertake research in developing countries.

5 DISCUSSION

Good progress is being made on the basic description of species in some countries. In others within South East Asia and the South Pacific region

further work is essential together with the establishment of good reference collections. Extensive research in applying new genetic and scanning electron microscope techniques is long overdue in order to distinguish the complexes of sibling species.

The generic/subgeneric classification is also badly in need of revision and this will demand further investigation.

Biological and ecological research in specific areas such as larval and adult feeding will also make major contributions to our understanding of species.

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Taxonomic studies on oriental fruit fly

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Abstract

The Dacus dorsalis complex of fruit flies in South East Asia is an example of the prolific speciation that has occurred in the Dacinae. The complex consists of a large number of species, some still unknown. Of those that are known, some have economic pest status while others have no such reputation. Five species have been bred from commercial fruits, 2 in the Philippines, 2 in Malaysia and Dacus dorsalis Hendel. D. dorsalis was first described from Taiwan and its distribution and pest status are now uncertain. Dacus occipitalis Bezzi has been recorded only from the Philippines and is a pest species. Dacus pedestris Bezzi, known only from the philippines, is not a pest. In these studies, the type series of D. dorsalis, D. occipitalis and D. pedestris have been studied. The identity of the species in Hawaii and Surinam need clarification. The results of these studies have two significant economic considerations - (1) the development of Plant Quarantine guidelines and post-harvest disinfestation regulations, and (2) the use of appropriate cultures in Sterile Insect Release Method eradication programmes.

Introduction

Sibling species are common within the Dacinae and their existence has been illustrated by Drew (in press) who defined 20

species complexes in the South Pacific Region. The best known is the tryoni complex in eastern Australia containing Dacus tryoni (Froggatt) (Queensland fruit fly) and several other pest species.

The major pest in South East Asia has been called Dacus dorsalis Hendel (Hardy, 1969, 1973, 1974; Drew, 1978). It is now evident that commercial fruit infestations in the region are due to a number of closely related species within a complex that we can name the dorsalis complex. The taxonomy of some of these species has been studied in the ACIAR project entitled "Fruit flies in Malaysia". Although the project has been centred on Malaysia, it was important to study populations in other countries and particularly those that are the type localities of some species.

Materials and Methods

Specimens were collected at localities in Indonesia, Malaysia and the Philippines. Where possible, material was reared from hosts, collected at male lures (cue lure and methyl eugenol) and hand collected in host plants. Males for pheromone analyses were frozen live in dry ice and subsequently stored at -100°C until dissection of the pheromone glands.

Type specimens of D. dorsalis, D. occipitalis and D. pedestris were received on loan from the respective museums at which they are held.

The various populations were compared in the following studies -

(1) Morphology, including scanning electron microscopy and measurements of ovipositors;

(2) Male Pheromones - GCMS analyses of pheromones dissolved in pentane; this has been done for the 2 Malaysian, one Philippine and the Hawaiian populations;

(3) Mating Behaviour in host plants; this has been done for the 2 Malaysian populations.

Results

The dorsalis complex is best defined as follows: Bactrocera species with clear wing membrane except for a narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells colourless or with a pale tint and without dense microtrichia, mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a narrow dark basal band, abdominal terga III - V orange-brown or red-brown with a medial longitudinal dark band and variable dark markings on base of tergum III and lateral margins of all 3 terga, males attracted to methyl eugenol.

The following 5 species are of economic importance in South East Asia.

Dacus dorsalis Hendel

Type Locality: Taiwan

Diagnosis: Broad lateral postsutural vittae; narrow costal band; pale coloured legs; abdominal terga III-V with a narrow medial longitudinal dark vitta forming a T with a transverse dark band across anterior margin of tergum III, anterolateral corners of terga IV and V with triangular dark

markings. Ovipositor with aculeus needle shaped; spicules elongate and narrow with 7-12 uneven dentations.

Dacus occipitalis (Bezzi)

Type Locality: Philippines (Los Banos, Mt. Makiling, Mt Banahao, Manila, Batbatan Is., Davao (Mindanao)).

Diagnosis: Broad lateral postsutural vittae narrowing slightly to end at pa. bristle; broad costal band; legs dark coloured; abdominal terga III-V with a broad medial longitudinal dark vitta forming a T with a transverse dark band across anterior margin of tergum III, anterolateral corners of terga IV and V with rectangular dark markings. Ovipositor with aculeus blunt; spicules rounded with 5-10 small dentations.

Philippine B

Distribution: Widespread throughout Philippines.

Diagnosis: Broad lateral postsutural vittae; broad costal band; legs dark coloured; abdominal terga III - V with a narrow medial longitudinal dark band forming a T with a transverse dark band across anterior margin of tergum III, anterolateral corners of terga IV and V with triangular dark markings. Ovipositor with aculeus needle shaped; spicules shell shaped with 6-18 dentations.

Malaysian A

Distribution: Widespread in Peninsula Malaysia.

Diagnosis: Broad lateral postsutural vittae; broad costal band; legs dark coloured; abdominal terga III-V with a broad medial longitudinal dark band forming a T with a transverse dark band across anterior margin of tergum III, anterolateral corners of terga IV and V with rectangular dark markings. Ovipositor with aculeus needle shaped; spicules shell shaped with 12-15 dentations.

Malaysian B

Distribution: Widespread in Peninsula Malaysia.

Diagnosis: Broad lateral postsutural vittae; narrow costal band; legs dark coloured; abdominal terga III-V with a narrow medial longitudinal dark band forming a T with a transverse dark band across anterior margin of tergum III, anterolateral corners of terga IV and V with triangular dark markings. Ovipositor with aculeus needle shaped; spicules long and narrow with 10-24 dentations.

Male Pheromone Analyses

The analyses of the pheromone gland extracts have shown that the Malaysian A pheromone consists primarily of a ketoalcohol that is not present in the other species. The Malaysian B pheromone consists of very small quantities of an amide and spiroketals.

The Hawaiian population pheromone is similar to Malaysian B but does contain small amounts of additional chemicals. The specimens of Philippine B were field collected at methyl eugenol and consequently contained large quantities of methyl eugenol metabolites which blanked out the other chemicals.

Discussion

There are 5 dorsalis complex species that can be identified and which are pests of commercial fruits in South East Asia. These are D. dorsalis, D. occipitalis, Philippine B, Malaysian A, Malaysian B. D. dorsalis has not been collected in the Philippines and Malaysia in spite of extensive collecting in those countries. The geographic distribution and pest status of D. dorsalis is unknown. The four species, other than D. dorsalis, are major pests although Philippine B and Malaysian A are the most prominent.

Studies reported by Drew (1987) and Drew and Lloyd (1987) have shown that mating occurs within the host plant and that mate recognition in the Tephritidae is closely associated with the host plant and the release of male pheromones during the pre-mating (or courtship) period. Field observations in Malaysia (Drew, unpub. data) have shown that Malaysian A and Malaysian B mate in the same commercial host plants (eg. guava, starfruit) but never inter-breed. The markedly different male pheromones are probably significant factors in mate recognition in these species. Further pheromone analyses of the Philippine B and Hawaiian populations are necessary before the present studies are finalised. The pheromone analyses appear to be valuable in assisting to define sibling species of Dacinae.

Extensive studies are still required before names can be placed on three of the species, and in order to establish the geographic distributions of all species. Studies on the populations in Hawaii and Surinam are needed before they can be defined.

Countries planning SIRM eradication programmes will need to be certain of the identity of the infestation to be eradicated. For example, purchase of sterile pupae from the USDA facility in Honolulu would only be feasible if that species was the one requiring eradication.

With respect to quarantine legislation for post-harvest disinfestation treatments, it may be feasible to establish treatments for the dorsalis complex and not the individual species.

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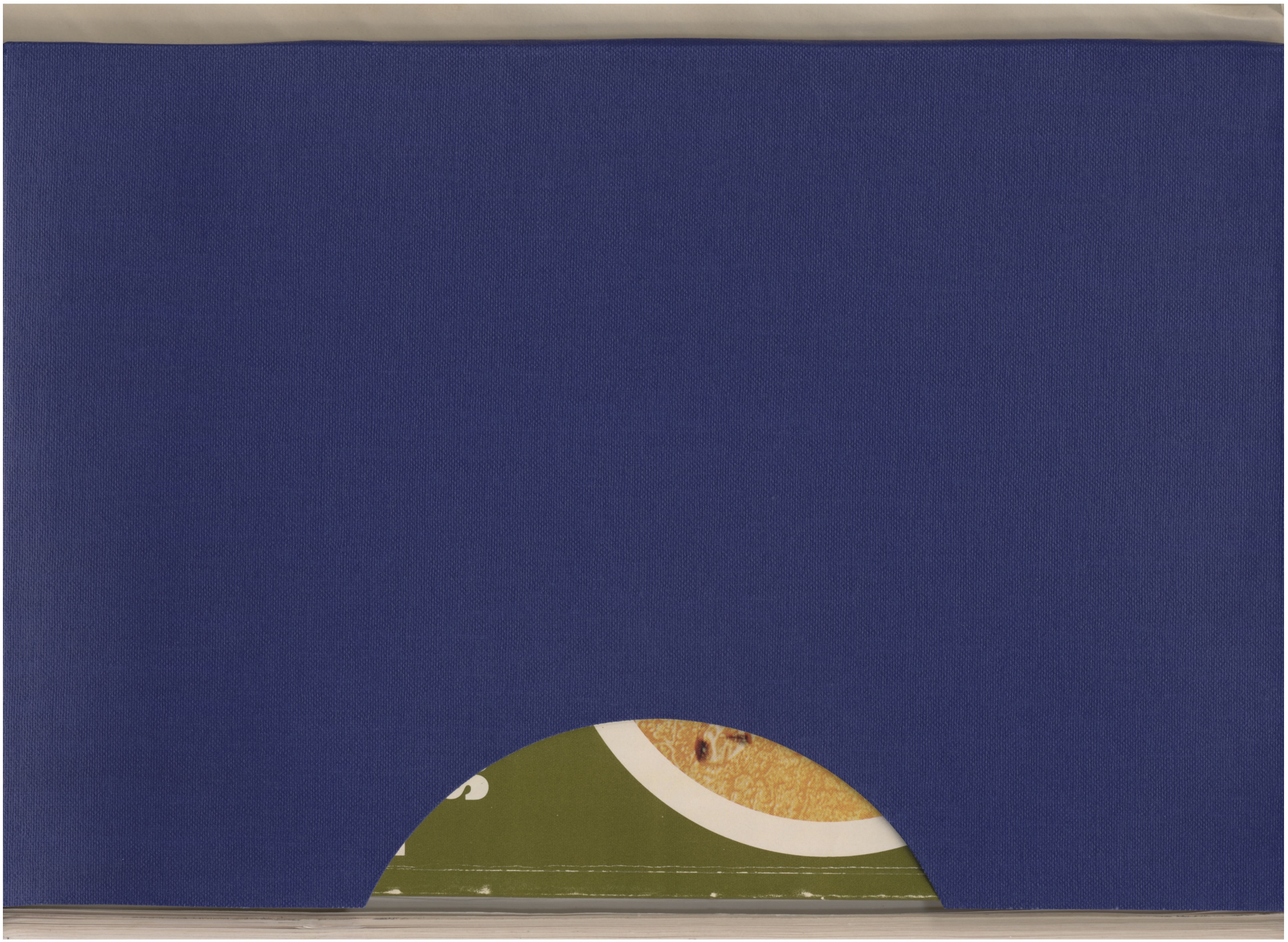

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Economic Fruit Flies of the South Pacific Region



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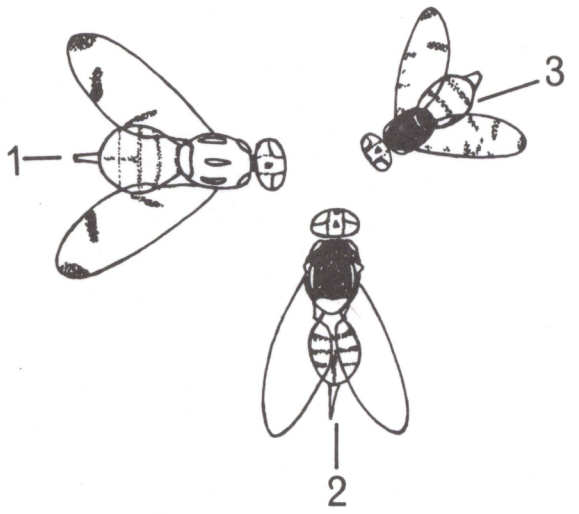

1. *Dacus (Zeugodacus) cucurbitae* Coquillett
2. *Dacus (Bactrocera) dorsalis* Hendel
3. *Ceratitis capitata* (Wiedemann)

Cover photograph was provided by the Department of Entomology, University of Hawaii.

ECONOMIC FRUIT FLIES OF THE SOUTH PACIFIC REGION

ECONOMIC FRUIT FLIES OF THE SOUTH PACIFIC REGION

by

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PREFACE

The first edition of this publication was designed to highlight the importance of fruit flies to horticultural industries in the South Pacific region and to emphasise the quarantine significance of movement of species between regions and countries. Sections on the use of male sterility and chemicals in eradication and suppression of fruit fly populations were included. This allowed the production of a volume consolidating relevant knowledge on species, hosts, taxonomy, distribution and appropriate eradication and suppression technology.

Since publication, an amount of new information in each area has become available. This fact and wide demand for the first edition has prompted the authors to up-date their data which are now presented in a second edition.

One of the more significant changes has been the omission of *Dacus dorsalis* Hendel as a species present within Australia. Research in the interim proved that the insect previously considered to be that species is a quite distinct fly described as *Dacus opiliae* by Drew and Hardy in 1981.

Other changes include the presentation of a new key to the Dacine species of the region following further study by the senior author. For example, *Dacus aquilonis* (May) from the Northern Territory is now discussed and a number of species have been re-defined following access to additional overseas type material.

Further references from recent literature are included and information, available following a 1980 survey in Papua New Guinea, on the economic potential of a number of additional species of fruit fly is summarised.

Personally and on behalf of the administrators in both Australian Quarantine and Technical research areas, all of whom have encouraged the authors in the preparation of the text, I wish to thank them for their efforts. I also wish to record our thanks to the great many people both within Australia and elsewhere who have assisted in the collection of specimens and in making materials available for study.

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SECTION I TAXONOMY

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(1) PREPARATION OF MATERIAL FOR TAXONOMIC STUDIES

ADULTS—Previously, damage has been caused to valuable adult fruit fly specimens in collections through incorrect pinning methods. Many important taxonomic characters exist on the thorax and these are destroyed by placing large pins through this area.

The best method of setting adult specimens for holding in permanent collections is to place a stainless steel micropin dorsoventrally through the thorax (in the mesonotal area), and then stage the steel on a piece of polyporus pith about 1.2 cm long. The pith can then be supported in collection drawers (or storage boxes) by No. 5 insect pins. This method results in a minimum of damage to the specimen.

Equipment necessary for pinning adult specimens may be obtained in Australia from—Australian Entomological Supplies, 35 Kiwong Place, Yowie Bay, New South Wales, 2228.

The equipment mentioned is as follows:—
"Minuten" stainless steel pins (micropins),
Polyporus pith (about 3 mm square),
No. 5 Nylon headed pins (Catalogue No. 701D).

LARVAE—Identification of larval specimens to species is extremely difficult and not yet possible in most cases. For this reason, when larvae are collected in fruit it is generally best to rear them through to the adult stage for identification, as described in Section IV (5).

If collected larvae must be killed, they should be placed in hot Dietrich's fixative solution (60 parts water, 30 parts 95 per cent ethanol, 10 parts formalin, 1 part glacial acetic acid) for 2 hours and then transferred to 80 per cent ethanol.

Also it should be noted that for the few species that can be identified as larvae the identification is based on characters of mature or final stage larvae.

GENITALIA AND ABDOMINAL STERNUM PREPARATION—In the male, the shape of abdominal sterna I and V and certain structures on abdominal segment IX (the genital segment) have been found valuable at the generic level (Drew, 1972a) and parts of the ovipositor have provided useful characters at the species level (Hardy, 1973; 1974).

In addition, measurements of some male endoskeletal structures in the genital segment have been found useful in assessing the physiological age of specimens (Drew, 1969).

Some of the characters on the male genital segment and abdominal sterna can be studied *in situ*. If additional microscope examination is required, the methods of preparation described below should be found suitable. Methods of preparation necessary for studying the ovipositor and the male endoskeletal structures are also described.

Male endoskeletal structures:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes, allow to soak in this solution for 12-24 hours;
(b) cut abdomen open and clean out;
(c) wash abdomen in 10 ml water containing a few drops of 10 per cent acetic acid;
(d) wash abdomen in three different sets of distilled water;
(e) stain in mercurochrome stain for 10 minutes (a 1 per cent solution of stain powder mixed in water);
(f) place in absolute alcohol for 2-3 minutes;
(g) place in clove oil for 15 minutes;
(h) dissect the structures from the abdomen and mount in canada balsam—the flat section of the genitalia (the fultella) should be mounted on a flat glass microscope slide; the three-dimensional sections of the genitalia should be mounted in a glass cavity microscope slide (in the cavity they can be moved into a suitable position before they set firm, in order to facilitate subsequent examination).

If mounts of the fultella are required for measuring for age studies, staining in chlorazol black E stain was found to be better than mercurochrome.

Male abdominal sterna:

(a) to (d) as for male endoskeletal structures;
(e) stain in chlorazol black E stain for 5 minutes (a 0.5 per cent solution of stain dissolved in 70 per cent ethanol);
(f) place in absolute alcohol for 2-3 minutes;
(g) place in clove oil for 15 minutes;
(h) mount sterna on a flat glass microscope slide in canada balsam; the sterna are small and surrounded by membrane, thus allowing the entire ventral area (including all sterna) to be removed from the abdomen in one layer for mounting on a slide.

Ovipositor:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes;
(b) wash thoroughly in water;
(c) place in chloralphenol or phenol until cleared enough to allow suitable differentiation of characters under the microscope (chloralphenol is a mixture of equal parts of chloral hydrate and phenol); this process usually takes about 15 minutes;
(d) mount in euparal on a flat glass microscope slide.

Male genital segment:

(a) dissect off abdomen, boil in 10 per cent potassium hydroxide for 5-10 minutes, allow to soak in this solution for 12-24 hours;

either

(b) treat as for (b) and (c) in ovipositor technique,

or

(c) stain with mercurochrome stain as for male endoskeletal structures (b) to (g);

(d) dissect the genital segment from the remainder of the abdomen and mount in a glass cavity microscope slide, either as for (d) in the ovipositor technique or (h) in the male endoskeleton technique; this three-dimensional structure can be moved around in the cavity before setting until the required area of view is visible.

(2) STUDY OF MATERIAL

Some characters important in identification, namely, male and female genitalia, thoracic bristles and microtrichia in the costal cells require clear, high power, stereo microscopy. For example, often the bristles are broken off and so high power examination is required to see if they were present or always absent. It is, therefore, impossible to identify most fruit fly species without the aid of a good quality stereo microscope.

Thoracic colours are often difficult to see under the microscope due to the reflection of light off minute hairs on the mesonotum. This problem can be overcome by turning the specimen with the head pointing away from the light source and wetting the mesonotum with absolute alcohol using a fine hair brush.

Important characters occur on the head, thorax, abdomen, wings and legs. For this reason, specimens should be maintained in the best possible condition and particular care should be taken during transportation of collected material from the survey areas to the laboratory.

(3) MORPHOLOGY

This section is devoted to an explanation of the morphological characters of adult fruit flies, with particular reference to the taxonomic characters.

HEAD (Figures 1, 2)

Frons—that area on the anterior surface of the head, bounded by the eyes laterally and between the black ocellar triangle (which is on the dorsal margin of the head) and the antennae.

Antero-medial hump—a small hump in the centre of the frons.

Superior fronto-orbital bristles (s.or.)—the most dorsal pair of bristles on the frons—there is always only one pair in the subfamily Dacinae (tropical fruit flies).

Inferior fronto-orbital bristles (i.or.)—the two or three pairs of bristles that occur on the frons below the *s.or.* bristles.

Lunule or frontal lunule—a small raised area between the antennal bases and the frons.

Vertex—the dorsal area of the head between the eyes, frons and occiput.

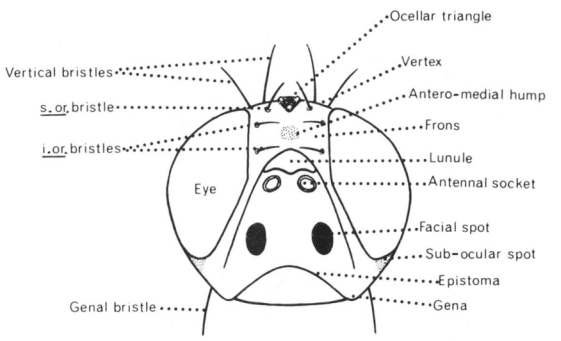

Figure 1—Head of fruit fly (Tephritidae: Dacinae)—anterior view

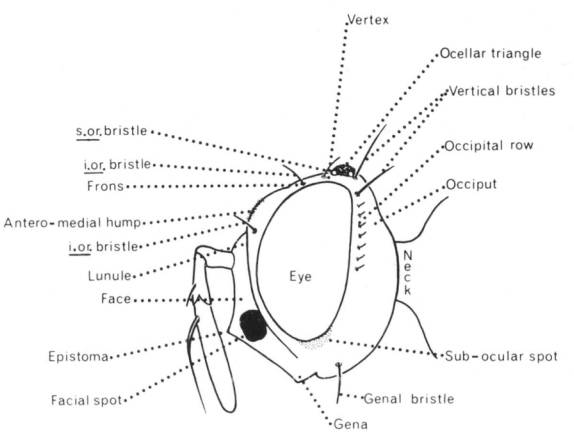

Figure 2—Head of fruit fly (Tephritidae: Dacinae)—lateral view

Face—an inverted V-shaped area on the anterior surface between the antennae and the ventral margin of the head (epistoma).

Facial spots—two dark spots are often present, one on each ventrolateral corner of the face. The presence or absence of these spots is a valuable species character. In some species the face is entirely black.

Epistoma—the ventral margin of the face.

Genae—the area of the head on each side below the eyes.

Sub-ocular spots—a dark spot on each gena adjacent to the eye margin.

Occiput—the whole posterior area of the head below and behind the eyes.

Occipital rows—a row of bristles on the occiput along the posterior margin of each eye.

Antennae—the antennae are 3-segmented and possess an arista (elongate bristle) on the dorsal surface of each apical segment (segment III). The ratio of the combined lengths of the three antennal segments to the vertical length of the head is an important generic character.

THORAX (Figures 3, 4, 5)

Humeral calli—rectangular protuberances on the anterolateral corners of the dorsal surface of the thorax. These are part of the mesothorax.

Notopleural calli—raised triangular protuberances on the notopleura, between the humeral callus and the base of the wing. There is one notopleural callus on each side of the thorax. The colour of the humeral and notopleural calli is an important taxonomic character.

Hypopleural calli—two rounded raised protuberances on each side of the thorax posteroventral to the wing base.

Postnotum—the plate on the posterior end of the thorax below the scutellum and between the hypopleural calli.

Sternopleura—the region below the mesopleuron and pteropleuron and above the fore and mid coxae on each side of the thorax.

Scutellum—a triangular section cut off by an impressed line from the posterior margin of the mesonotum.

Bristles—sc. = scutellar bristles—2 or 4 bristles on the scutellum.

prsc. = prescutellar bristles—2 bristles on the posterior margin of the mesonotum just anterior to the scutellum—these bristles may be present or absent.

p.sa. = posterior supra-alar bristles—a pair of bristles above the base of each wing, on the posterolateral corners of the mesonotum; in lateral view, one bristle is dorsal to the other and in line with the lateral post-sutural vitta.

a.sa. = anterior supra-alar bristles—a bristle directly above the base of each wing on the lateral margin of the mesonotum; these bristles may be present or absent.

mpl. = mesopleural bristles—a bristle on the mesopleuron below each notopleural callus.

npl. = notopleural bristles—a pair of bristles on each notopleural area—the posterior notopleural bristle is on the apex of the triangular notopleural callus and the anterior notopleural bristle is midway between the humeral and notopleural calli.

scp. = scapular bristles—four bristles along the anterior margin of the mesonotum.

The number of *sc.* bristles and the presence or absence of *prsc.* and *a.sa.* bristles are valuable taxonomic characters at the subgeneric level.

Mesopleural stripes—a yellow band on each lateral surface of the thorax which covers the posterior margin of the mesopleuron, the anterior margin of the pteropleuron and usually continues onto the upper margin of the

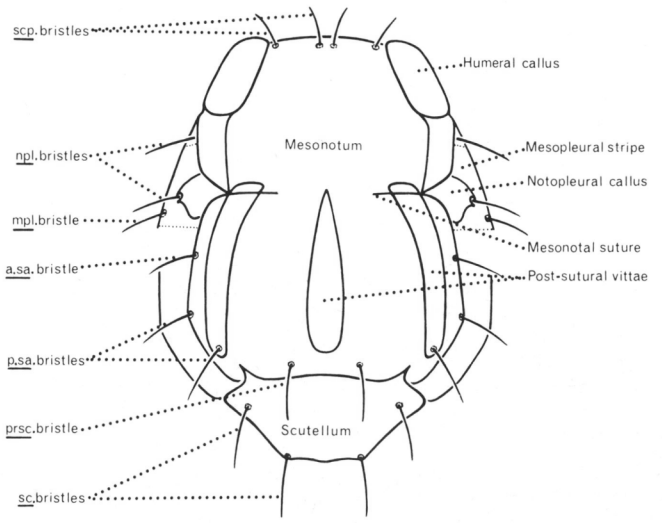

Figure 3—Thorax of fruit fly (Tephritidae: Dacinae)—dorsal view

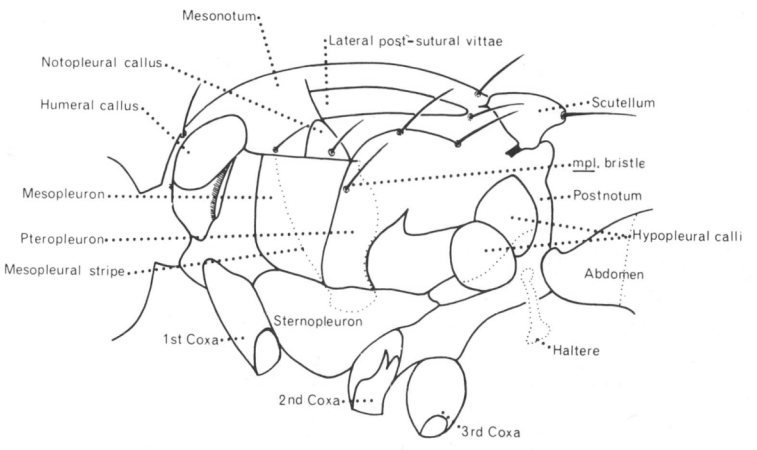

Figure 4—Thorax of fruit fly (Tephritidae: Dacinae)—lateral view

sternopleuron. The shape and size of these stripes are important species characters, especially their width in relation to the humeral calli.

Lateral post-sutural vitta—a yellow band (or stripe) along each lateral margin of the mesonotum; these stripes vary in shape and size, may begin at or anterior to the mesonotal suture and end before, at or posterior to the upper *p.sa.* bristle. Also a lateral yellow band often connects the humeral and notopleural calli.

Medial post-sutural vitta—a single median yellow band running along the mid line of the mesonotum.

The presence or absence of these post-sutural vittae, their shape, size and length in relation to the upper *p.sa.* bristles are valuable taxonomic characters.

Mesonotal suture—an impressed line on the mesonotum, running from the inner margin of each notopleural callus towards the centre of the mesonotum. A triangular yellow band may run from each notopleural callus along the mesonotal suture.

Legs—the shape of the major leg segments (coxa, femur, tibia and tarsus) does not vary between species; the colour of these segments however, does often vary and is a valuable taxonomic character. In one species, *Callantra petioliforma* May, there is a row of spines along the ventral margin of the fore femora (Figure 53).

Wings—veins: the wing venation is reduced as a result of fusion of some veins. An explanation of the venation is best gained from studying Figure 5. Veins R_2 and R_3 are fused to give vein R_{2+3}, R_4 and R_5 fused to R_{4+5}, M_1 and M_2 fused to M_{1+2}, M_3 and M_4 fused to M_{3+4}, and CuA and 1A are fused at their extremities to give CuA+1A. There is usually a dense mass of microtrichia at the extremity of CuA+1A in males, but this is absent in females.

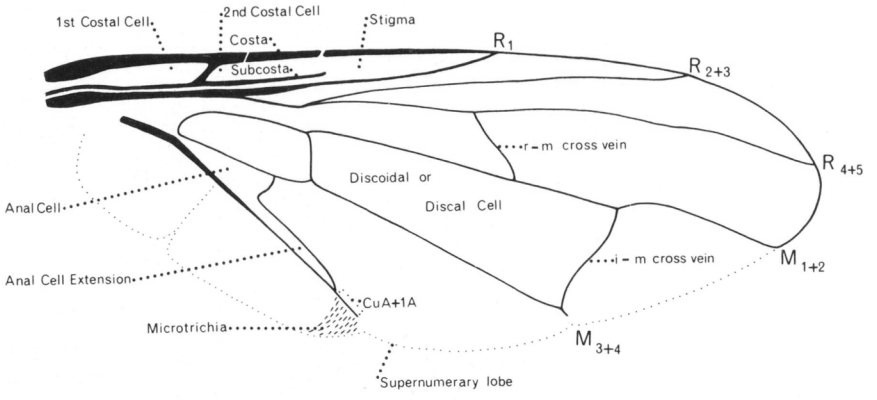

Figure 5—Wing of fruit fly (Tephritidae: Dacinae)

Important characteristics of the family Tephritidae are—(a) two breaks in the costal vein on the anterior margin of the wing above the second costal cell; and (b) the short, fine sub-costal vein in the second costal cell.

cells: the cells in the wing and the supernumerary lobe are illustrated in Figure 5. Within the costal cells there is often a mass of small microtrichia and the presence or absence of these is a specific character. The supernumerary lobe is reduced in size in the males of some species and in the females of all species. The presence or absence of colour in the costal cells is an important species character.

colour patterns: there are important taxonomic characters in the variations of colour patterns in the wing. These patterns are often termed infuscations because of their fuscous colouration. Within the subfamily Dacinae, there is almost always a fuscous costal band running around the costal margin from the wing base to the apex of the wing and a fuscous anal streak which runs through the anal cell and above the anal cell extension and vein CuA + 1A to the wing margin (Figure 52). There is considerable variation between species in the width of the costal band and in the numerous colour patterns that occur across the wing in addition to the costal band and anal streak. The costal band is classed as narrow if it is confluent with or overlaps vein R_{2+3} but does not reach vein R_{4+5}. It is broad if it is confluent with or overlaps vein R_{4+5}.

ABDOMEN (Figures 6, 7)

The general abdominal shape in dorsal view can be—(a) petiolate and clavate (club-shaped); (b) elongate-oval; or (c) oval. In the male there are five well developed abdominal segments, segments VI to VIII are absent, while segment IX exists as a reduced genital segment (Drew, 1969). Characters on segment IX and abdominal sternum V of the male are valuable at the generic

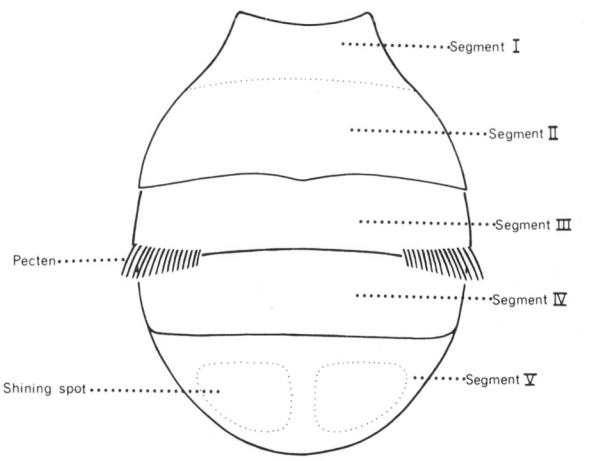

Figure 6—Abdomen of fruit fly (Tephritidae: Dacinae)—dorsal view

level. In the female, abdominal segments I to V are well developed, segment VI is absent while segments VII to IX are modified to form the ovipositor (Drew, 1969). Abdominal terga I to V are usually free but in a few species they are fused.

In the male of most species there is a pecten (or comb) of cilia on the posterolateral corners of tergum III, and a pair of large oval shining spots on tergum V.

Abdominal shape, fusion or non-fusion of abdominal terga, presence or absence of cilia on tergum III and variation in abdominal colour patterns, are all valuable taxonomic characters.

Hardy (1973, 1974) has demonstrated that characters on the apical segment of the female ovipositor (abdominal segment IX) are also good for species differentiation.

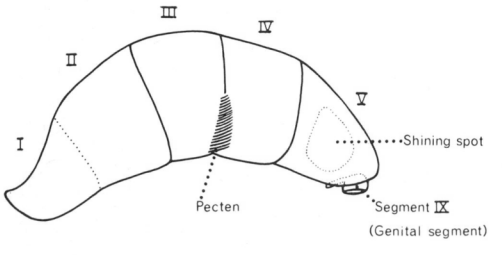

Figure 7—Abdomen of fruit fly (Tephritidae: Dacinae)—lateral view

COLOUR PATTERNS

Thoracic and abdominal colour patterns are depended upon for separation of fruit fly species and this causes many difficulties in identification of specimens. Within a species it is common to find extremely large variations in colour patterns (see Drew, 1974b: pp. 65, 71, 90) and this has been a cause of mis-identification by some workers. Such intra-specific variation must be understood and this can only be done by studying large series of specimens. Once such studies have been undertaken colour patterns become quite valuable taxonomic characters.

The main colours referred to in species keys are fuscous (dark brown, approaching black—a plain mixture of black and red), fulvous (tawny or brownish-yellow), black (dull or glossy), yellow, orange-brown, red-brown, brown.

(4) FRUIT FLY SPECIES OF ECONOMIC IMPORTANCE

In this section, all species of known economic or potential economic importance of Tephritidae (subfamily *Dacinae*) in the South Pacific region are discussed. It is important to realise that many of these species have the potential to become serious economic pests either in the regions where they presently occur (if horticulture is developed in these regions in future years) or in countries with already well developed horticulture (if such species are introduced to these countries).

It is hoped that information provided in this section will assist entomologists to identify readily the fruit fly species which present a serious threat to fruit and vegetable industries in the South Pacific area. The quick and accurate identification of these species is of vital importance to the application of control, suppression or eradication techniques. These techniques vary with each species and must be applied as soon as possible after the detection of a new introduction or outbreak.

Extensive fruit fly monitoring programmes in northern and eastern Australia have provided considerable data on the distribution of species. As a result, it is possible to give updated distribution records for most species. For species either new to Australia or with a wide distribution range, maps are presented.

In this section, subgenus *Dacus (Bactrocera)* Macquart is used instead of *Dacus (Strumeta)* Walker because *Strumeta* is a junior synonym of *Bactrocera* (Hardy, 1976). *Strumeta* has been used consistently as a subgenus of *Dacus* by most taxonomists involved with the subfamily Dacinae. However, the status of *Bactrocera* is now clear and this subgenus must be used for all species formerly placed in *Strumeta*.

Hardy (1951) showed that the species name *bilineatus* (Perkins and May) is preoccupied in the genus *Dacus* by *D. bilineatus* Walker. Hardy (1959) also showed that *D. bilineatus* Walker belongs to the genus *Dimeringophrys* Enderlein within the subfamily Trypetinae. Because *bilineatus* is a pre-occupied name, Hardy (1951) established a new name for the species described by Perkins and May. He named it *Dacus mayi* Hardy. In subsequent literature on Australian Tephritidae (May, 1953; 1957; 1963) the name *mayi* was overlooked and *bilineatus* used incorrectly. This has caused some confusion for later workers and this explanation is given for the use of *mayi* Hardy in the following section.

The known commercial hosts are also given for each species.

(A) Species within Australia—Some species in this section also occur in countries outside Australia.

Callantra aequalis (Coquillett)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Ayr (northern Queensland).

A large wasp-like species; facial spots large and elongate; thorax red-brown to fuscous; lateral post-sutural vittae absent; mesopleural stripes narrow; triangular yellow markings along anterior margin of mesonotal suture; humeral calli fuscous; notopleural calli yellow; scutellum yellow to fulvous; wing with a very broad fuscous costal band confluent with M_{1+2}; costal cells fuscous with microtrichia covering all of both cells; abdomen generally fuscous with a large oval red-brown spot on centre of tergum V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except large fuscous spots around orbital bristles and on antero-medial hump; latter covered with pale setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule red-brown to fuscous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with large, elongate black spots almost reaching to epistoma. *Genae* fulvous; large, dark fuscous sub-ocular spots present; bristles fuscous. *Occiput* red-brown, yellow along eye margin; occipital rows with 4-7 well developed fuscous bristles each side. *Antennae* red-brown; a strong red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura fuscous, tending red-brown below humeral calli. Mesonotum red-brown to fuscous with no dark markings. Yellow markings as follows: notopleural calli; narrow triangles running along anterior margin of mesonotal suture, with bases at notopleural calli and apices at inner margins of mesonotal suture; very narrow mesopleural stripes, each less than width of notopleural callus above, extending onto sternopleuron below as a small yellow spot, anterior margin straight; anterior corners of upper hypopleural calli (remainder fuscous); a broad band across centre of lower hypopleural calli (remainder fuscous). Humeral calli fuscous. Lateral post-sutural vittae absent. *Postnotum* red-brown to fuscous. *Scutellum* yellow to fulvous except for a broad triangular fuscous basal band. *Bristles: sc.* 2, *prsc.* absent, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; bristles generally weak and red-brown to fuscous. *Legs:* coxae and femora fuscous to dark fuscous, tibiae fuscous, tarsal segments fulvous; middle tibiae each with an apical black spur. *Wings:* costal cells fuscous, microtrichia covering all of both costal cells; reminder of wings tinged with extremely pale fuscous except fuscous stigma, very broad costal band confluent with M_{1+2} for its entire length, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A in male. Supernumerary lobe weak in both sexes.

Abdomen—Elongate, clavate and slightly petiolate; terga fused; pecten present on tergum III of male. Tergum I fuscous, tending towards red-brown along intersegmental line between terga I and II. Tergum II fulvous except for a very large oval fuscous spot over the anterior 2/3 of the tergum but not reaching lateral margins. Terga III to V fuscous except for a large oval red-brown spot on centre of tergum V and a very narrow pale fuscous medial longitudinal band on tergum V. In some specimens the red-brown spot and the medial longitudinal band extend onto tergum IV. Often the medial longitudinal band is absent or reduced to small narrow lines. Ovipositor strongly developed with the visible portion of oviscape red-brown, large, oval in transverse cross section and tapering sharply posteriorly in dorsal view.

Comments—There is little evidence that *C. aequalis* is capable of breeding in any commercial fruits. The only commercial host record is from the type specimens which were reported as being bred from orange at Gosford, New South Wales (Froggatt, 1909: p. 91). The absence of subsequent commercial host records for this species throws some doubt on the authenticity of the host record for the type specimens. Consequently, this species is included in this paper for discussion but it is not regarded as an economic pest.

Dacus (Afrodacus) jarvisi (Tryon)

(Figure 8)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Innisfail (northern Queensland).

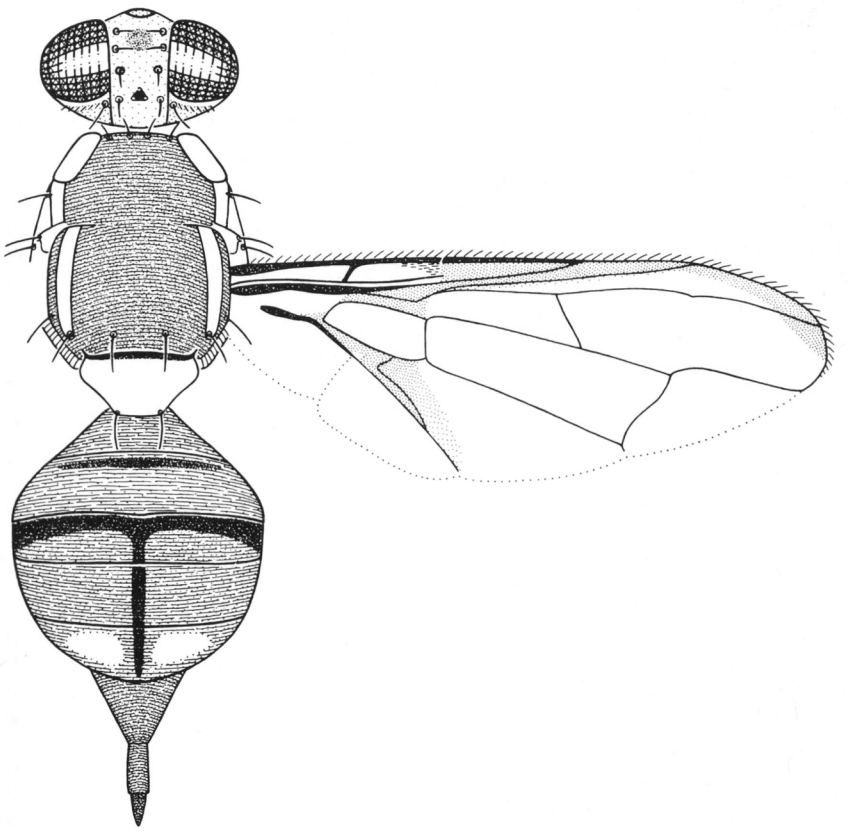

Figure 8—*Dacus (Afrodacus) jarvisi* (Tryon) (X14)

A medium sized pale species; facial spots small and oval; thorax red-brown with no dark markings; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow and joined by a lateral yellow band; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless with microtrichia in outer portion of second costal cell only; abdomen with terga III to V orange-brown except for a narrow transverse black band along anterior margin of tergum III and a narrow medial longitudinal fuscous to black band over all three terga.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with at most pale fuscous around *s.or.* bristles and on antero-medial hump; latter covered with short pale setae; bristles fulvous to dark fulvous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small, oval black spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 3-5 well developed fulvous bristles and a large number of small pale bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; pale fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; lateral bands connecting humeral and notopleural calli; medium sized mesopleural stripes, each ending at anterior *npl.* bristle above, continuing onto sternopleuron below, anterior margin convex; upper hypopleural calli (posterior apices red-brown or fuscous); anterior $\frac{3}{5}$ lower hypopleural calli (remainder red-brown or fuscous); two moderately broad, parallel sided, lateral post-sutural vittae ending behind upper *p.sa.* bristles. *Postnotum* red-brown. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band just overlapping R_{2+3} and expanding at apex of wing to end midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I fulvous; tergum II fulvous except some specimens with a narrow transverse pale fuscous band along anterior margin but not reaching lateral margins; terga III to V orange-brown except for a narrow transverse fuscous to black band along anterior margin of tergum III (not reaching lateral margins in some specimens) and a narrow medial longitudinal fuscous to black band on terga III to V (this band varies in colour and continuity and it often exists only as a spot on terga IV and V). A pair of shining spots on tergum V.

Comments—D. jarvisi occurs across northern Australia from Broome in Western Australia to Cape York in Queensland, along the entire eastern coast of Queensland and south to the Sydney area in New South Wales (Figure 9). During 1981 it was collected on the following Torres Strait Islands—Thursday, Horn, Badu, Yorke and Darnley. In Queensland, this species is a

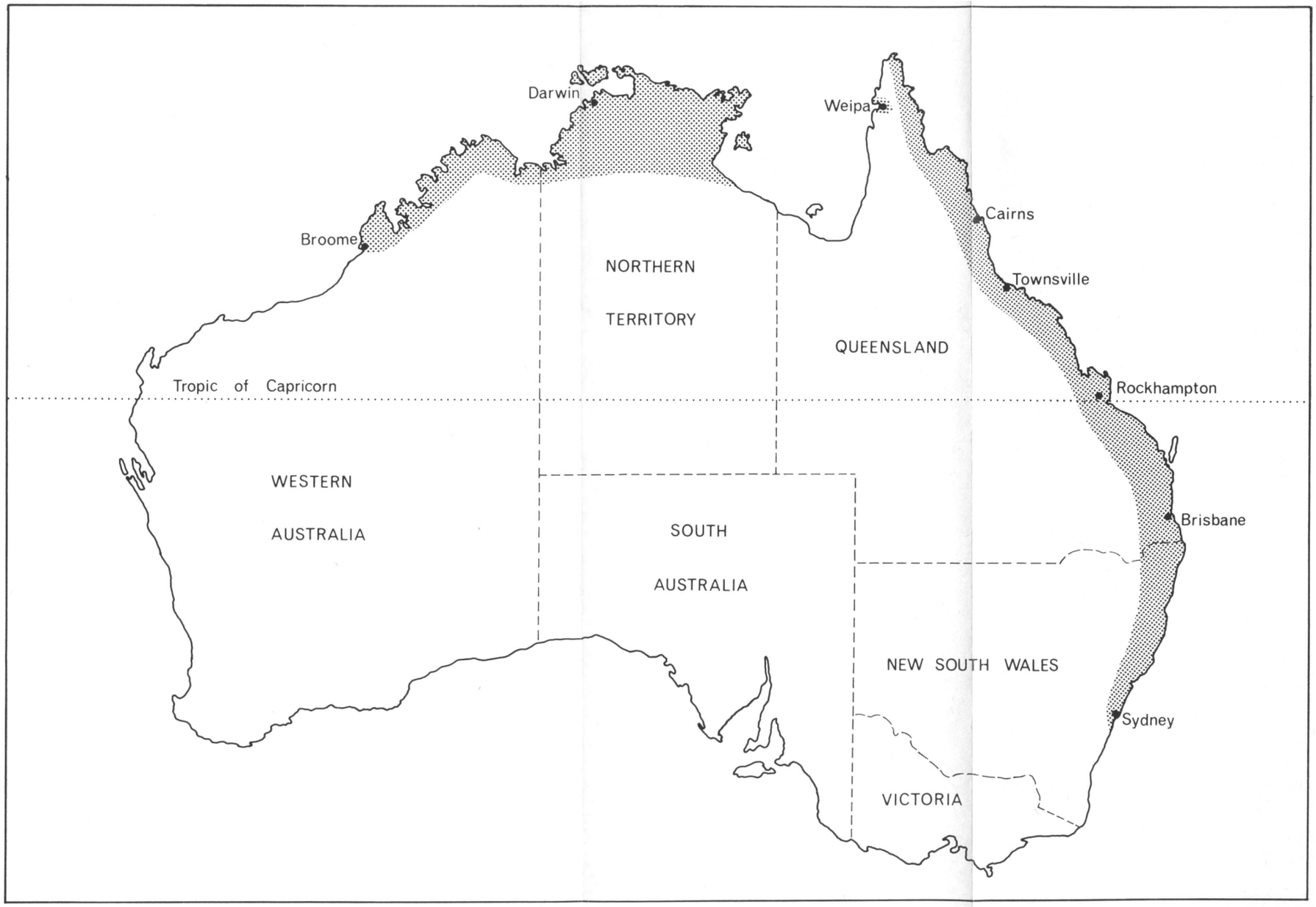

Figure 9—Map of Australia showing distribution of *D. jarvisi*

pest of deciduous fruits, mangoes, persimmons and guavas. May (1963) classified this species as one of major importance and stated that, throughout its range, it is supported from season to season by commercial hosts.

It is more prevalent and more abundant in the northern areas of Queensland than in the southern part of its distribution. Because it does not respond to male lures, it is difficult to monitor and so its exact distribution is presently unknown.

Dacus (Austrodacus) cucumis French

(Figure 10)

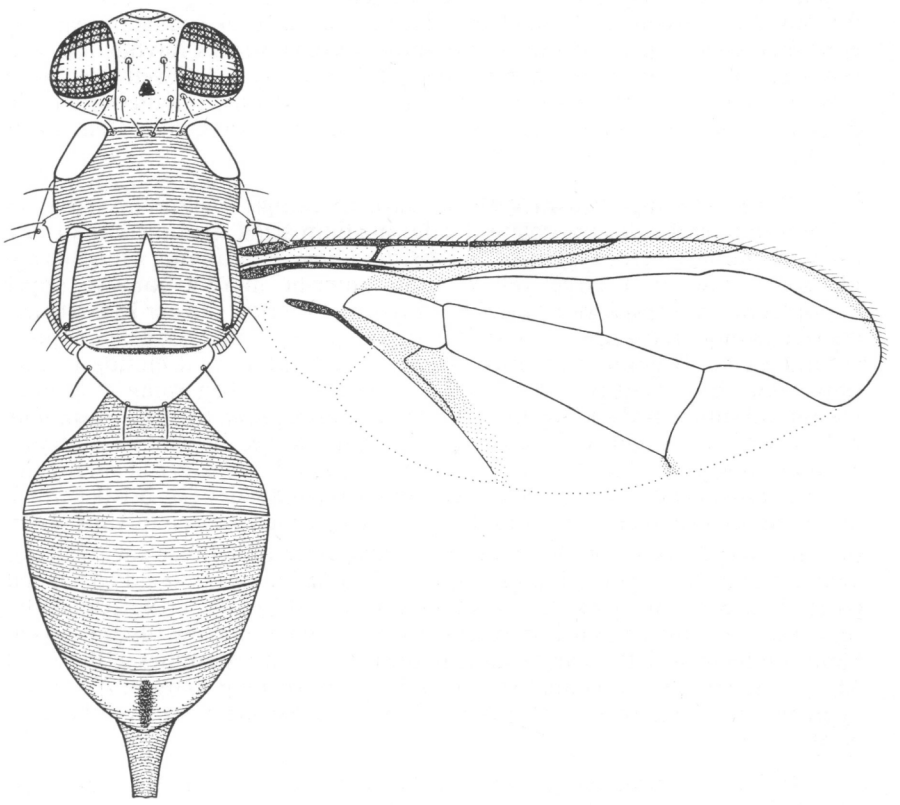

Figure 10—*Dacus (Austrodacus) cucumis* French (X13)

Material studied: A series of specimens collected at localities from Gatton (south-eastern Queensland) to Cairns (northern Queensland).

A medium sized pale species; facial spots small and oval; thorax orange-brown; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells pale fulvous with microtrichia in outer portion of second costal cell only; abdomen fulvous with broad lateral longitudinal orange-brown bands over terga III to V and a narrow medial longitudinal orange-brown to fuscous band on tergum V (this may be of varying length over terga III to V).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump covered with short pale setae; bristles fuscous: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small, circular fuscous or black spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-6 well developed fulvous or fuscous bristles each side. *Antennae* fulvous; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Orange-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a large yellow spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{3}{4}$ lower hypopleural calli (remainder red-brown); two moderately broad parallel sided lateral post-sutural vittae, beginning anterior of mesonotal suture and ending behind upper *p.sa.* bristles; a broad medial post-sutural vitta beginning at level of mesonotal suture and ending just before line of upper *p.sa.* bristles. *Postnotum* red-brown. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 4, *prsc.* absent, *p.sa.* 2, *a.sa.* absent, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous to black except the second pair of *sc.* bristles which are sometimes smaller in size and the *mpl.* bristle which is often fulvous. *Legs:* fulvous except basal $\frac{2}{3}$ of all femora pale fulvous; middle tibiae each with an apical dark fulvous spur. *Wings:* costal cells pale fulvous (second costal cell paler than first), microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe very weak.

Abdomen—Oval; terga free; pecten absent on tergum III. Tergum I orange-brown; tergum II orange-brown except for a brown fulvous band over posterior $\frac{1}{3}$ to $\frac{1}{2}$ of tergum and narrowing to end at posterolateral corners; terga III to V fulvous except for two broad lateral longitudinal orange-brown bands over all three terga and sometimes meeting along anterior margin of tergum III, a narrow medial longitudinal band which is orange-brown on tergum III and orange-brown to dark fuscous on terga IV and V (this band is

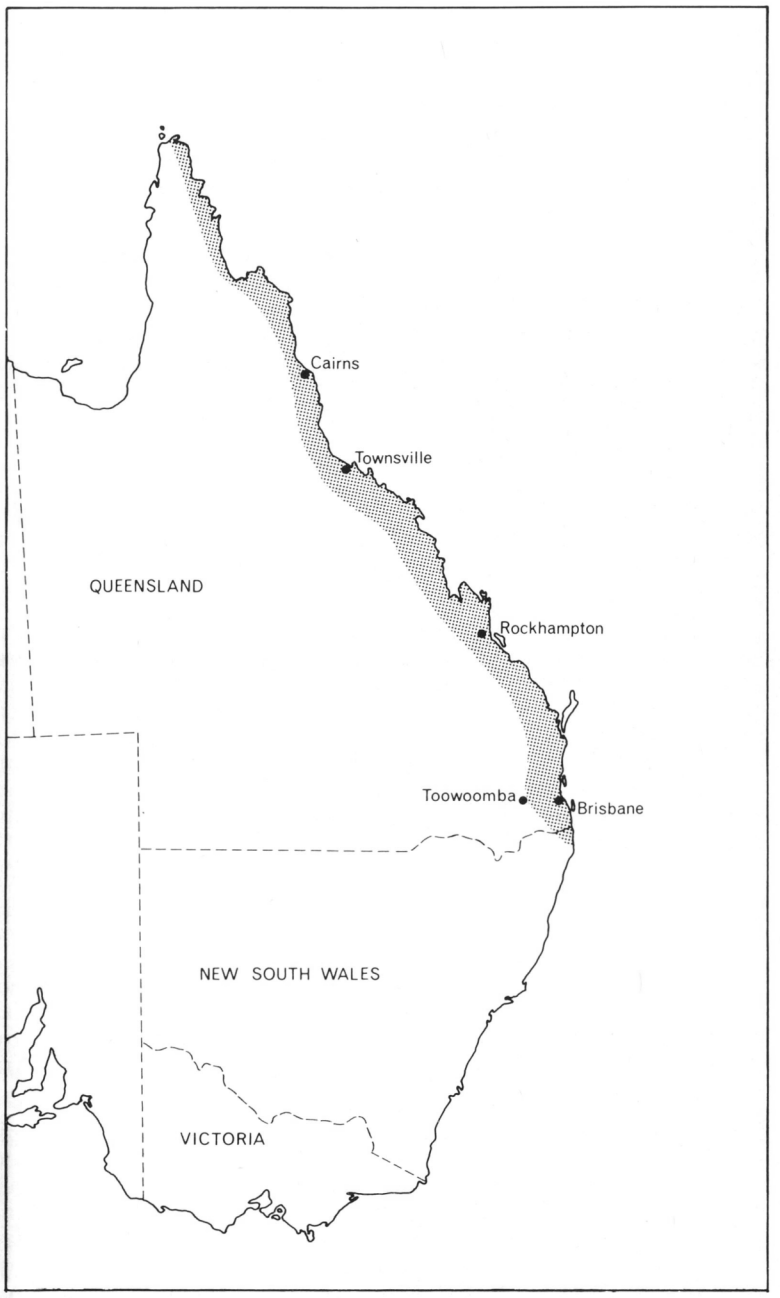

Figure 11—Map of eastern Australia showing distribution of *D. cucumis*

broader on tergum V). In the female, the medial longitudinal fuscous band is limited to tergum V. A pair of shining spots on tergum V.

Comments—D. cucumis is a serious pest of all cucurbits, tomatoes and papayas. It causes serious crop losses before harvest and is responsible for restrictions against the marketing of these crops on markets outside of its known distribution. May (1963) considered this species as one of major importance and stated that its populations were larger in the northern areas of Queensland than in the southern areas.

D. cucumis is distributed along the eastern coast of Australia from Cape York in the north to the Queensland-New South Wales border district in the south (Figure 11). It was recently recorded from the Northern Territory (Fitt, 1980). Because this species does not respond to any of the male lures it is difficult to monitor and so its geographic distribution is not fully defined.

Dacus (Bactrocera) aquilonis (May)

(Figure 12)

Material studied: A series of specimens collected at localities in north-west Australia (the northern regions of Northern Territory and Western Australia).

A medium sized species; facial spots large and oval; mesonotum pale red-brown with small fuscous markings; lateral post-sutural vittae present; mesopleural stripes ending just posterior of anterior notopleural bristle; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak; costal cells fuscous, microtrichia covering all of second costal cell and most of first cell; abdominal terga III to V pale orange-brown except pale fuscous along anterior margin of tergum III and widening to cover lateral margins and a medial longitudinal pale fuscous band on terga III and IV.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous without dark markings; antero-medial hump with a small number of short pale setae; bristles fulvous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with large oval black spots. *Genae* fulvous; brown sub-ocular spots present; bristles red-brown. *Occiput* fulvous, yellow along eye margins; occipital rows with 4-6 well developed dark bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a long fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Mesonotum pale red-brown with a narrow fuscous longitudinal band each side of mid line. Pleural areas pale red-brown except fuscous on sternopleuron and above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, reaching almost to anterior *npl.* bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices pale red-brown); anterior 3/5 lower hypopleural calli (remainder pale red-brown); two lateral post-sutural vittae, narrowing

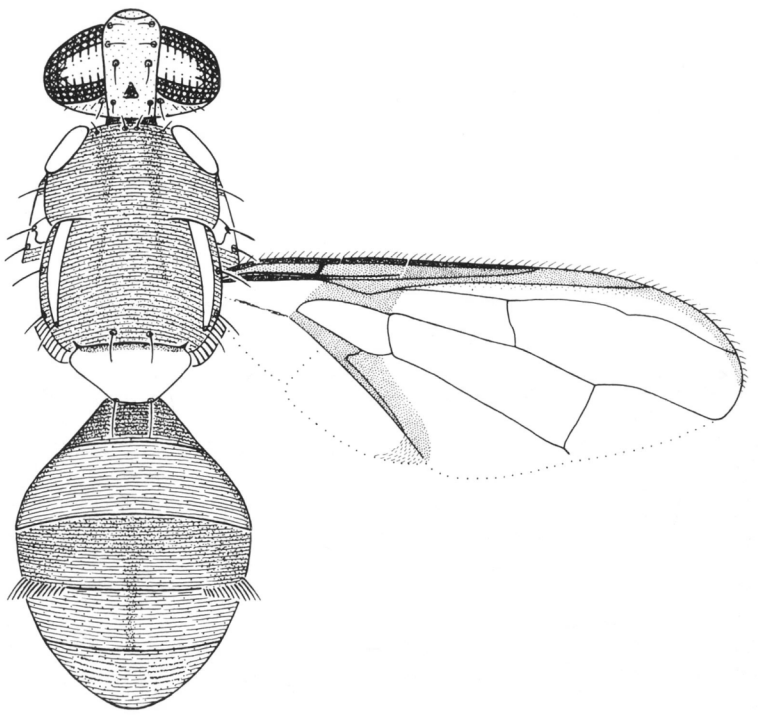

Figure 12—*Dacus (Bactrocera) aquilonis* (May) (X13)

slightly posteriorly and ending at upper *p.sa.* bristles. *Postnotum* pale red-brown. *Scutellum* yellow except for narrow pale red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 2, *npl.* 2, *scp* 4; well developed and red-brown. *Legs:* all segments fulvous except pale fuscous on hind tibiae; rows of long pale setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. *Wings:* costal cells fuscous, microtrichia covering all of second costal cell and most of first cell; remainder of wings colourless except dark fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I pale fuscous except for a narrow pale orange-brown band along posterior margin; tergum II pale orange-brown, tending whitish posteriorly and with pale fuscous on lateral margins. Terga III to V pale orange-brown except for pale fuscous to very pale fuscous band along anterior margin of tergum III which widens to cover lateral margins and with a narrow medial longitudinal very pale fuscous band on terga III and IV. A pair of shining spots on tergum V.

Comments—D. aquilonis is closely related to *Dacus tryoni* (Froggatt) (Queensland fruit fly) and has been reared from grapefruit, peach and guava in the Northern Territory (Allwood and Angeles, 1979). Laboratory tests in quarantine conditions in Brisbane have shown that *D. aquilonis* and *D. tryoni* hybridise readily, producing fertile progeny (Drew, unpublished data).

Dacus (Bactrocera) breviaculeus Hardy

(Figure 13)

Material studied: A series of specimens collected at localities from Ayr to Atherton in northern Queensland.

A medium sized species; facial spots oval; thorax generally red-brown; a pair of longitudinal fuscous bands on mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells extremely pale fulvous with microtrichia in outer portion of second costal cell only; abdomen with broad lateral longitudinal fuscous to black bands and a narrow medial longitudinal pale fuscous band on terga III to V.

Head—Generally fulvous. *Frons* of medium width; fulvous except fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with medium sized oval black spots not reaching epistoma. *Genae* fulvous; medium sized brown sub-ocular spots present; bristles red-brown. *Occiput* red-brown, yellow along eye margin; occipital rows with 3-6 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleural areas fuscous except red-brown below humeral callus. Mesonotum red-brown except for a large circular fuscous spot between humeral callus and notopleural suture and a large oval fuscous spot on the inner margin of each lateral post-sutural vitta (these fuscous patterns vary from extremely pale fuscous to dark fuscous, and occasionally the posterior markings are absent). Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a yellow spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown to fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two lateral post-sutural vittae of medium width, parallel sided or tapering slightly posteriorly and ending at upper *p.sa.* bristles. *Postnotum* red-brown to fuscous. *Scutellum* yellow except for narrow red-brown basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae and hind tibiae pale fuscous; middle tibiae each with an apical red-brown spur. *Wings:* costal cells extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless except

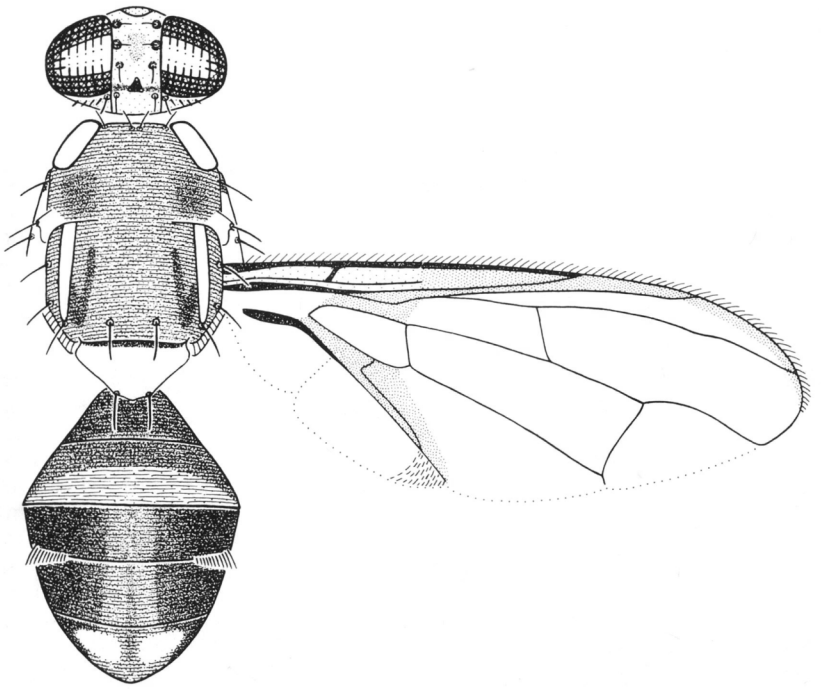

Figure 13—*Dacus (Bactrocera) breviaculeus* Hardy (X13)

fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and ending beyond extremity of R_{4+5}, a broad fuscous anal streak ending at wing margin. A dense aggreation of microtrichia around CuA+1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III of males. Tergum I fuscous except for a narrow transverse red-brown band along posterior margin but not reaching lateral margins. Tergum II fulvous except for a broad transverse fuscous band across anterior $\frac{1}{2}$ of tergum and expanding over lateral margins. Terga III to V orange-brown except for a pair of broad lateral longitudinal bands and a very narrow medial longitudinal band over all three terga. In most specimens the lateral longitudinal bands are fuscous, however, in a few specimens they are black and are joined along anterior margin of tergum III. Generally, the medial longitudinal band is pale fuscous and most distinct on tergum IV and anterior $\frac{1}{2}$ of tergum V (occasionally this medial longitudinal band is absent). A pair of shining spots on tergum V.

Comments—D. breviaculeus occurs in the eastern coastal areas of Queensland north from Rockhampton. It has been bred from guava in this area. Presently, it can be regarded as being only of minor economic importance.

Dacus (Bactrocera) bryoniae (Tryon)

(Figure 14)

Material studied—A series of specimens collected at localities throughout eastern Queensland.

A large species; facial spots medium sized and pointed anteriorly; mesonotum dull black; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow; wing with a broad fuscous costal band and anal streak; costal cells fulvous with microtrichia in outer $\frac{1}{2}$ of second cell only; abdominal terga III to V orange-brown with a broad transverse dark fuscous to black band on tergum III and a medial longitudinal dark fuscous band over all three terga, anterolateral corners of abdominal terga IV and V fuscous.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except small fuscous markings around orbital bristles and on antero-medial hump; latter covered with a large number of short dark setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule fuscous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with irregularly circular facial spots drawn out to a point anteriorly but not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present; bristles fuscous. *Occiput* fulvous (tinged with fuscous in a few specimens), yellow along eye margin; occipital rows well developed with 4-11 strong fuscous to black bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; a strong fuscous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dull black with brown markings as follows: below humeral calli; above mid coxae; below and behind lateral post-sutural vittae; along mesonotal suture; above notopleural calli; above notopleural suture between humeral and notopleural calli; on mesonotum adjacent to humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, each slightly broader than notopleural callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing posteriorly to end at upper *p.sa.* bristles (in a small number of specimens the lateral post-sutural vittae appear to end before the upper *p.sa.* bristles due to an increase in the area of brown colouration). *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs*: all coxae fuscous; remainder of legs fulvous except hind tibiae dark fulvous (in some specimens the mid tibiae tend dark fulvous basally and hind femora are correspondingly fuscous); rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except dark fulvous stigma, a broad fuscous costal band slightly overlapping R_{4+5} along its entire length and ending between extremities of R_{4+5} and M_{1+2}, a narrow area of infuscation along anterior $\frac{1}{2}$ of r-m cross vein, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

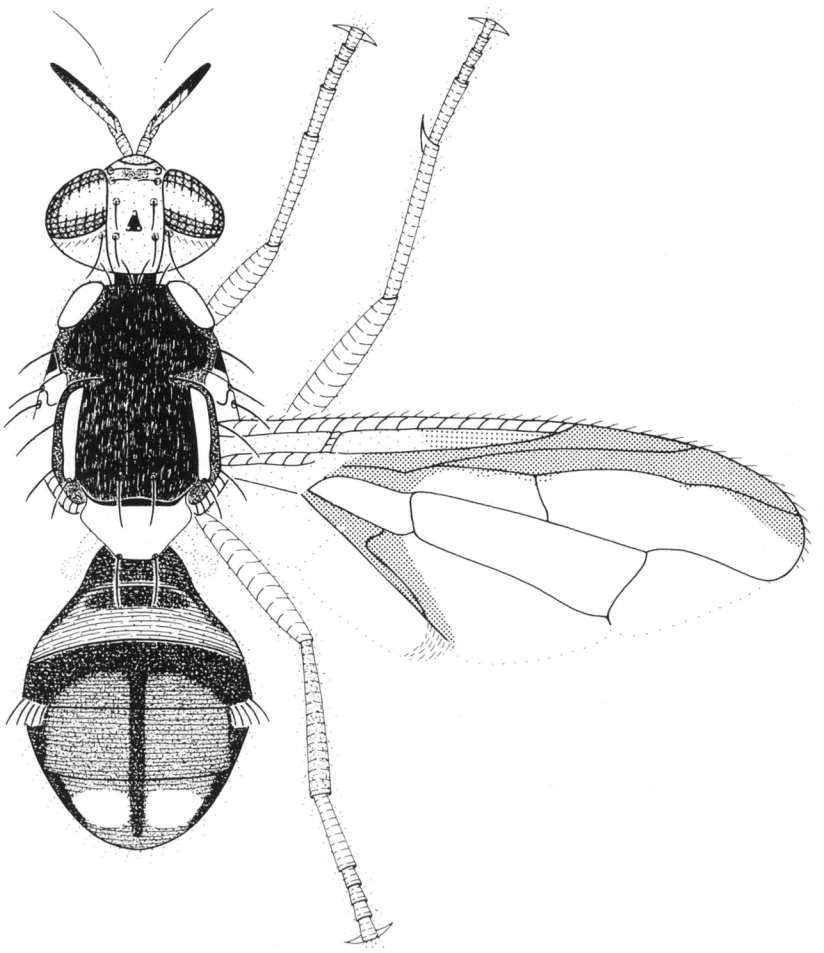

Figure 14—*Dacus (Bactrocera) bryoniae* (Tryon) (X12)

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I fuscous with narrow orange-brown band along posterior margin (in some specimens the dark area is dark fuscous to black); tergum II orange-brown with anterolateral corners fuscous and with a transverse dark fuscous to black band which becomes narrower and paler laterally (generally this band is at most equal to $\frac{1}{2}$ the width of the tergum); terga III to V orange-brown with a broad transverse dark fuscous to black band of varying width across anterior margin of tergum III and widening to cover lateral margins, anterolateral corners of terga IV and V fuscous, the pair of shining spots on tergum V brown, a medium sized medial longitudinal dark fuscous band running from transverse band on anterior margin of tergum III to end just before posterior margin of tergum V.

Comments—*D. bryoniae* is a pest of capsicum, mangoes and passionfruit in Queensland. It is not considered to be a pest species in the Northern Territory. In Papua New Guinea it is a very destructive pest of bananas (Dr. J. Stibick, personal communication). It occurs throughout eastern coastal areas of Queensland and as far south as Sydney in New South Wales, the northern coastal areas of Western Australia and the Northern Territory, Melville and Bathurst Islands. Outside Australia it is widespread through Papua New Guinea and associated islands and islands of the Bismarck Archipelago.

Dacus (Bactrocera) cacuminatus (Hering)

(Figure 15)

Material studied: A series of specimens collected at localities from Gatton (south-eastern Queensland) to Atherton Tableland (northern Queensland).

A medium sized species; facial spots medium sized and circular; thorax generally dark red-brown with a characteristic arrow shaped dark fuscous to black pattern on the mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless with microtrichia in outer portion of second costal cell only; abdominal terga III to V orange-brown with dark fuscous to black along anterior margin of tergum III and with similarly coloured medial and lateral longitudinal bands.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without small pale fuscous markings around orbital bristles and on antero-medial hump; latter covered with short pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.;* lunule fulvous or fuscous. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous with medium sized circular black spots not reaching epistoma. *Genae* fulvous; medium sized, brown sub-ocular spots present; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 3-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on apex and outer surface of third segment; fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dark red-brown with dark markings as follows: entire pleural areas dark fuscous to black except below humeral calli (generally dark fuscous below wings and black anterior to mesopleural stripes and on sternopleura); brown below lateral post-sutural vittae and on posterior margin of mesonotum; a characteristic dark fuscous to black pattern on the mesonotum, with base along posterior margin, with a medial longitudinal band narrowing to a point as it reaches anterior margin and with two shorter lateral bands also pointed anteriorly (this pattern is often reduced to a narrow dark fuscous outline, delineating the 3-pointed marking). Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a yellow spot, anterior margin convex; upper hypopleural calli (posterior apices black), anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two moderately broad lateral post-sutural vittae narrowing slightly posteriorly and ending at or just before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow except for narrow black

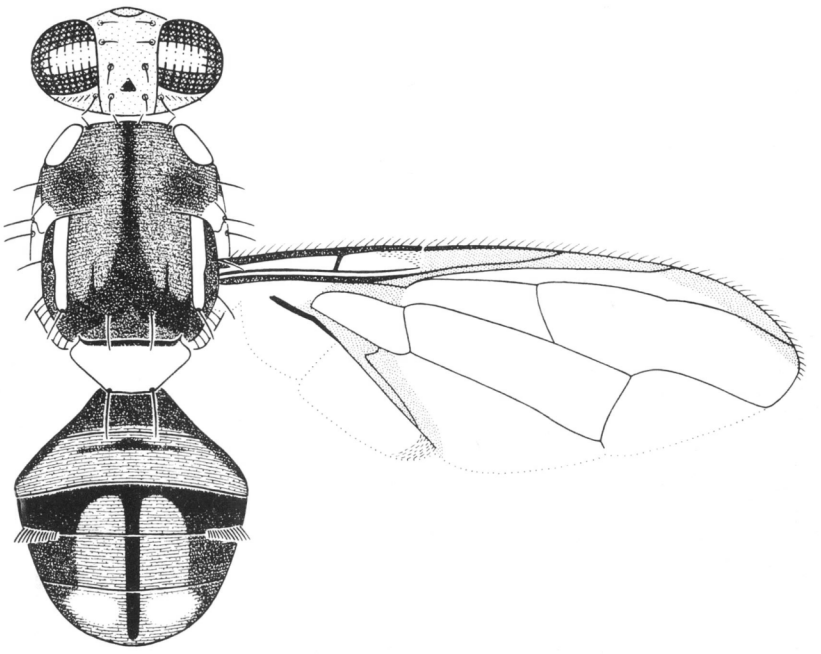

Figure 15—*Dacus (Bactrocera) cacuminatus* (Hering) (X12)

basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous except mid coxae, hind coxae and hind tibiae pale fuscous; middle tibiae each with an apical red-brown to fuscous spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only, remainder of wings colourless except fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and widening beyond extremity of this vein to end midway between R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I fuscous to black except for a narrow orange-brown transverse band along posterior margin not reaching lateral margins; tergum II orange-brown except for a narrow transverse fuscous band just behind anterior margin and not reaching the fuscous lateral margins; terga III to V orange-brown except for dark fuscous to black along anterior margin of tergum III and dark fuscous to black medial and lateral longitudinal broad bands. A pair of shining spots on tergum V. (The dark colour patterns on the abdomen vary from fuscous to black and in some specimens the lateral longitudinal bands are reduced by the expansion of orange-brown colouration on tergum IV.)

Comments—D. cacuminatus is a minor pest of tomatoes and capsicum in Queensland. It occurs throughout eastern Australia from Cape York in the north to the East Gippsland district in the south (Figure 16).

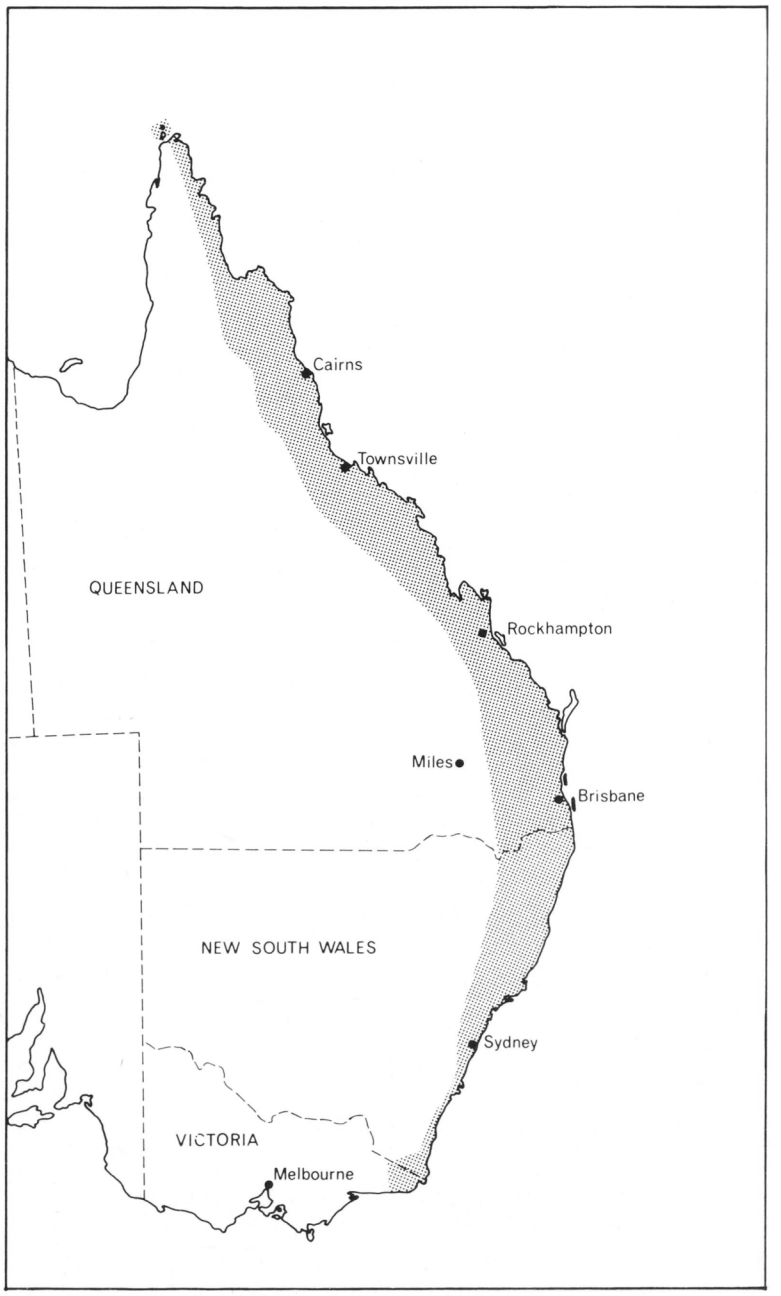

Figure 16—Map of eastern Australia showing distribution of *D. cacuminatus*

Dacus (Bactrocera) frauenfeldi Schiner

(Figure 17)

Material studied: A series of specimens collected at localities from Cape York to Papua New Guinea, islands of the Bismarck Archipelago and the Solomon Islands.

A medium sized dark coloured species; facial spots large and circular; mesonotum glossy black; lateral post-sutural vittae narrow and short; mesopleural stripes of medium width; humeral calli black; notopleural calli yellow; scutellum yellow with a glossy black triangular marking on dorsal surface; wing with a narrow and extremely pale fuscous costal band; a narrow transverse fuscous band across wing; costal cells pale fuscous; microtrichia in most of second costal cell only; abdominal terga III to V orange-brown with one broad medial and two broad lateral longitudinal black bands over all three terga.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with, at most, pale fuscous markings around orbital bristles; antero-medial hump covered with a small number of dark fulvous setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with large circular spots not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present; bristles black. *Occiput* black dorsally, fulvous ventrally, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a strong dark fuscous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight to slightly convex; upper hypopleural calli (posterior apices black); anterior $\frac{5}{6}$ lower hypopleural calli (remainder, including entire ventral margin black); two narrow short lateral post-sutural vittae tapering posteriorly to end just behind *a.sa.* bristles. Humeral calli black. *Postnotum* black. *Scutellum* yellow except for a black triangle on dorsal surface which varies in size from small (with apex at centre of scutellum) to large (with apex enveloping the two apical scutellar bristles). *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae fuscous, mid and hind coxae black; fore femora dark fulvous, basal $\frac{1}{3}$ and apex of mid femora and basal $\frac{4}{7}$ of hind femora dark fulvous (remainder dark fuscous to black); fore and mid tibiae dark fulvous, hind tibiae dark fuscous to black; tarsal segments fulvous except apical four segments of fore tarsi fuscous; rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells pale fuscous, microtrichia in most of second costal cell only; remainder of wings colourless except fuscous stigma, narrow extremely pale fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, a narrow fuscous transverse band from costal band to hind margin and enveloping r-m and i-m cross veins, a broad fuscous anal streak ending at wing margin and including

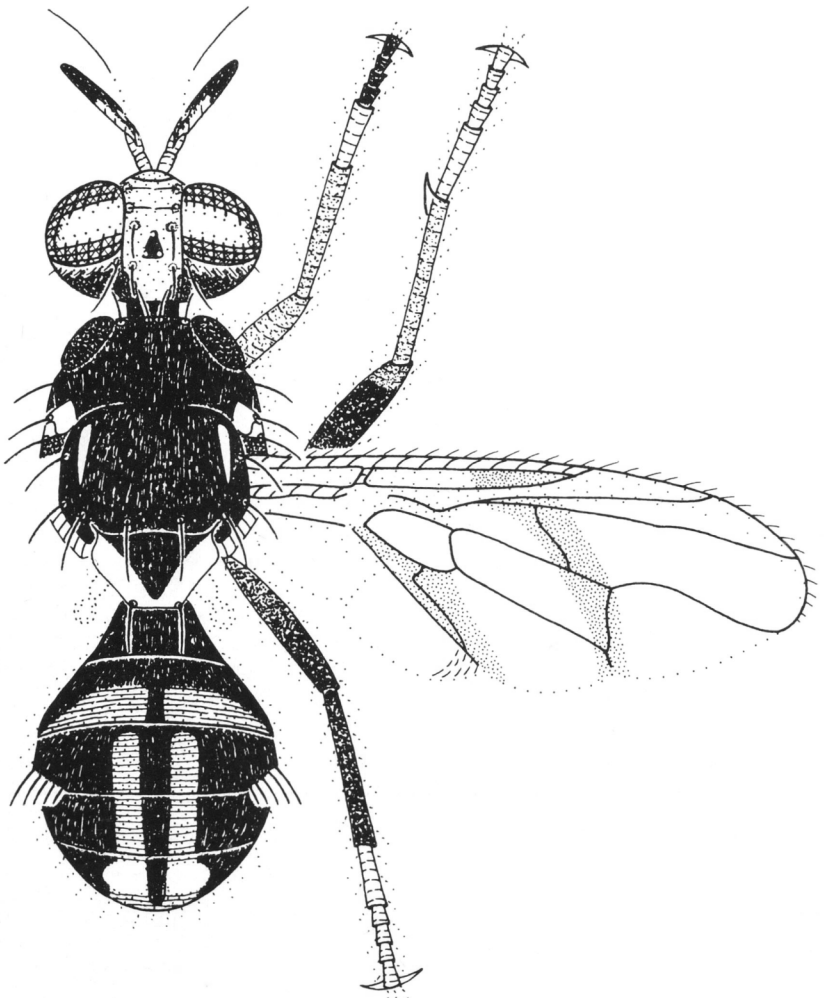

Figure 17—*Dacus (Bactrocera) frauenfeldi* Schiner (X15)

area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I black; tergum II orange-brown with a broad black transverse band across anterior margin which widens to cover lateral margins and a narrow medial longitudinal band running from transverse band to posterior margin; terga III to V vary between two extremes as follows: (1) orange-brown with two broad lateral longitudinal black bands running from anterior margin of tergum III to posterior margin of abdomen, a broad medial longitudinal black band

running from anterior margin of tergum III and narrowing posteriorly to end just before posterior margin of tergum V (the three longitudinal bands are usually connected along anterior margin of tergum III by a narrow transverse black band); (2) black with the posterior margin of tergum V and the pair of oval shining spots on tergum V dark brown.

Comments—D. frauenfeldi (the mango fly) has been bred from mango, breadfruit and guava. It is a very abundant species throughout its geographic range and almost certainly will become a serious pest when horticulture industries are developed in these areas. This species is distributed widely—in South-East Asia, northern Pacific islands, Papua New Guinea, islands of the Bismarck Archipelago, Bougainville Island, Solomon Islands and Australia (northern Queensland and islands of Torres Strait). Its distribution within northern Queensland is shown on Figure 18.

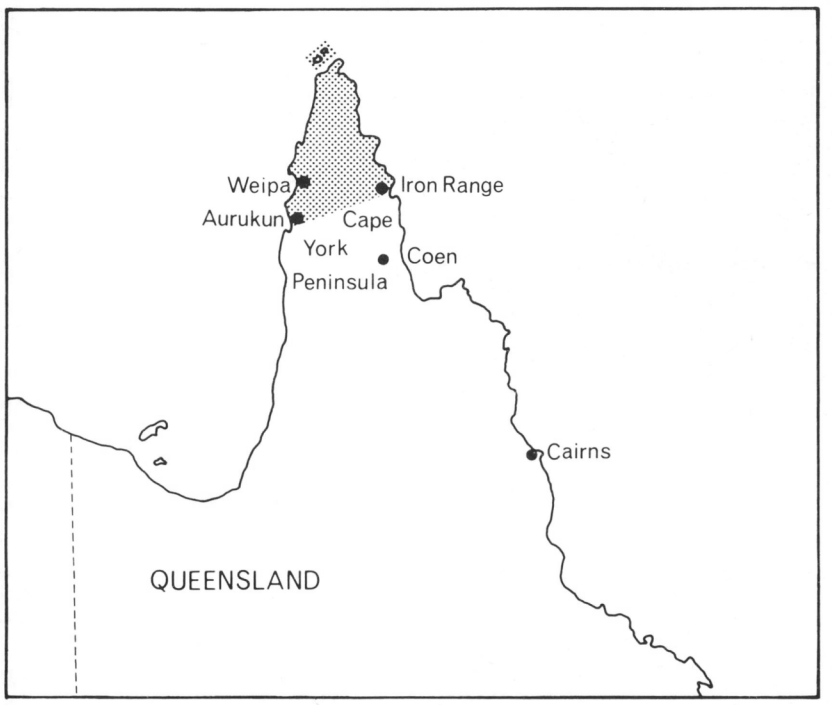

Figure 18—Map of Queensland showing distribution of *D. frauenfeldi*

Dacus (Bactrocera) halfordiae Tryon

(Figure 19)

Material studied: A series of specimens collected at localities from Brisbane to Toowoomba (south-east Queensland).

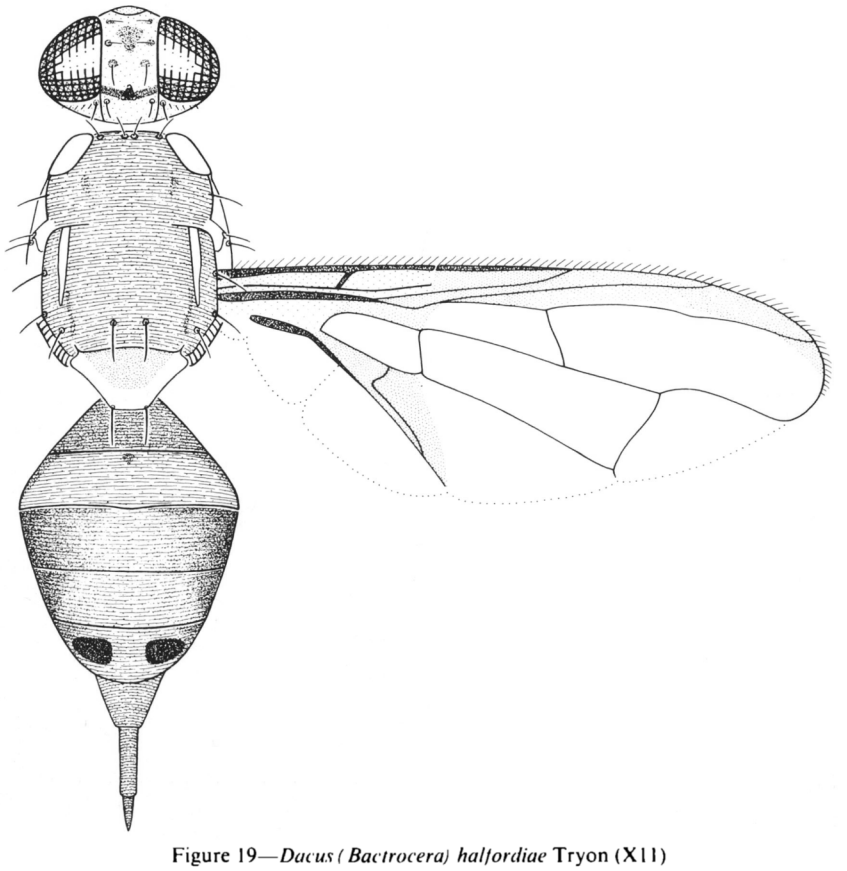

Figure 19—*Dacus (Bactrocera) halfordiae* Tryon (X11)

A medium sized pale coloured species; facial spots oval to pear shaped; thorax generally pale red-brown; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow with broad red-brown basal band; wing with a narrow fuscous costal band and anal streak; costal cells fulvous with microtrichia in outer portion of second costal cell only; abdomen generally orange-brown with at most fuscous markings on lateral margins of terga III and IV and with the shining oval spots on tergum V dark brown to fuscous.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous to dark fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fuscous. *Ocellar triangle* black. *Vertex* fuscous to dark fuscous. *Face* fulvous with medium sized oval to pear shaped spots not reaching epistoma. *Genae* fulvous; large dark brown sub-ocular spots present; bristles fuscous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-8 well developed fuscous

bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pale red-brown with dark markings as follows: fuscous anterior to mesopleural stripes, a small fuscous area along posterior margin of mesopleural stripes, fuscous to black above hind coxae, dark fuscous to black on sternopleura, a small fuscous spot posterocentrally of each humeral callus and occasionally a fuscous spot along inner posterior margin of lateral post-sutural vittae. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, each slightly wider than *npl.* callus above, continuing onto sternopleuron below as a yellow spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two narrow lateral post-sutural vittae narrowing posteriorly to end before the upper *p.sa.* bristles. *Postnotum* black centrally, red-brown laterally. *Scutellum* yellow except for broad red-brown basal band extending almost to centre of scutellum. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae fuscous and hind tibiae pale fuscous; middle tibiae each with an apical dark fuscous spur. *Wings*: costal cells fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless to extremely pale fulvous except for fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III in males. Tergum I fuscous except for a narrow orange-brown transverse band along posterior margin but not reaching lateral margins. Tergum II orange-brown with at most a small fuscous spot centrally just posterior of anterior margin. Terga III to V orange-brown with irregularly shaped fuscous patterns on lateral margins of all three terga and with the shining oval spots on tergum V fuscous. In some specimens the fuscous patterns on terga III and IV are quite broad, leaving only a narrow orange-brown pattern posterocentrally on tergum III and in the centre of tergum IV. In the specimens with increased areas of melanic pigmentation on terga III and IV, the oval shining spots on tergum V tend towards black. The ovipositor is strongly developed, red-brown and dorsoventrally compressed.

Comments—D. halfordiae is an incidental pest of citrus in Queensland and also attacks loquat and some myrtaceous fruits. It has been recorded from eastern Australia between Rockhampton (Queensland) and Sydney (New South Wales).

Dacus (Bactrocera) mayi Hardy

(Figure 20)

Material studied—A series of specimens collected at Toowoomba and Yarraman in south-eastern Queensland.

A medium sized pale species; facial spots oval; thorax dark red-brown with a pair of longitudinal dark bands running along the mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell; abdomen basically dark red-brown with a narrow medial longitudinal black band on terga III to V, generally with dark fuscous along anterior margin of tergum III and occasionally with pale fuscous colouration on lateral margins of terga III to V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous, without fuscous colouration around orbital bristles and on antero-medial hump (in a small percentage of specimens these fuscous colour patterns are present); antero-medial hump covered with short pale setae; bristles red-brown to fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous (in a small percentage of specimens the vertex is pale fuscous). *Face* fulvous with medium sized, oval black spots not reaching epistoma. *Genae* fulvous; small, brown sub-ocular spots present; bristles red-brown. *Occiput*

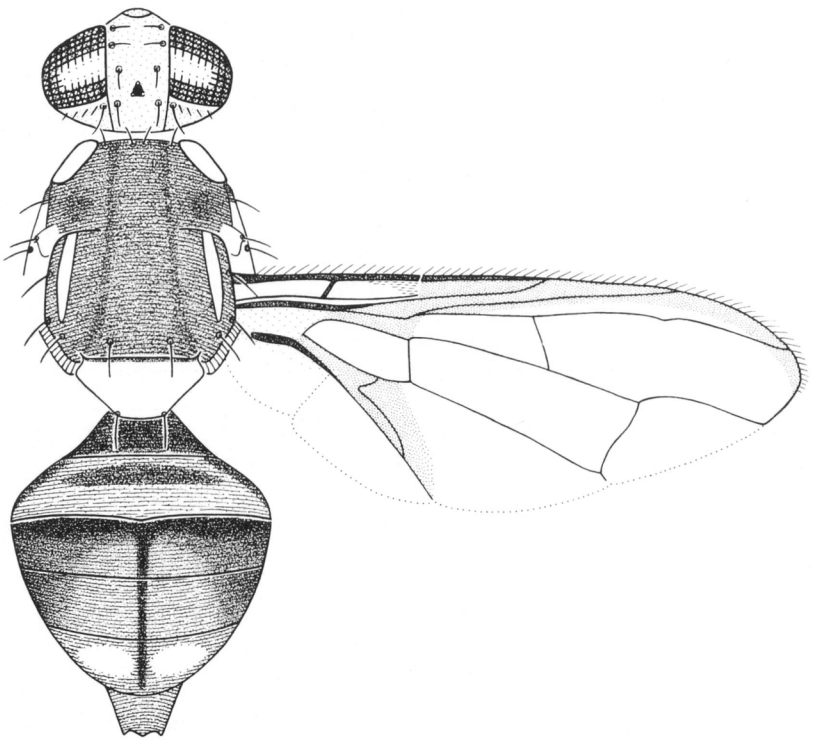

Figure 20—*Dacus (Bactrocera) mayi* Hardy (X13)

red-brown, yellow along eye margin; occipital rows with 3-5 well developed dark bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Dark red-brown with fuscous markings as follows: on mesopleura anterior to mesopleural stripes; on sternopleura; below wings; above hind coxae; a large spot each side of mesonotum between humeral and notopleural calli; a small elongate spot along inner posterior margins of lateral post-sutural vittae; a pair of moderately broad longitudinal bands running down mesonotum either side of the mid line (these bands begin at anterior margin of mesonotum and end before the posterior margin). In some specimens the dark colouration on the pleural areas is pale fuscous and the spots on the mesonotum between the humeral and notopleural calli and along the inner posterior margins of the lateral post-sutural vittae are absent. In some specimens all the dark colour patterns on the mesonotum are absent leaving an entirely dark red-brown mesonotum. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each slightly wider than notopleural callus above, continuing onto sternopleuron below as a small yellow spot, anterior margin straight; upper hypopleural calli (posterior apices dark red-brown to fuscous); anterior $\frac{2}{3}$ lower hypopleural calli (remainder dark red-brown to fuscous); two narrow lateral post-sutural vittae, narrowing posteriorly to end before upper *p.sa.* bristles. *Postnotum* red-brown, tending pale fuscous laterally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except hind tibiae pale fuscous; middle tibiae each with an apical spur. *Wings*: costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, a narrow fuscous costal band extending below R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III of males. Tergum I fuscous to dark fuscous except for a narrow transverse red-brown band along posterior margin and ending before lateral margins; tergum II fulvous (tending whitish) except for a moderately broad transverse fuscous to dark fuscous band just posterior to anterior margin and narrowing laterally to end before lateral margins. Terga III to V dark red-brown except for a broad fuscous to dark fuscous band along anterior margin of tergum III and a narrow medial longitudinal dark fuscous to black band over all three terga. There is no distinct colour pattern on the lateral margins of terga III to V but these margins are often clouded with fuscous colouration. In some specimens the band along the anterior margin of tergum III is pale fuscous and discontinuous in the centre of the tergum. A pair of shining spots on tergum V (these spots vary in colour from red-brown to dark red-brown).

Comments—D. mayi has been recorded from apricots in south-eastern Queensland. It occurs throughout the entire eastern coastal and sub-coastal districts of Queensland and is regarded as a species of minor pest status.

Dacus (Bactrocera) melas (Perkins and May)

Material studied: A series of specimens collected at localities from Brisbane, Nambour, Gatton, Gayndah, Toowoomba (in south-eastern Queensland) to Ayr (in northern Queensland).

A medium sized species; facial spots oval to pear shaped; thorax red-brown with fuscous markings on mesonotum; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous; microtrichia covering all of both costal cells; abdomen with terga III to V red-brown with fuscous along the anterior margin of tergum III and laterally over all three terga.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with short pale setae; bristles red-brown: 1 *s.or.*, 2 *i.or.*; lunule fulvous to fuscous. *Face* fulvous with medium sized, oval to pear shaped black spots not reaching epistoma. *Genae* fulvous; medium sized brown sub-ocular spots present; bristles fulvous. *Occiput* red-brown to pale fuscous, yellow along eye margin; occipital rows with 3-7 well developed red-brown bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

Thorax—Pleural areas generally fuscous except dark red-brown below humeral calli (occasionally the pleural areas are entirely red-brown). Mesonotum dark red-brown with dark fuscous markings as follows: a small spot laterally between humeral and notopleural calli; a spot along the inner posterior margin of the lateral post-sutural vittae; two narrow longitudinal bands running down the mesonotum either side of the central line. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a yellow spot, anterior margin convex; upper hypopleural calli (posterior apices fuscous to black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder fuscous to black); two narrow lateral post-sutural vittae, narrowing sharply posteriorly and ending well before upper *p.sa.* bristles. *Postnotum* fuscous to black. *Scutellum* yellow except for narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs*: fulvous except mid and hind coxae and hind tibiae fuscous (occasionally in the more heavily pigmented specimens the apices of the femora are tinged with fuscous); middle tibiae each with an apical black spur. *Wings*: costal cells fuscous, microtrichia covering all of both costal cells; remainder of wings colourless except fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A in males. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III of males. Tergum I fuscous except for a narrow transverse fulvous band along posterior margin but not reaching lateral margins; tergum II fulvous except for a broad transverse fuscous band across anterior $\frac{1}{2}$ of tergum and expanding to cover

lateral margins; terga III to V dark red-brown to fuscous except for darker fuscous markings of varying size as follows: a broad band along anterior margin of tergum III, broad lateral longitudinal bands and a narrow medial longitudinal band on all three terga. A pair of shining spots on tergum V.

Comments—At present there is some doubt as to whether *D. melas* is a good species. There are only a few specimens available which fit the description of Perkins and May. Most specimens named *D. melas* in the Department of Primary Industries collection fit *Dacus (Bactrocera) tryoni* (Froggatt). The material which fits *D. melas* has the mesonotal fuscous pattern expanded to cover most of the mesonotum. These specimens appear to be dark forms of *D. tryoni*, possessing increased areas of melanic pigmentation.

D. melas has been bred from 10 hosts which are also hosts of *D. tryoni*—loquat, apple, plum, pear, orange, grapefruit, kumquat, guava, date palm, passionfruit. It occurs throughout the entire eastern coastal area of Queensland.

Dacus (Bactrocera) musae (Tryon)

(Figures 21, 22)

Material studied: A series of specimens collected at localities in northern Queensland.

A medium sized species; facial spots irregularly oval; mesonotum dull black; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell only; abdomen generally orange-brown and occasionally with a dark fuscous to dull black narrow medial longitudinal band of varying length over terga III to V (in some specimens there are dark fuscous to dull black markings in the anterolateral corners of tergum III).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with a small number of short dark fulvous setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with two irregularly oval black spots not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present (absent in some specimens); bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 5-11 well developed dark fuscous bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a well developed dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura dark fuscous to black with brown below humeral calli, along sutures and above mid coxae. Mesonotum dull black with brown markings below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, above notopleural suture between humeral and notopleural calli, adjacent to humeral calli. Two extremes of melanic development occur, between individuals of this species, on the mesonotum as

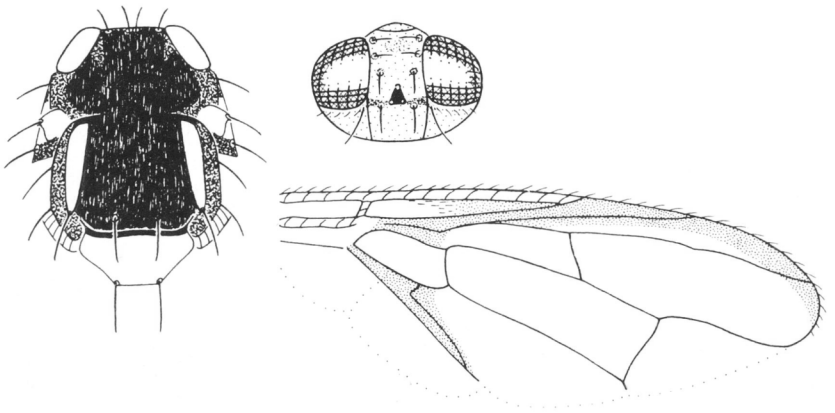

Figure 21—Head, thorax, wing of *Dacus (Bactrocera) musae* (Tryon) (X12)

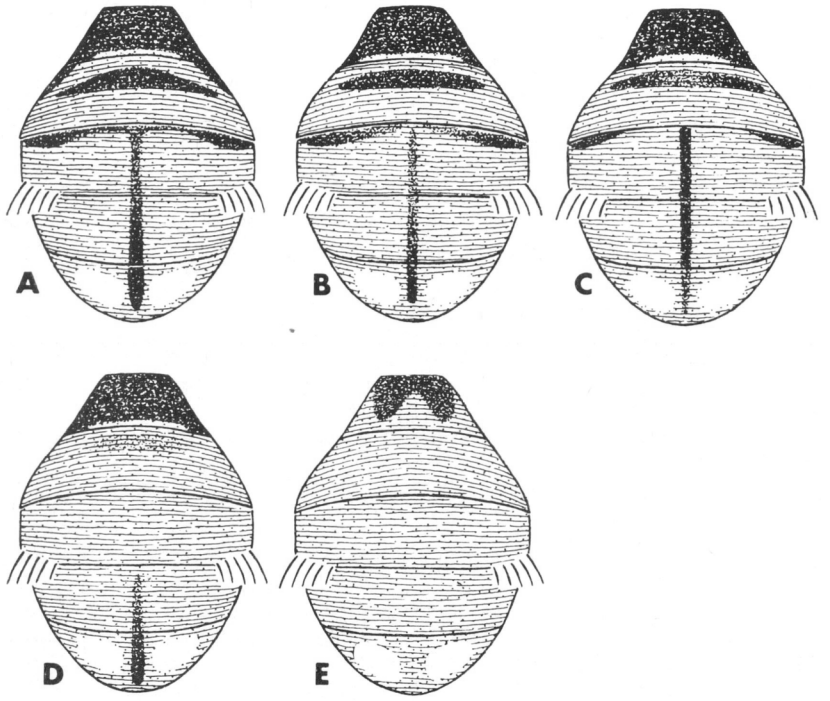

Figure 22—Colour variation in abdomen of *D. musae* (X12)

follows: (1) a reduction in dark colouration, brown patterns occurring on the posterior and anterior margins of the mesonotum; (2) an increase in dark colouration, the only brown markings being below the lateral post-sutural vittae, a very small area along the mesonotal suture and around notopleural calli. Gradations of melanic development between these extremes are always present in a large population sample. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight to slightly convex (this stripe is slightly narrower in some specimens); upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing slightly posteriorly to end at upper *p.sa.* bristles. *Postnotum* dull black. *Scutellum* yellow with a narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous. *Legs:* fore coxae fulvous to dark fulvous, mid and hind coxae fuscous; remainder of legs fulvous (occasionally the fore tibiae are dark fulvous and hind tibiae pale fuscous); rows of long dark fulvous setae on dorsal surface of fore femora; middle tibiae each with apical black spur. *Wings*: costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I dark red-brown to fuscous with a narrow orange-brown band along posterocentral margin; tergum II orange-brown tending whitish posteriorly and with a transverse fuscous to dark fuscous band just behind anterior margin which ends before lateral margins. The colour patterns on terga III to V vary considerably and five colour forms have been selected (Figure 22); however, it is noted that intermediate variations also occur between these five forms. The five colour forms are as follows; A—terga III to V orange-brown with a narrow fuscous band across anterior margin of tergum III which widens and becomes dark fuscous in anterolateral corners of this tergum, a medial longitudinal band which is fuscous on anterior region of tergum III and tends towards dark fuscous on anterior region of tergum V (this band ends well before posterior margin of tergum V); B—terga III to V as for form A except that the narrow fuscous band across anterior margin of tergum III is not continuous in centre of tergum; C—terga III to V orange-brown with narrow transverse dark fuscous markings on anterolateral margins of tergum III and a medial longitudinal band which is dark fuscous to dull black on terga III and IV and fuscous on tergum V (this band ends well before posterior margin of tergum V); D—terga III to V orange-brown with a narrow medial longitudinal dark fuscous band on posterior part of tergum IV and most of tergum V; E—terga III to V orange-brown with no dark markings or with only the anterolateral corners of tergum III fuscous.

Comments—D. musae (the banana fruit fly) is a major pest of bananas in northern Queensland and Papua New Guinea. Females oviposit in either ripe

or green bananas, and they can sting even young fruit as it appears on the bunch. In Queensland it has been recorded along the eastern coast as far south as Mt. Spec (65 km north of Townsville) (Figure 23). It occurs in the Torres Strait Islands, Papua New Guinea and associated islands, the islands of the Bismarck Archipelago and the Solomon Islands.

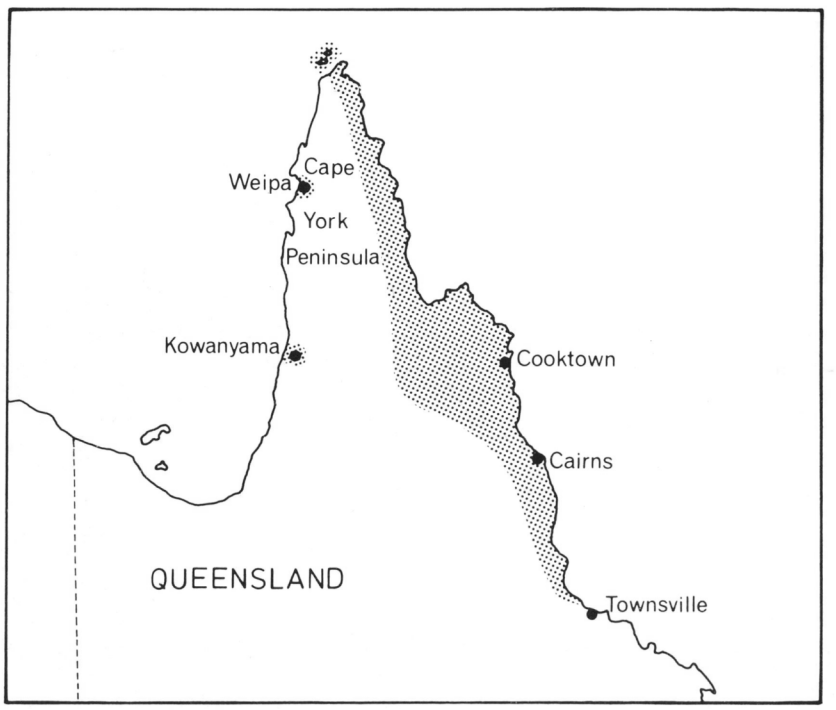

Figure 23—Map of Queensland showing distribution of *D. musae*

Dacus (Bactrocera) mutabilis (May)

(Figure 24)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Atherton (northern Queensland).

A medium sized pale coloured species; facial spots absent; thorax red-brown; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous with microtrichia covering all of second costal cell and most of first costal cell; abdomen generally orange-brown.

Head—Generally fulvous. *Frons* of even width; fulvous with at most pale fuscous around orbital bristles and on antero-medial hump; latter covered

with short pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous; facial spots absent. *Genae* fulvous; subocular spots generally absent, when present they are small and pale brown; bristles fuscous. *Occiput* red-brown, yellow along eye margin; occipital rows with 4-8 well developed red-brown bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; red-brown bristle on second segment; arista fulvous proximally (remainder fuscous to black).

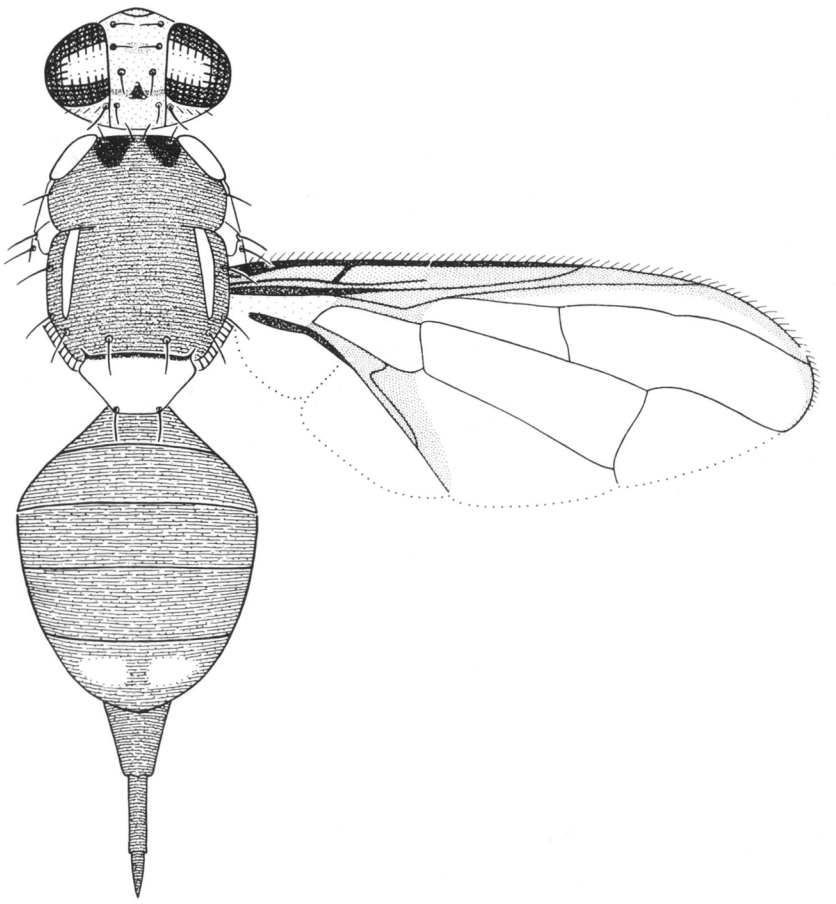

Figure 24-- *Dacus (Bactrocera) mutabilis* (May) (X13)

Thorax—Red-brown with black markings as follows: on sternopleura; above hind coxae; a pair of large, oval spots on anterior margin of mesonotum inside each humeral callus. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above,

continuing onto sternopleuron below as a yellow spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ¾ lower hypopleural calli (remainder black); two narrow lateral post-sutural vittae, narrowing sharply posteriorly to end well before upper *p.sa.* bristles. *Postnotum* black, with a narrow dark red-brown band centrally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. In most specimens the *a.sa.* bristles are either weak or absent. *Legs*: fulvous except hind tibiae fuscous; middle tibiae each with an apical black spur. *Wings*: costal cells fuscous (there is a paler spot in the centre of the second costal cell), microtrichia covering all of second costal cell and most of first costal cell; remainder of wings colourless except dark fuscous stigma, narrow fuscous costal band slightly overlapping R_{2+3} and widening beyond extremity of this vein to end between extremities of R_{4+5} and M_{1+2}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III of males. All abdominal terga orange-brown with no dark markings. A pair of shining spots on tergum V. The ovipositor is strongly developed, with the visible portion of oviscape red-brown, elliptical in transverse cross-section and tapering posteriorly in dorsal view.

Comments—D. mutabilis has been bred from kumquat in south-eastern Queensland. It is of only minor economic importance. It occurs along the eastern coast of Queensland and is more prevalent in south-eastern Queensland.

Dacus (Bactrocera) neohumeralis Hardy

(Figure 25)

Material studied: A series of specimens collected at localities from Toowoomba (south-eastern Queensland) to Cairns and the Atherton Tableland (northern Queensland).

A medium sized species; generally dark in appearance; facial spots medium sized and oval; thorax generally red-brown with a pattern of dark fuscous to black markings; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral calli dark brown to fuscous; notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak; costal cells fuscous with microtrichia covering all of second costal cell and outer ½ of first costal cell; abdomen with terga III to V generally dark fuscous to dull black and tending towards red-brown medially.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; latter covered with a large number of short, pale setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous to fuscous. *Face* fulvous with medium sized, oval black spots not reaching epistoma. *Genae* fulvous; small brown sub-ocular spots present; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-9 well developed dark fulvous bristles each

side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

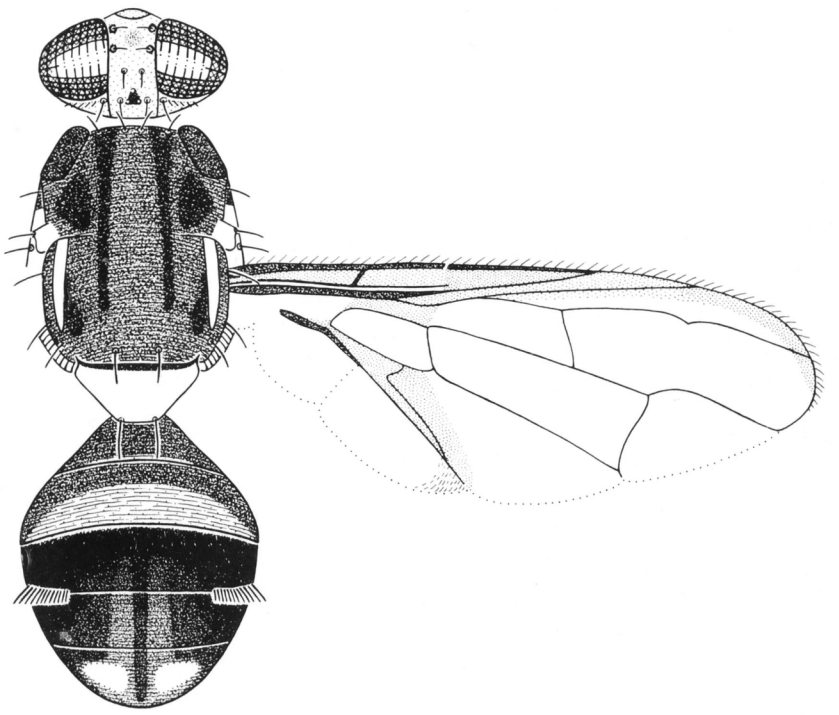

Figure 25—*Dacus (Bactrocera) neohumeralis* Hardy (X13)

Thorax—Dark red-brown (tending towards fuscous) except dark fuscous to black markings as follows: anterior to mesopleural stripes; on pteropleura; below wings; inside posterior $\frac{1}{2}$ of lateral post-sutural vittae; a large oval spot between humeral and notopleural calli dorsal to notopleural sutures; two moderately broad longitudinal bands on mesonotum running from anterior margin of mesonotum to end well before *prsc.* bristles; (the dark markings on the mesonotum vary markedly in size—they may be greatly reduced until almost absent or so enlarged that they almost merge together, giving the appearance of a uniformly darkened mesonotum). Humeral calli dark brown to fuscous. Yellow markings as follows: notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle as above, continuing onto sternopleuron below as a yellow spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two moderately broad lateral post-sutural vittae, narrowing slightly pos-

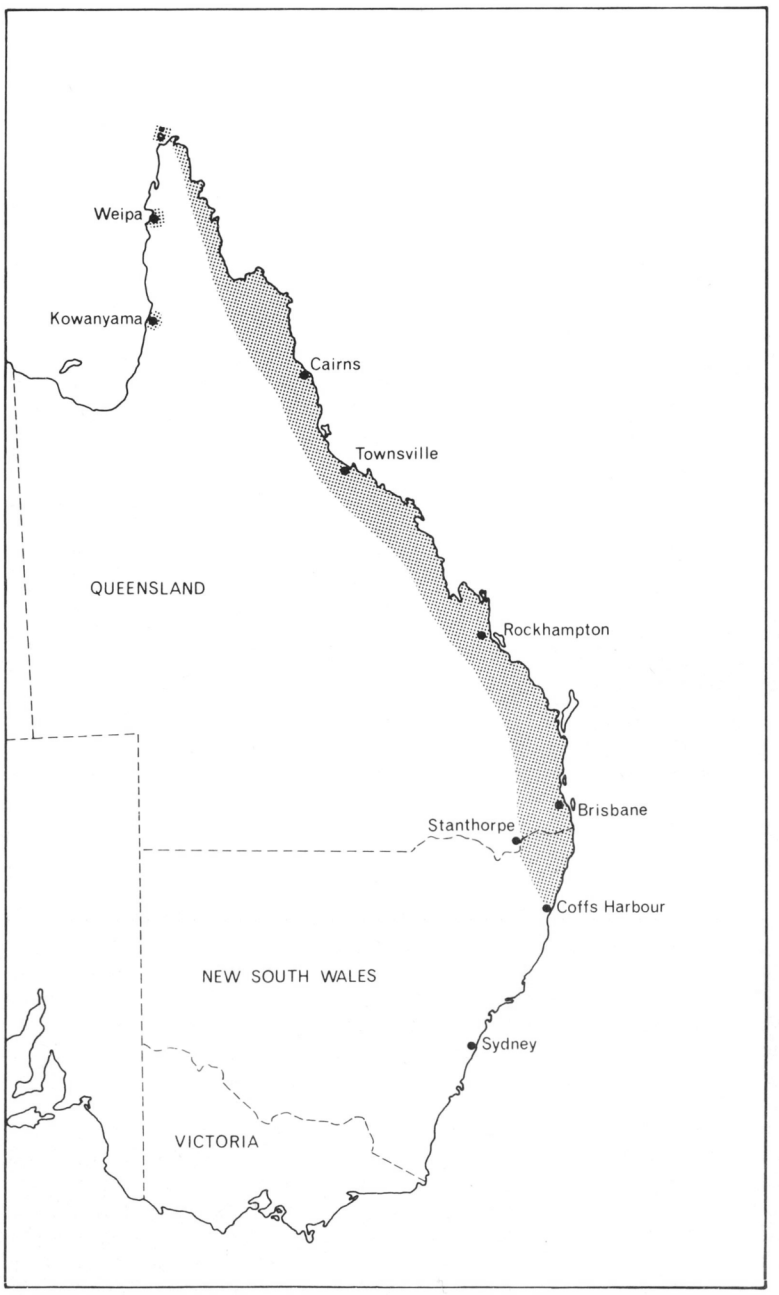

Figure 26—Map of eastern Australia showing distribution of *D. neohumeralis*

teriorly and ending before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow except for narrow black basal band. *Bristles*: *sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark red-brown. *Legs*: fulvous except coxae and hind tibiae fuscous; middle tibiae each with an apical black spur. *Wings:* costal cells fuscous, microtrichia covering all of second costal cell and outer $\frac{1}{2}$ of first costal cell; remainder of wings colourless except dark fuscous stigma, narrow fuscous costal band overlapping R_{2+3} and ending just beyond extremity of R_{4+5}, a broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA+1A. Supernumerary lobe weak.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I fuscous except for a narrow transverse orange-brown band along posterior margin but not reaching lateral margins; tergum II fulvous except for broad fuscous transverse band over anterior $\frac{1}{2}$ of tergum and expanding to cover lateral margins; terga III to V dark fuscous to dull black except for two narrow dark red-brown bands (tending fuscous on tergum III) either side of a narrow medial longitudinal fuscous band from centre of tergum III to posterior margin of tergum V. A pair of shining spots on tergum V.

Comments—D. neohumeralis is a major pest of most commercial fruit crops in Queensland. Taxonomically it is very closely related to *D. tryoni* and both species possess similar host fruits. In some commercial fruits these species occur in a 50:50 ratio, and often, *D. neohumeralis* predominates. *D. neohumeralis* occurs throughout the eastern coast of Australia from Cape York in the north to Coffs Harbour in the south (Figure 26). It is more prevalent in the northern wet tropical areas than in the cooler southern areas. May (1963) recorded this species as one of major economic importance. It occurs in coastal districts of Queensland receiving an annual rainfall greater than 760 mm (30 inches). It occurs in Papua New Guinea and islands in Torres Strait.

Dacus (Bactrocera) tryoni (Froggatt)

(Figures 27, 28)

Material studied: A series of specimens collected at localities throughout Queensland.

A medium sized species; facial spots pear shaped; mesonotum red-brown with fuscous markings; lateral post-sutural vittae present; mesopleural stripes narrow; humeral and notopleural calli yellow; scutellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells fuscous; microtrichia covering most of second costal cell and outer $\frac{1}{2}$ of first costal cell; abdomen with terga III to V blotched fuscous overlying paler red-brown which shows through in central areas of terga.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous around orbital bristles and on antero-medial hump; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule darkened. *Ocellar triangle* black. *Vertex* pale fuscous. *Face* fulvous with two pear shaped spots (tending oval) not quite reaching epistoma. *Genae* fulvous; sub-ocular spots pale; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 6-8 strong fuscous

bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; arista fulvous proximally (remainder black).

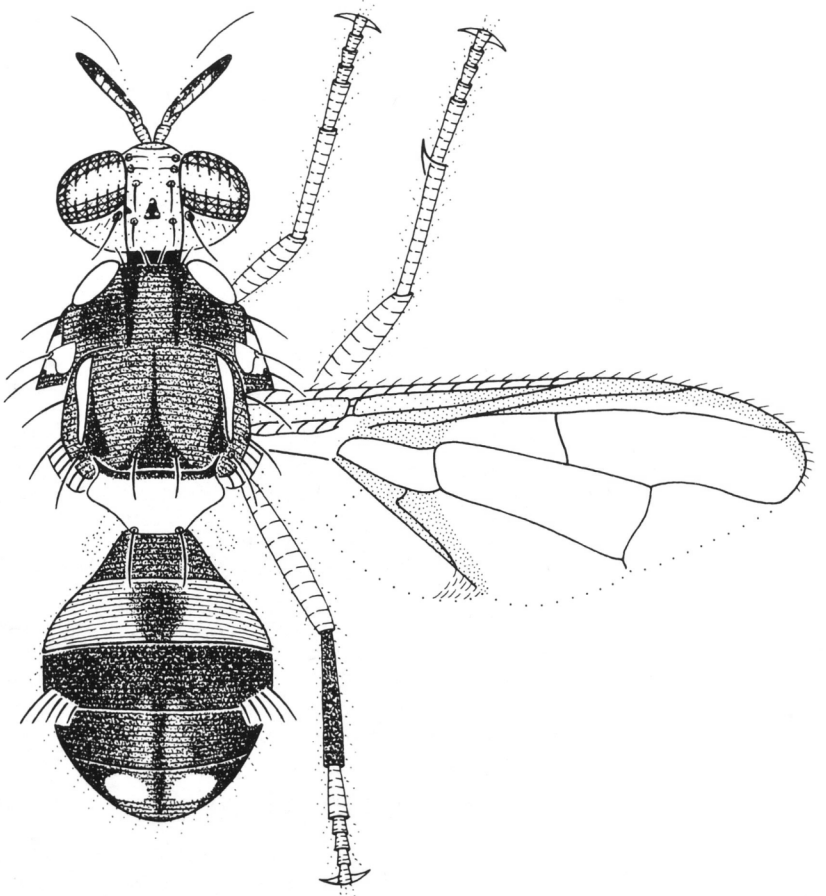

Figure 27—*Dacus (Bactrocera) tryoni* (Froggatt) (X13)

Thorax—Generally rich red-brown. Pleura rich red-brown with black on most of sternopleuron, a spot above hind coxae and beneath wings; blotched fuscous to black along anterior and posterior edges of mesopleural stripes. Mesonotum with a central tomentose band appearing greyish; fuscous markings as follows: two narrow longitudinal bands which run from anterior margin between central tomentose band and humeral calli and end before mesonotal suture; between humeral and notopleural calli; along inner posterior margins of post-sutural vittae; on posterior marginal area of

mesonotum (may be absent in some specimens). Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes ending midway between notopleural callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a transverse spot; upper hypopleural calli (posterior apices red-brown); $\frac{5}{8}$ lower hypopleural calli (remainder red-brown); two narrow, triangular, lateral post-sutural vittae ending before upper *p.sa.* bristles (level with lower *p.sa.* bristle). *Postnotum* fuscous laterally and red-brown centrally. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs:* fulvous except for middle and hind coxae and hind tibiae fuscous; middle tibiae each with apical black spur. *Wings*: costal cell fuscous, microtrichia covering all of second costal cell and outer $\frac{1}{2}$ of first costal cell; remainder of wings colourless except dark fulvous stigma, narrow fuscous costal band overlapping R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, broad fuscous anal streak ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males and weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I dark red-brown to fuscous; tergum II fulvous with posterior $\frac{1}{2}$ tending whitish; terga III to V blotched fuscous overlying red-brown which shows through chiefly in central areas of each tergum. A faintly visible thin medial longitudinal fuscous band on terga III to V (not visible in some specimens). A pair of shining spots on tergum V which tend towards yellow-brown. In some specimens terga III to V are paler in the central areas, the fuscous pattern being confined to the anterior margin of tergum III and lateral margins of the three terga (Figure 28).

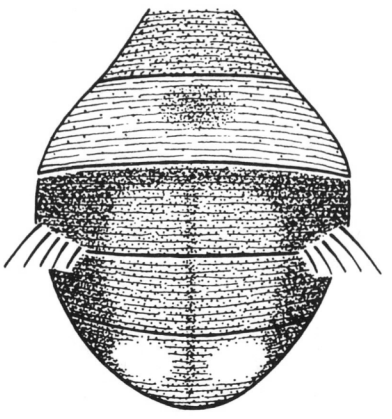

Figure 28—Abdomen of pale form of *D. tryoni* (X18)

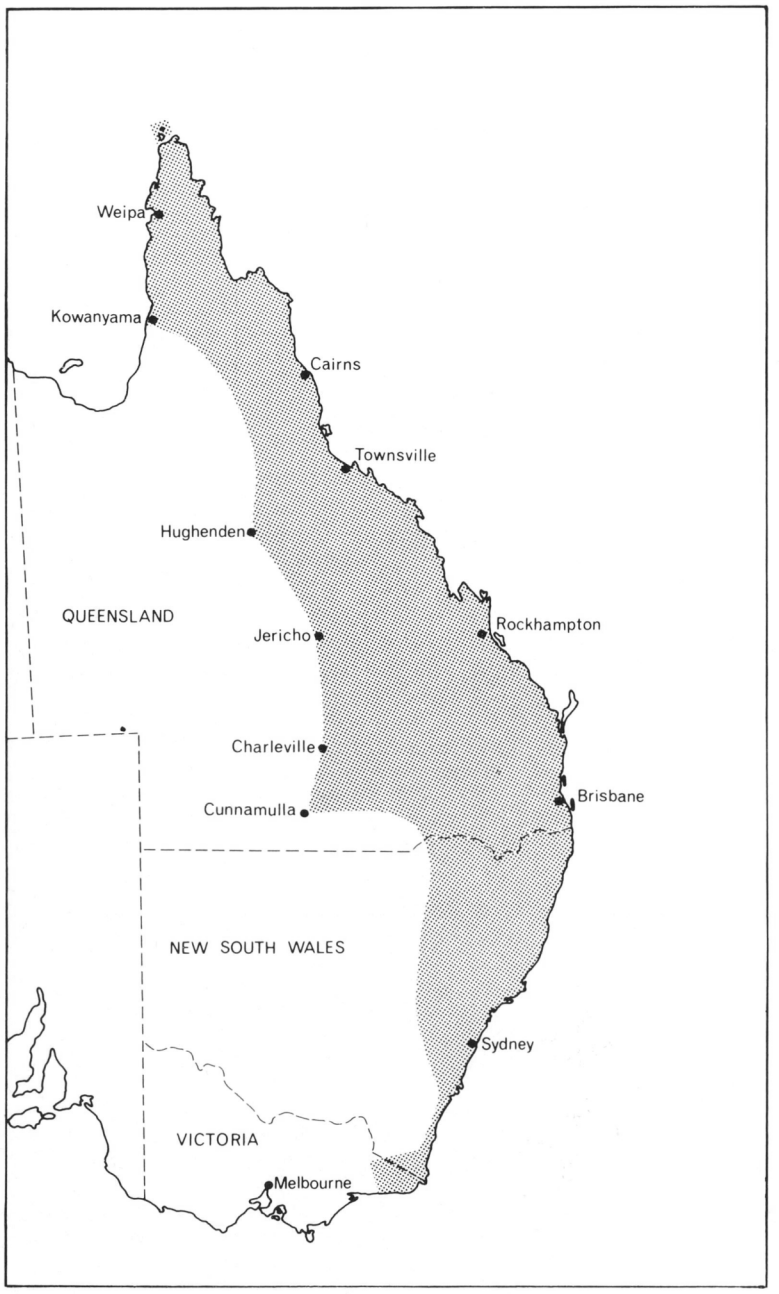

Figure 29—Map of eastern Australia showing distribution of *D. tryoni*

Comments—D. tryoni (the Queensland fruit fly) is the most destructive insect pest of fruit and vegetable crops in Australia. It infests all commercial fruit crops (except pineapple and strawberries) and many vegetable crops. It has been recorded from over 100 host plants in Queensland but probably occurs in many more. Many of the hosts are wild plant fruits which are responsible for the development of extremely large fly populations in forest areas.

It is most probable that *D. tryoni* and *D. dorsalis* are ecological homologues and are of equal pest status. Almost certainly, they infest the same range of fruits and possess similar climatic tolerances.

The distribution of *D. tryoni* within Australia is given in Figure 29. Outside Australia it has been recorded in Papua, New Caledonia, Austral Islands, many islands of the Society group and Easter Island. It was eradicated from Easter Island soon after it was detected in 1971 (see Section III (2C)). It has spread outwards into the South Pacific region from Australia within the last 10 years—an example of how a serious fruit fly pest species can be distributed with the aid of man in the present age of high speed travel. It was first recorded in the Austral Islands (Tubuai) in March 1977 by N. L. H. Krauss (personal communication, D. E. Hardy). The record from Papua is of one teneral specimen bred ex *Eugenia*.

(B) Species outside Australia—Species described in this section do not occur within Australia.

Dacus (Paradacus) decipiens Drew

(Figures 30, 31)

Material studied: A series of specimens collected at localities in New Britain.

A medium sized species; facial spots oval; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with broad pale fuscous costal band and anal streak and with an irregular S-shaped pale fuscous marking across the centre; costal cells extremely pale fuscous; microtrichia in outer $\frac{1}{3}$ of second cell; abdomen generally fulvous with a narrow medial longitudinal fuscous band on tergum V.

Female

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with at most small fuscous markings around orbital bristles; antero-medial hump covered with a large number of short, fulvous setae; bristles black: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous with medium sized, oval, fuscous to black spots not reaching

epistoma. *Genae* fulvous; pale brown sub-ocular spots present; bristles black. *Occiput* fulvous, small pale fuscous areas dorsally, yellow along eye margin; occipital rows with a large number of strong fulvous bristles each side. *Antennae* fulvous with no dark markings; a strong fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura red-brown except pale fuscous markings as follows: along anterior margin of mesopleural stripes; on sternopleura below yellow spot; on pteropleura behind mesopleural stripes; above hind coxae. Mesonotum red-brown except two broad lateral longitudinal fuscous bands running inside lateral post-sutural vittae from posterior margin to anterior margin. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each ending just before anterior *npl.* bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{5}{6}$ lower hypopleural calli (remainder red-brown); two broad, parallel sided lateral post-sutural vittae beginning anterior to mesonotal suture and ending at upper *p.sa.* bristles; a broad medial post-sutural vitta beginning anterior to mesonotal suture and ending at level of upper *p.sa.* bristles. *Postnotum* black laterally, red-brown centrally. *Scutellum* yellow except for narrow red-brown basal band. *Bristles: sc.* 4, *prsc.* absent, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4 to 7 (inner bristles generally weak and fulvous); *hm.* 5 specimens with one pair which are generally weak and fuscous to black, 1 specimen with one weak pale bristle on one side, 1 specimen with no bristles; all bristles well developed and black except where otherwise stated above. *Legs:* all segments fulvous, femora tending whitish basally; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae each with an apical black spur. *Wings:* costal cells extremely pale fuscous, second cell paler in centre, microtrichia in outer $\frac{1}{3}$ of second costal cell only; remainder of wings colourless except pale fuscous stigma, broad pale fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M_{1+2}, and irregular pale fuscous marking across wing which runs from costal band (enveloping r-m cross vein and forming a large blotch in discoidal cell) to hind margin at M_{3+4} and recurving back along i-m cross vein and then recurving back along M_{1+2}, a broad pale fuscous anal streak ending at wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe very weak.

Abdomen—Oval; terga free; no pecten on abdominal tergum III. Terga I to V fulvous except broad lateral fuscous margins on tergum I and a narrow medial longitudinal fuscous band on tergum V (terga III to V in some specimens). A pair of shining spots on tergum V. Visible portion of oviscape orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown, with one pair of lobes at its tip (Figure 31).

Male

Head—As for female.

Thorax—As for female except as follows: wings (a) with aggregation of microtrichia around CuA + 1A; (b) supernumerary lobe very strong.

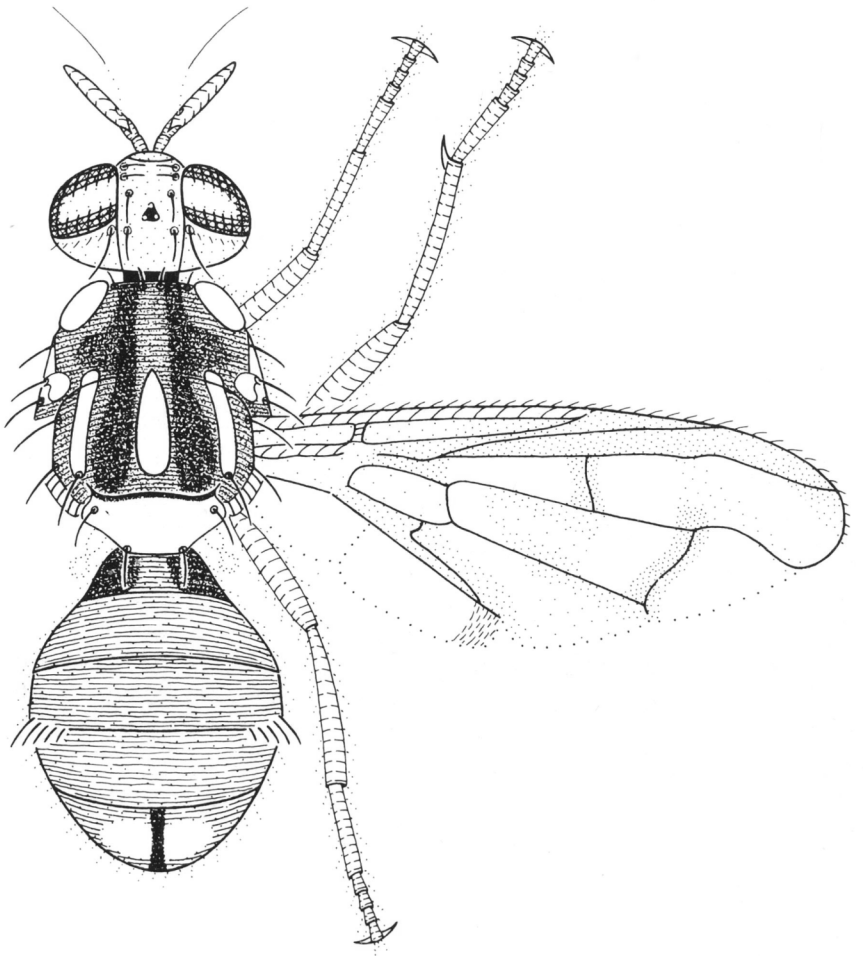

Figure 30—*Dacus (Paradacus) decipiens* Drew (X10)

Abdomen—As for female except as follows: (a) with pecten on abdominal tergite III; (b) posterior lobe of surstylus long; (c) posterior margin of abdominal sternum V with a slight concavity.

Comments—This species has been recorded only from New Britain where it is a very serious pest of pumpkins. It probably infests a wide range of cucurbits. If introduced into Australia, it could become a more serious pest of cucurbits than the endemic *D. cucumis*. Like *D. cucumis*, *D. decipiens* does not respond to any of the known male lures.

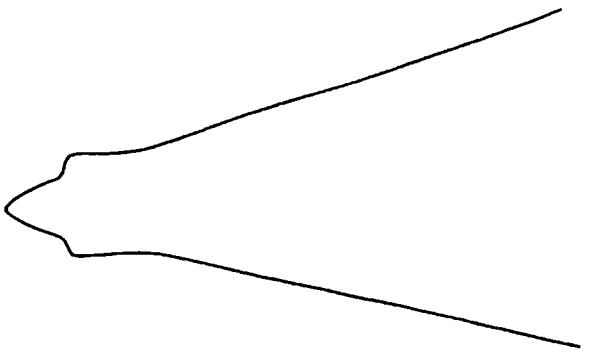

Figure 31—Tip of aculeus of *D. decipiens* (X300)

Dacus (Paratridacus) atrisetosus (Perkins)

(Figure 32)

Material studied: A series of specimens collected at localities in Papua New Guinea.

A medium sized species; facial spots small and circular; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with narrow fuscous costal band and anal streak; costal cells pale fulvous; microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal terga III to V orange-brown with fuscous on lateral margins of tergum III and a narrow medial fuscous band on tergum V.

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except small fuscous area on antero-medial hump; latter covered with short dark fulvous setae; bristles fuscous: 1 *s.or.*, 2-3 *i.or.*; lunule fulvous. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous with small circular fuscous spots not reaching epistoma. *Genae* fulvous; sub-ocular spots small and pale brown when present; bristles fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-6 well developed fulvous bristles and a large number of small paler bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment; a strong fulvous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

Thorax—Red-brown with irregularly shaped fuscous markings as follows: anterior to mesopleural stripes (but not below humeral calli); on pteropleura; on sternopleura; above hind coxae; a very large circular spot between humeral calli and anterior margins of lateral post-sutural vittae; a

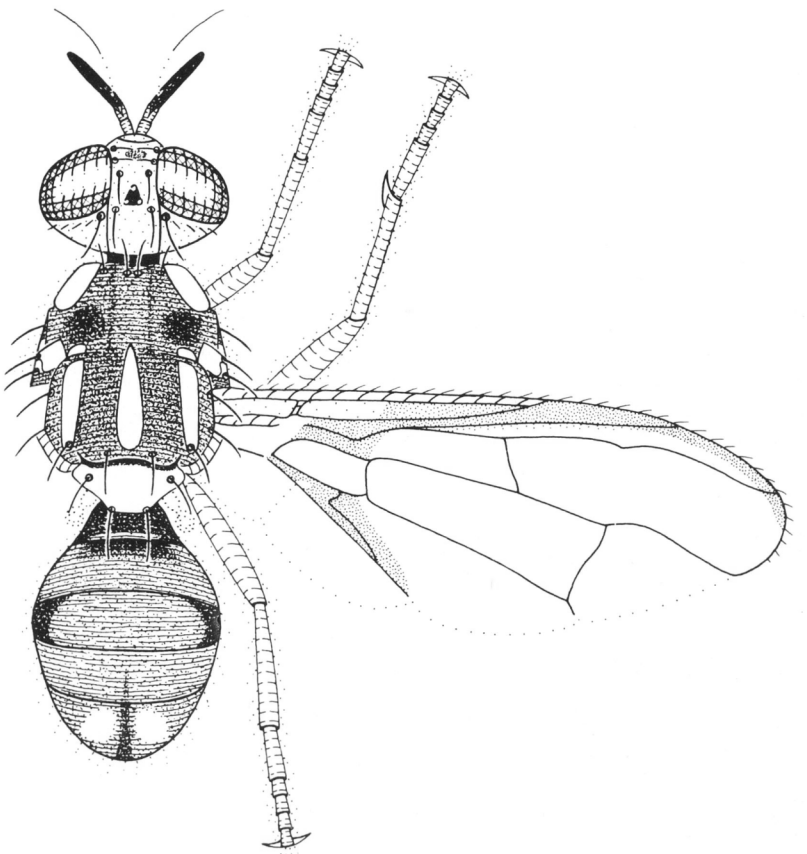

Figure 32—*Dacus (Paratridacus) atrisetosus* (Perkins) (X13)

large pattern between post-sutural vittae which may extend back to posterior margin of mesonotum; a narrow band running from anterior margin of mesonotum just inside each humeral callus to unite with colouration between lateral and medial post-sutural vittae. There is a large amount of variation in the fuscous colour patterns: (1) the pleura vary from red-brown and devoid of fuscous colouration to entirely fuscous with only red-brown below humeral calli—between these extremes there are various developments of infuscation; (2) the mesonotum varies from (a) red-brown with a small amount of infuscation between post-sutural vittae and a large fuscous spot between humeral calli and anterior margin of lateral post-sutural vittae to (b) entirely infuscated except for red-brown area running from anterior point of medial post-sutural vitta to anterior margin of mesonotum between humeral calli—between these extremes there are various developments of infuscation. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of

medium width, each extending to midway between anterior margin of notopleural callus and anterior *npl.* bristle above, anterior margin slightly convex and continuing onto sternopleuron below as a large transverse spot; upper hypopleural calli (posterior apices red-brown to fuscous); $\frac{5}{7}$ lower hypopleural calli (remainder red-brown to fuscous); two moderately broad, parallel sided, lateral post-sutural vittae beginning anterior to mesonotal suture and ending behind upper *p.sa.* bristles; a broad medial post-sutural vitta beginning at level of *prsc.* bristles and narrowing anteriorly to end just anterior of mesonotal suture. *Postnotum* black except tending brown medially. *Scutellum* yellow except narrow red-brown to fuscous basal band. *Bristles: sc.* 4, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fulvous, rows of long fulvous setae on dorsal surface of fore femora; mid tibiae with apical black spur. *Wings:* costal cells pale fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M_{1+2}, and a narrow fuscous anal streak ending before wing margin. No dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Elongate oval; terga free; no pecten on tergum III. Tergum I fuscous except orange-brown along posterior margin; tergum II orange-brown except fuscous along anterior $\frac{1}{3}$ which may not reach lateral margins; terga III to V orange-brown, sometimes with fuscous on lateral margins of tergum III and generally with a narrow medial fuscous band on tergum V. A pair of shining spots on tergum V.

Comments—D. atrisetosus is known only from Papua New Guinea, where it appears common at higher altitudes. In this area it has been bred from cucurbits. A large number of specimens of this species are held in the collection of the Wau Ecology Institute, Papua New Guinea where they were reared from pumpkin, watermelon, several varieties of squash and cucumber during 1978. Its pest status would be minor compared with *D. cucurbitae* and *D. decipiens.*

Malloch (1939) recorded a female of *D. cucumis* from Mondo (1,524 m), Papua. *D. cucumis* almost certainly does not occur outside Australia and Malloch probably had a specimen of *D. atrisetosus.*

It does not respond to any of the known male lures and therefore is difficult to monitor.

Dacus (Zeugodacus) cucurbitae Coquillett

(Figure 33)

Material studied: A series of specimens collected at localities in Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island.

A medium sized species; facial spots large and oval; mesonotum red-brown with fuscous markings; lateral and medial post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scutellum yellow; wing with a broad fuscous costal band and anal streak

(costal band expanded into a large spot) and with infuscation on i-m and r-m cross veins; costal cells colourless; microtrichia in outer portion of second costal cell; abdominal terga III to V orange-brown with black markings as follows—a narrow transverse band along anterior margin to tergum III, on anterolateral corners of each tergum and a medial longitudinal band on terga III to V.

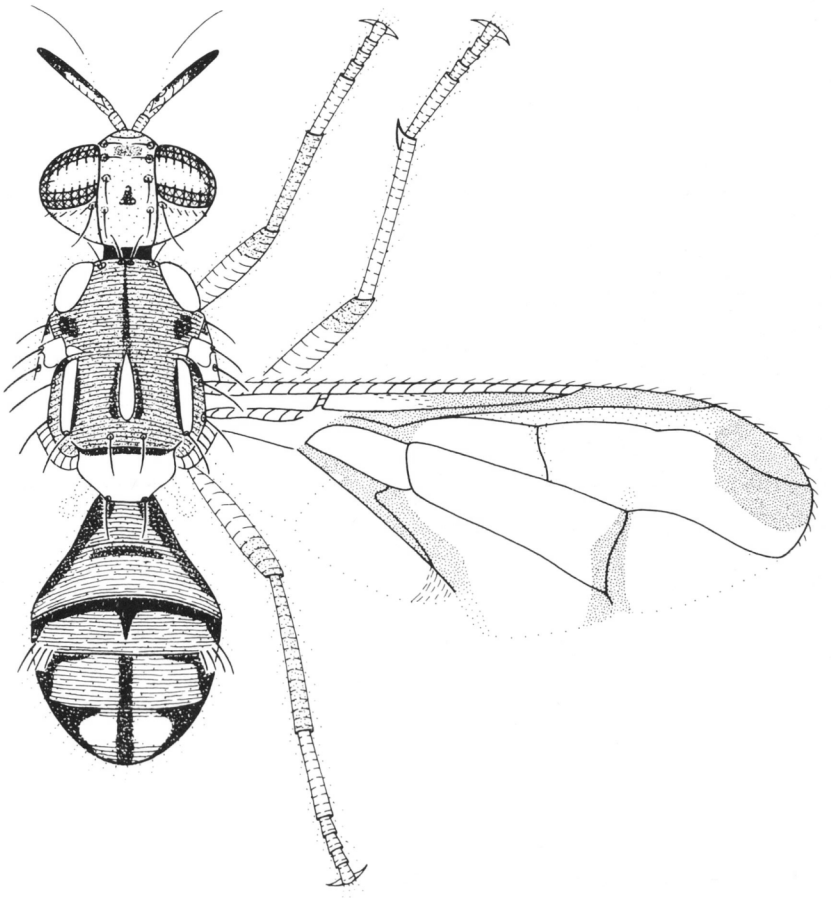

Figure 33—*Dacus (Zeugodacus) cucurbitae* Coquillett (X13)

Head—Generally fulvous. *Frons* of even width; fulvous except pale fuscous around orbital bristles and on antero-medial hump (absent in a few specimens); latter covered with short setae; bristles fuscous: 1 *s.or.*, 3 *i.or.* (4 *i.or.* bristles in a few specimens); lunule darkened. *Ocellar triangle* fuscous to black. *Vertex* fulvous. *Face* fulvous except large oval facial spots not reaching epistoma. *Genae* fulvous; brown sub-ocular spots present; bristles fuscous.

Occiput fulvous, yellow along eye margin; occipital rows well developed, with many long pale bristles each side. *Antennae* fulvous, with fuscous on apex and outer surface of third segment; a long fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

Thorax—Red-brown with variation from no dark markings to fuscous markings as follows: along anterior margin of mesopleural stripes; on sternopleura; above hind coxae; on pteropleura; posterior to notopleural calli; along inner margin of lateral post-sutural vittae; an irregular marking between humeral calli and notopleural calli; a narrow band around medial post-sutural vitta which extends forward medially to the anterior margin of the mesonotum (variation in the above colour characters occurs irregularly throughout the specimens studied—the patterns that are most variable are as follows: on sternopleura; on pteropleura; the band around the medial post-sutural vitta). Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripes of medium width, each extending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior $\frac{2}{3}$ lower hypopleural calli (remainder red-brown); two moderately broad, lateral post-sutural vittae beginning before mesonotal suture and narrowing slightly posteriorly to end at the upper *p.sa.* bristles; a short, narrow, medial post-sutural vitta beginning at level of mesonotal suture and widening posteriorly to end before level of *prsc.* bristles. *Postnotum* red-brown (with a fuscous tinge on lateral margins in some specimens). *Scutellum* yellow, except for narrow red-brown basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; bristles mostly well developed and fuscous. This species has a large variation in chaetotaxy. The chaetotaxy mentioned above is the normal pattern for this species; however, the following variations occur; *sc.*—4; *prsc.*—3 or 4; *a.sa.*—1 bristle on one side only or bristles absent on both sides; *npl.*—3 bristles on one side and 2 on the other side; *scp.* 1, 2, or 3 strong bristles with a corresponding number of weak bristles to make 4 bristles, or 1 or 2 outer bristles with 1 weak fulvous inner bristle, or 3 well developed bristles only. The percentage variation based on the number of specimens having irregular chaetotaxic patterns are as follows: *sc.* 22%; *prsc.* 19%; *a.sa.* 22%; *npl.* 4%; *scp.* 37%. There is a large amount of variation in the bristles which are important in subgeneric classification, namely, *sc.*, *prsc.*, and *a.sa.* These variations do not show any pattern between geographic localities. *Legs:* all segments fulvous except fore and hind tibiae and apical $\frac{1}{3}$ of all femora dark fulvous (in some specimens the fore tibiae are fulvous); rows of long fulvous setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except a broad fuscous costal band confluent with R_{4+5} (except a narrow clear area above this vein distal to r-m cross vein) and ending at apex of wing in a large dark fuscous spot which does not reach extremity of M_{1+2}, a band of dark fuscous colouration around i-m cross vein which reaches wing margin, a narrow tint of infuscation around r-m cross vein, a broad fuscous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe strong in males, weak in females.

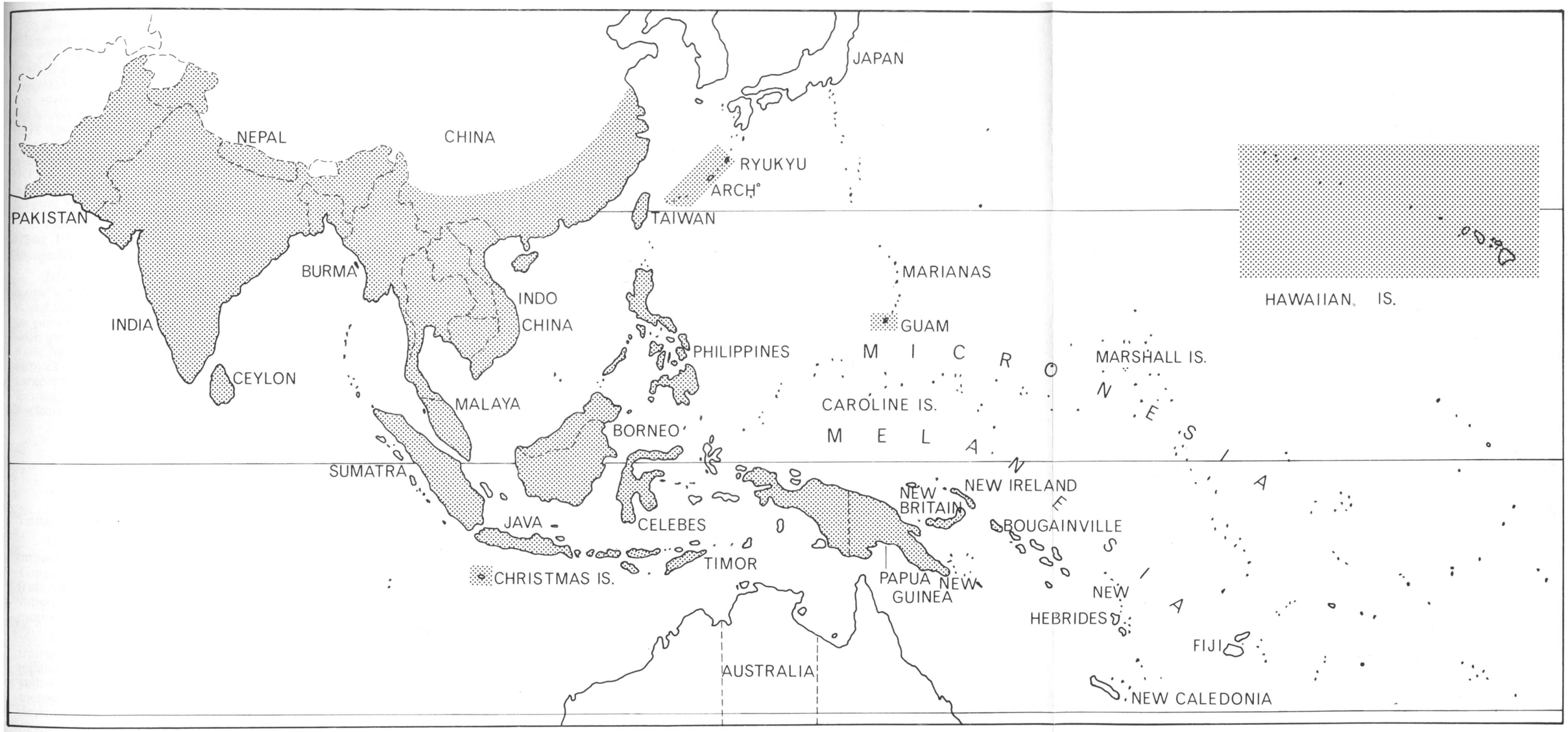

Figure 34—Map of Asian and Pacific regions showing distribution of *D. cucurbitae*

Abdomen—Elongate oval; terga free; pecten present on tergum III. Tergum I orange-brown with broad fuscous lateral bands; tergum II orange-brown, tending whitish on posterior ½ and with narrow fuscous bands on anterolateral margins, and in some specimens, with a narrow transverse fuscous band centrally just posterior of anterior margin; terga III to V orange-brown except a narrow transverse black band along anterior margin of tergum III which expands over anterolateral corners, a narrow medial longitudinal dark fuscous to black band from anterior margin of tergum III and widening posteriorly to end at or just before posterior margin of tergum V (this band is usually absent on posterior portion of tergum III or across intersegmental line between terga III and IV), and anterolateral margins of terga IV and V fuscous (reduced or absent in a few specimens). A pair of shining spots on tergum V.

Comments—In the South Pacific area, *D. cucurbitae* has been recorded from Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island. Its worldwide distribution is shown in Figure 34.

D. cucurbitae is the major fruit fly pest of vegetable crops and one of the world's most active and serious fruit fly pest species. Its introduction into Australia would cause problems of enormous magnitude and for this reason its presence in Papua New Guinea and associated islands must be regarded with great concern. It is the only fruit fly pest of cucurbits that responds to a male lure and this makes the monitoring of its populations easier. It is also subject to eradication or suppression using the male annihilation technique. A large number of specimens of this species are held in the collection of the Wau Ecology Institute, Papua New Guinea where they were reared from rockmelon, several varieties of cucumber and marrow.

Dacus (Notodacus) xanthodes (Broun)

(Figures 35, 36)

Material studied: A series of specimens collected at localities in Fiji, Tonga and Western Samoa.

In the original description, this species was listed as being found in fruit imported into New Zealand from Rarotonga (Cook Islands), Suva and Tonga. It appears that these records were based on the occurrence of larvae in fruit and not on adults bred from the larvae. *D. xanthodes* has never been subsequently recorded from Rarotonga Islands and so this record is probably incorrect.

A medium sized species; facial spots small and circular; mesonotum transparent and possessing a shining orange-brown colouration; lateral and medial post-sutural vittae present; humeral and notopleural calli joined by a yellow band; posterior ⅔ humeral calli yellow; notopleural calli orange-brown; mesopleural stripe reduced in size and not reaching notopleural callus dorsally; scutellum orange-brown with lateral margins yellow; wing with a narrow fuscous costal band and broad fulvous anal streak; costal cells pale fulvous; microtrichia in outer portion of second costal cell; abdominal terga pale orange-brown with no dark markings.

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump small and covered with a small number of short fulvous setae; bristles black: 1 *s.or.*, 3 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with small circular facial spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles black. *Occiput* fulvous; occipital rows with 2-6 well developed fulvous bristles and many small pale bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment and the outer surface of first segment; a strong fuscous bristle on the second segment; arista fulvous proximally (remainder black).

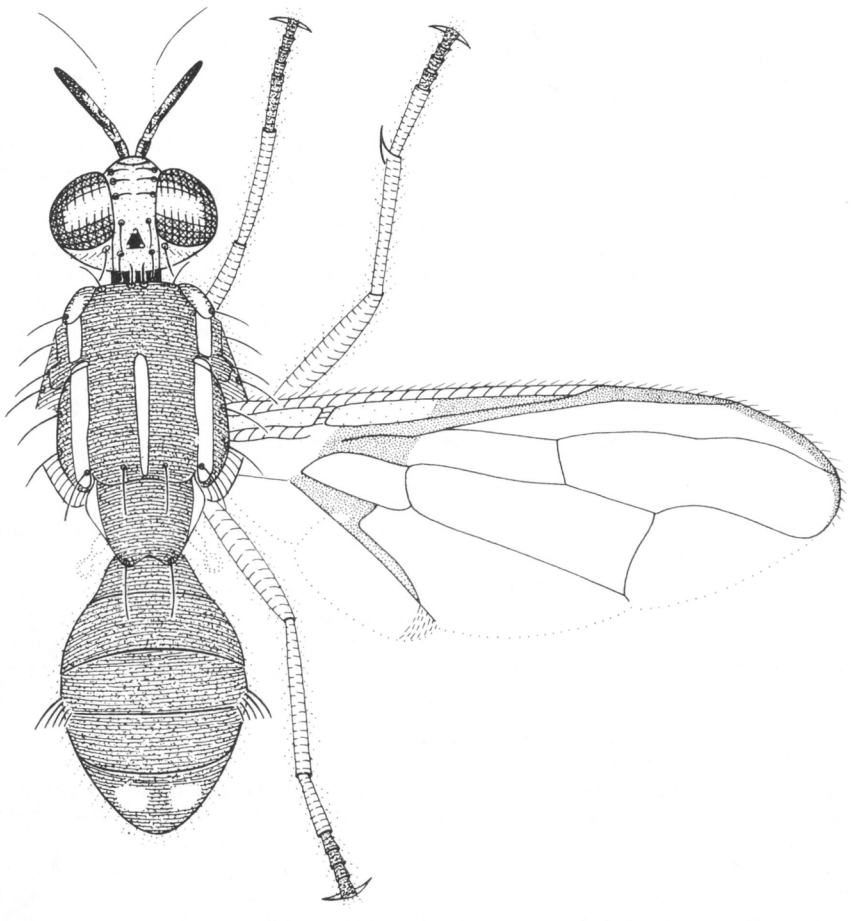

Figure 35—*Dacus (Notodacus) xanthodes* (Broun) (X13)

Thorax—Pleura transparent and with a shining fulvous colouration produced by internal muscle attachments; mesonotum transparent and with a shining orange-brown colouration except irregular dark markings due to attachments of large dorsoventral flight muscles. Yellow markings as follows: broad band on posterior $\frac{2}{3}$ of humeral calli (remainder of humeral calli fulvous); a broad lateral yellow band running from humeral calli to end just before lateral post-sutural vittae; two broad lateral post-sutural vittae beginning before mesonotal suture and narrowing slightly posteriorly to end at posterior margin of mesonotum; a narrow medial longitudinal vitta beginning at level of mesonotal suture and ending at level of lower *p.sa.* bristles; a large central spot on posterior $\frac{2}{3}$ of anepisternum and this continues onto anterior margin of anepimeron; anterior $\frac{2}{3}$ lower hypopleural calli (remainder orange-brown). Notopleural calli orange-brown. Upper hypopleural calli fulvous. *Postnotum* orange-brown. *Scutellum* orange-brown with lateral margins yellow; the scutellum is elongate with dorsal surface flattened and posterior margin drawn out to a point at bases of bristles. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *hm.* 1, *scp.* 4; all bristles well developed and black except inner scapulars reduced and fulvous in some specimens. *Legs:* fulvous except fore tarsi and apical four segments of mid and hind tarsi dark fulvous; middle tibiae with apical black spur. *Wings:* costal cells extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings extremely pale fulvous except narrow fuscous costal band confluent with R_{2+3} and ending betweeen extremities of R_{4+5} and M_{1+2}, a broad fulvous anal streak darkest in anal cell and ending at wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; terga free; pecten present on tergum III. All terga transparent and shining; colour of terga pale orange-brown with no dark markings; pair of spots on tergum V present but not shining.

Female

Head—As for male.

Thorax—As for male except as follows: (1) no dense aggregation of microtrichia around vein CuA + 1A; (2) supernumerary lobe weak.

Abdomen—As for male except as follows: (1) no pecten on tergum III; (2) visible portion of oviscape with basal $\frac{1}{3}$ pale orange-brown (remainder dark fuscous), dorsoventrally flattened and tapering posteriorly in dorsal view. Length of visible portion of oviscape to length of tergum V, 2.5:1. Aculeus strongly sclerotized, red-brown, needle shaped at its tip (Figure 36).

Comments—This species has the following distinctive characters: (1) 3 *i.or.* bristles on frons; (2) presence of one pair of well developed *hm.* bristles; (3) the integument of the head, thorax and abdomen is generally transparent giving the specimens a mottled appearance as internal tissues are visible; (4) the integument is soft and this is particularly noticeable on the abdominal terga which curl inwards ventrally in dead specimens; (5) the pair of spots on abdominal tergum V have a rough appearance compared with the smooth shining spots of most species.

D. xanthodes has been recorded from Fiji, Western Samoa and Tonga.

This species has been bred from pineapple, citrus, papaya, granadilla, guava and tomatoes. It has the potential to become a very serious pest if introduced into areas where extensive horticulture is carried out.

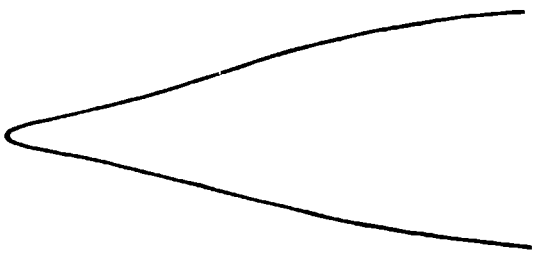

Figure 36—Tip of aculeus of *D. xanthodes* (X145)

Dacus (Bactrocera) curvipennis Froggatt

(Figure 37)

Material studied: A series of specimens collected in New Caledonia.

A small species; facial spots elongate and pale fuscous; mesonotum black; lateral post-sutural vittae present; humeral and notopleural calli yellow; mesopleural stripes narrow; scutellum yellow; wing with a broad fuscous costal band and anal streak; costal cells pale fuscous, microtrichia covering second costal cell; abdominal terga III to V orange-brown with a narrow fuscous band along anterior margin of tergum III, fuscous to black laterally on tergum III and fuscous anterolaterally on terga IV and V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except pale fuscous markings around orbital bristles; antero-medial hump covered with a small number of short pale setae; bristles dark fulvous: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* dark fulvous. *Face* fulvous with very small, elongate, pale fuscous spots not reaching epistoma. *Genae* fulvous; sub-ocular spots absent; bristles dark fulvous. *Occiput* fulvous, yellow along eye margin; occipital rows well developed, with 3-7 strong dark fulvous bristles each side. *Antennae* fulvous, with fuscous on the apex and outer surface of the third segment; a strong dark fulvous bristle on the dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Black with dark brown below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli and inside humeral calli (in one specimen the humeral and notopleural calli are connected by a broad dark brown band above the notopleural suture); with brown below humeral calli and above middle coxae. Yellow markings as follows: humeral

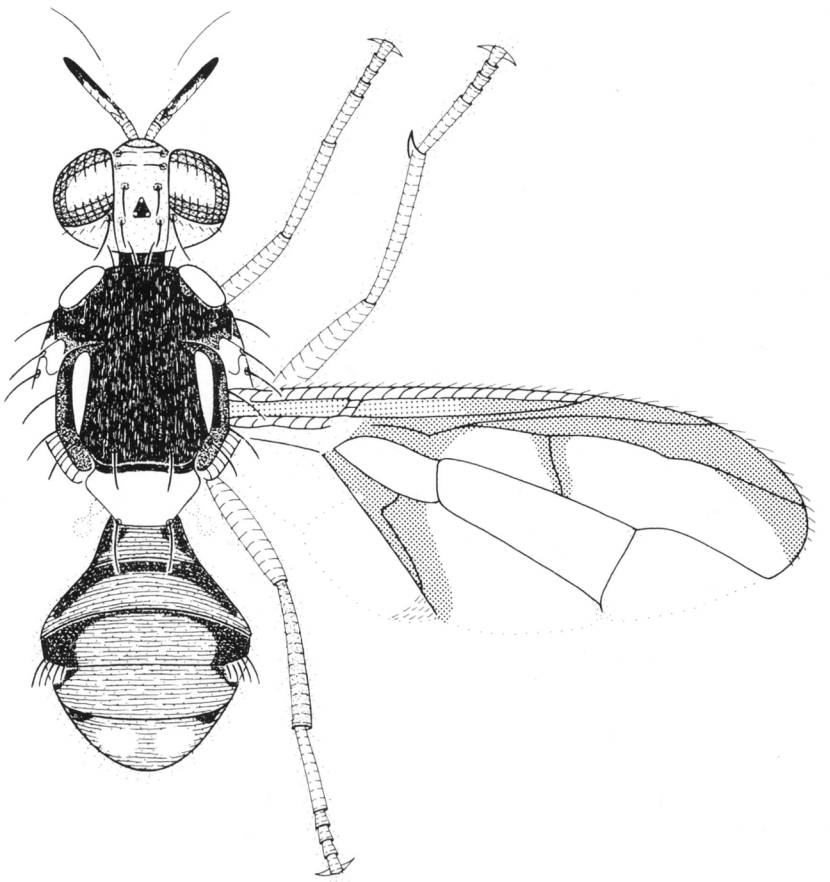

Figure 37— *Dacus (Bactrocera) curvipennis* Froggatt (X16)

calli; notopleural calli; narrow mesopleural stripes, extending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); posterior $\frac{3}{5}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing posteriorly to end before the upper *p.sa.* bristles as a result of brown colouration surrounding this bristle and covering the yellow vitta at its extremity. *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fulvous. One specimen has 3 *prsc.* bristles, one specimen has three pair of *p.sa.* bristles, and one specimen has 3 *p.sa.* bristles on one side. *Legs:* all segments fulvous except mid and hind coxae and hind tibiae dark fulvous; rows of long fulvous setae on dorsal surface of

fore femora; middle tibiae with apical black spur. *Wings:* costal cells pale fuscous, microtrichia covering all of second costal cell and outer portion of first costal cell; remainder of wings colourless except broad fuscous costal band confluent with R_{4+5} and ending just before extremity of M_{1+2}, a broad fuscous band along r-m cross vein, a broad fuscous anal streak ending at wing margin and including area covered with dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I orange-brown with broad fuscous bands on lateral margins (these fuscous bands may be reduced in size in some specimens); tergum II orange-brown with a narrow transverse fuscous band just posterior of anterior margin and which widens to cover the anterolateral margins (this fuscous band decreases in size in some specimens and is absent except for a very faint transverse infuscation in other specimens); terga III to V orange-brown with a narrow transverse fuscous band along anterior margin of tergum III which merges into broad lateral black margins, and anterolateral corners of terga IV and V fuscous (in some specimens the fuscous band along the anterior margin of tergum III and the fuscous anterolateral corners of terga IV and V are absent, leaving only the broad black lateral margins of tergum III). A pair of shining spots on tergum V.

Female

Head—As for male.

Thorax—As for male except (1) no aggregation of microtrichia around CuA + 1A; (2) supernumerary lobe weak; (3) proportion of anal cell extension to CuA + 1A, 1.65:1.

Abdomen—As for male except (1) no pecten on abdominal tergum III; (2) visible portion of oviscape flattened, narrowing posteriorly in dorsal view and dark fulvous to fuscous in colour; length of visible portion of oviscape to length of tergum V, 0.82:1.

Comments—*D. curvipennis* infests citrus in New Caledonia. It presently is not known outside this locality.

Dacus (Bactrocera) dorsalis Hendel

(Figure 38)

Material studied: For this description, specimens collected from India, Thailand, Malaysia, Saipan and Hawaii have been studied.

A medium sized dark coloured species; facial spots circular; mesonotum black; lateral post-sutural vittae present; mesopleural stripes of medium width; humeral and notopleural calli yellow; scuttellum yellow; wing with a narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer portion of second costal cell only; abdomen with transverse black band on basal margin of tergum III and a medial longitudinal fuscous to black band on terga III to V.

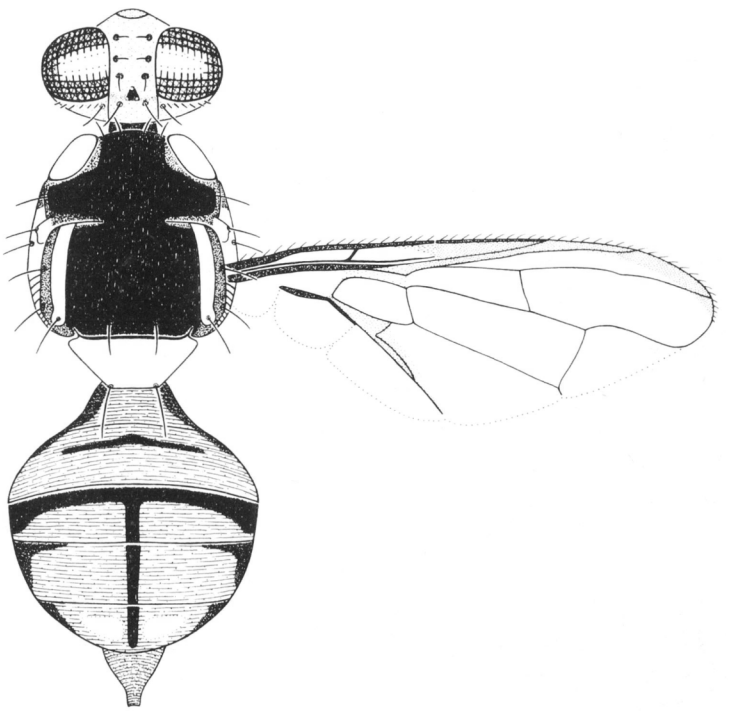

Figure 38—*Dacus (Bactrocera) dorsalis* Hendel (X12)

Male

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without fuscous around orbital bristles and on antero-medial hump; latter covered with short dark setae; bristles fuscous: 1 *s.or.*, 2 *i.or.;* lunule fulvous to fuscous. *Ocellar triangle* black. *Vertex* dark fulvous to fuscous. *Face* fulvous with medium sized, circular black spots not reaching epistoma. *Genae* fulvous; medium sized, brown sub-ocular spots present or absent; bristles fuscous. *Occiput* fulvous, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of third segment; fulvous bristle on second segment; arista fulvous proximally (remainder black).

Thorax—Black except brown markings as follows: below humeral calli; above mid coxae; below wings; below and behind lateral post-sutural vittae; along mesonotal suture; above notopleural calli; between humeral and notopleural calli dorsal to notopleural suture; around humeral calli and often along posterior margin of mesonotum. The brown patterns vary in size and

shape in some specimens, particularly on the mesonotum where the expansion of these areas reduces the black colouration to a variety of irregular shapes. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripes, each ending midway between anterior margin of *npl.* callus and anterior *npl.* bristle above, continuing onto sternopleuron below as a large yellow spot, anterior margin convex; (in some specimens the mesopleural stripe is narrow, approaching width of *npl.* callus and with anterior margin straight); upper hypopleural calli (posterior apices black); anterior $\frac{4}{5}$ lower hypopleural calli (remainder black); two broad, parallel sided, lateral post-sutural vittae, broadly rounded posteriorly and ending behind upper *p.sa.* bristles. *Postnotum* black, tending fuscous medially. *Scutellum* yellow except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fulvous except fuscous on fore and hind tibiae of Thailand material, and only occasionally fuscous on hind tibiae of specimens from other areas; middle tibiae each with an apical red-brown spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band usually confluent with R_{2+3} (sometimes just overlapping this vein) and widening beyond extremity of this vein to end just beyond extremity of R_{4+5}, a narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe weak. In Australian material the costal band overlaps R_{2+3} in all specimens.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I fulvous with narrow fuscous markings on lateral margins; tergum II fulvous with narrow fuscous to black markings on anterolateral margins and a narrow transverse fuscous to black band along anterior margin and ending before lateral margins (the dark markings on tergum II often become paler and may even be absent); terga III to V fulvous with a transverse fuscous to black band along anterior margin of tergum III and a medial longitudinal fuscous to black band on terga III to V, occasionally with fuscous to black markings on anterolateral corners of terga IV and V (definitely without lateral longitudinal bands on terga III to V). A pair of shining spots on tergum V. There is a large variation in the size of the fuscous to black markings on terga III to V—the bands may be reduced to a series of elongate spots and the medial longitudinal band may even be absent; the anterolateral markings on terga IV and V are often absent.

Female

See Hardy (1969) for female ovipositor characters as these are useful in separating closely related species within the *dorsalis* complex.

Comments—Hardy (1969) and Drew (1975) discussed the taxonomy and zoogeography of the *Dacus dorsalis* (Hendel) complex of species in South-East Asia and the South Pacific area. Presently, there are 18 described species which form this complex, 9 endemic to South-East Asia and 9 to the South Pacific. The existence of so many closely related species and the occurrence of a wide range of colour forms within each species makes identification extremely difficult.



Figure 39—Map of Asian and Pacific Regions showing distribution of *D. dorsalis*

A species in north-west Australia, previously thought to be *D. dorsalis* (Drew 1976, 1978) has now been described as a separate species, *Dacus (Bactrocera) opiliae* Drew and Hardy (1981).

Within Australia, *D. dorsalis* is most closely related to *Dacus (Bactrocera) endiandrae* (Perkins and May) (Figure 49), *D. opiliae* Drew and Hardy, *Dacus (Bactrocera) silvicola* (May) and *Dacus (Bactrocera) musae* (Tryon). *D. endiandrae* and *D. silvicola* differ from *D. dorsalis* in having lateral post-sutural stripes which narrow posteriorly and end before the upper *p.sa.* bristle and in possessing broad lateral fuscous to black margins on abdominal terga III to V, while *D. musae* differs in possessing a broader costal band and in having the abdomen predominantly orange-brown without dark markings. *D. opiliae* differs from *D. dorsalis* in the shape of scales on the ovipositer, metaphase plate chromosome configuration and tissue enzyme composition.

In South-East Asia, *D. dorsalis* is most closely related to *Dacus (Bactrocera) muiri* Hardy and Adachi, *Dacus (Bactrocera) occipitalis* (Bezzi) (Figure 50) and *Dacus (Bactrocera) pedestris* (Bezzi) (Figure 51). *D. muiri* and *D. pedestris* differ from *D. dorsalis* on characters of the ovipositor (see Hardy, 1969) while *D. occipitalis* has a wider costal band.

Within the *dorsalis* complex, only *D. cacuminatus*, *D. dorsalis*, *D. musae* and *D. pedestris* are known to be of economic pest status.

In Hawaii, *D. dorsalis* has been bred from 173 species of host plants covering 112 genera. Throughout its range, it is a "broad generalist" feeder and is assumed capable of breeding in almost all fleshy fruits. *D. dorsalis* is a most serious pest species and in Hawaii it is destructive to all marketable fruit crops except pineapple and strawberries. The latter two fruits, however, are recorded hosts of the fly.

D. dorsalis is distributed widely throughout most Asian and South-East Asian countries and most major northern Pacific islands (Figure 39).

Dacus (Bactrocera) facialis Coquillett

(Figure 40)

Material studied: A series of specimens collected on islands in Tonga.

A small species; facial spots absent; mesonotum black; lateral post-sutural vittae very short and narrow; humeral and notopleural calli yellow; mesopleural stripes broad; scutellum generally yellow but sometimes with a fuscous to black triangular pattern on dorsal surface; wing with a narrow fuscous costal band and pale fuscous anal streak; costal cells colourless; microtrichia in outer corner of second cell; abdominal terga III to V orange-brown with lateral and medial longitudinal fuscous to black bands over all three terga (the lateral bands are usually broken on the posterolateral corners of tergum IV).

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump covered with short fulvous setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* dark fuscous to black. *Vertex* fulvous. *Face* fulvous; facial spots absent. *Genae* fulvous; sub-ocular spots absent; bristles fulvous. *Occiput* fulvous ventrally, fuscous to black dorsally, yellow along eye margin; occipital rows with 5-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on outer surface of third segment; a well developed fuscous bristle on dorsal surface of second segment; arista fulvous proximally (remainder fuscous).

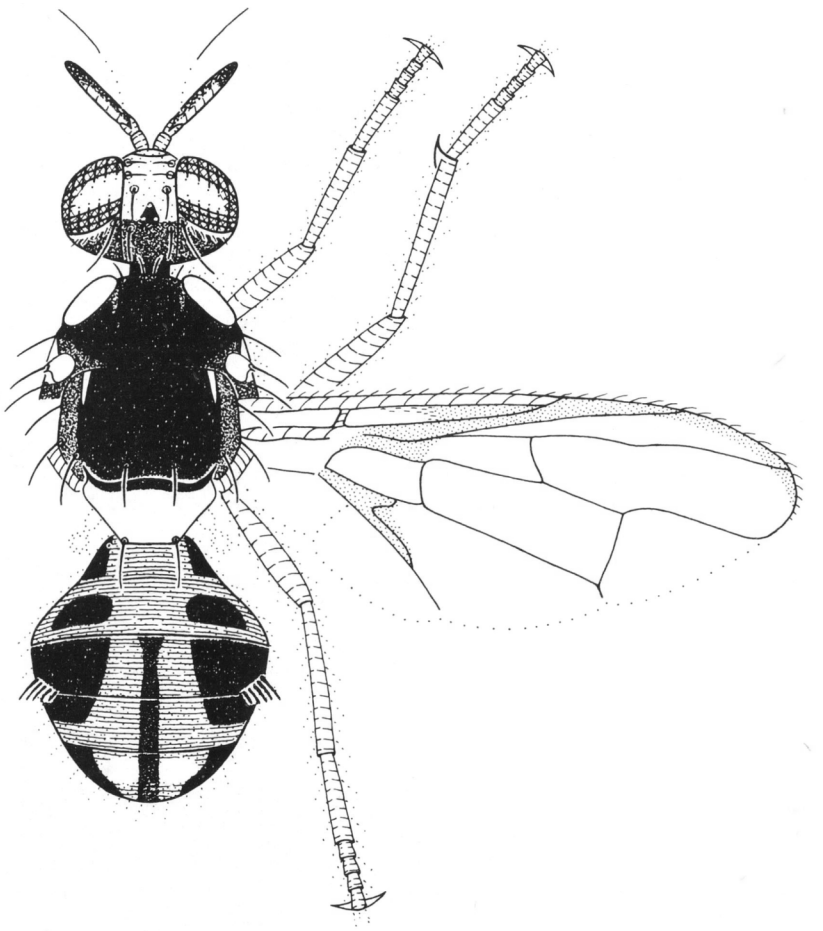

Figure 40—*Dacus (Bactrocera) facialis* Coquillett (X14)

Thorax—A variable amount of melanic pigmentation is evident. Pleura fulvous without dark markings or with dark markings between two extremes as follows: (1) pale fuscous markings on sternopleuron and on the lower $\frac{1}{2}$ of anepimeron posterior to mesopleural stripe; (2) black with red-brown below humeral calli and above mid coxae. Mesonotum generally dark fuscous to black, the area of which varies as follows: (1) in specimens where the pleura are mostly fulvous, there are brown markings on the mesonotum as follows—below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, a narrow stripe inside humeral calli; (2) in specimens with pleura mostly black, the mesonotum is black with brown markings as follows—a small area below *a.sa.* bristle; above notopleural calli; a small elongate spot in some specimens replacing the lateral post-sutural vittae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, each ending just before humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior $\frac{4}{5}$ lower hypopleural calli (remainder black); two narrow short lateral post-sutural vittae narrowing posteriorly to end just behind level of *a.sa.* bristles. *Postnotum* dark fuscous to black, tending brown centrally. *Scutellum* mostly yellow but with variable fuscous to black patterns (these patterns vary from a narrow basal band to a medial longitudinal triangular band over the entire scutellum). *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and fuscous. *Legs:* all segments fulvous; rows of long fulvous setae on dorsal surface of fore femora; middle tibiae with apical fuscous to dark fuscous spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, narrow fuscous costal band confluent with R_{2+3} and broadening after crossing extremity of R_{2+3} to end between extremities of R_{4+5} and M_{1+2}, a narrow pale fuscous anal streak ending well before wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I orange-brown with no dark markings or with two large lateral fuscous to dark fuscous spots; tergum II orange-brown with two large transverse fuscous to black spots on lateral margins; a small medial longitudinal fuscous spot is present on each of terga I and II in some specimens; terga III to V orange-brown with broad lateral fuscous to black margins on tergum III, anterolateral margins of terga IV and V fuscous to black, a moderately broad medial longitudinal fuscous to black band running from anterior margin of tergum III to posterior margin of tergum V (in some specimens the dark markings on terga III to V are increased in size so that there are two broad lateral longitudinal fuscous to black bands running from anterior margin of tergum III to posterior margin of tergum V and which meet along anterior margin of tergum III). A pair of shining spots on tergum V.

Female

Head—As for male.

Thorax—As for male except as follows: (1) no aggregation of microtrichia around CuA + 1A; (2) supernumerary lobe weak.

Abdomen—As for male except as follows: (1) no pecten on abdominal tergum III; (2) visible portion of oviscape fuscous to dark fuscous, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown, with apex needle shaped.

Comments—D. facialis has been recorded infesting a range of fruits and vegetables, including citrus, peach, mango, guava, capsicum and tomato. It is recognised as a serious pest species with the potential to be of major importance if introduced into major fruit and vegetable producing countries.

This species has been recorded from Tongatapu island and the Ha'apai Group in Tonga. It is probably widespread throughout the islands of Tonga.

Dacus (Bactrocera) kirki Froggatt

(Figure 41)

Material studied: A series of specimens collected at localities in Western Samoa, American Samoa, Tonga, Niue Island and Tahiti.

A medium sized species; facial spots large and oval; mesonotum glossy black; post-sutural vittae absent; humeral calli yellow (anterodorsal margin black); notopleural calli yellow; mesopleural stripes of medium width; scutellum glossy black with yellow lateral margins; wing with a narrow pale fuscous costal band and anal streak; costal cells extremely pale fuscous; microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal tergum I glossy black, abdominal terga II to V orange-brown with a broad glossy black transverse band on base of tergum II and broad lateral and medial longitudinal glossy black bands over all four terga.

Head—Generally fulvous. *Frons* narrowing posteriorly; dark fulvous with pale fuscous around orbital bristles; antero-medial hump with, at most, only a few short dark fulvous setae; bristles black: 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* dark fulvous. *Face* fulvous with large oval facial spots reaching epistoma. *Genae* dark fulvous; brown sub-ocular spots present; bristles dark fuscous to black. *Occiput* black dorsally, dark fulvous ventrally, yellow along eye margin; occipital rows with 4-8 well developed black bristles each side. *Antennae* with first and second segments fulvous to dark fulvous, third segment fuscous except dark fulvous on inner basal surface; a strong fuscous bristle on dorsal surface of second segment; arista dark fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (anterodorsal margin black); notopleural calli; mesopleural stripes of medium width, each slightly wider than notopleural callus above, continuing onto sternopleuron below as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder black). Lateral post-sutural vittae absent. *Postnotum* black. *Scutellum* glossy black with extreme lateral margins yellow. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae dark fulvous, mid and hind coxae dark fuscous to black; all femora dark fulvous; fore tibiae fuscous, mid tibiae dark fulvous, hind tibiae dark fuscous to black; fore tarsi dark fuscous

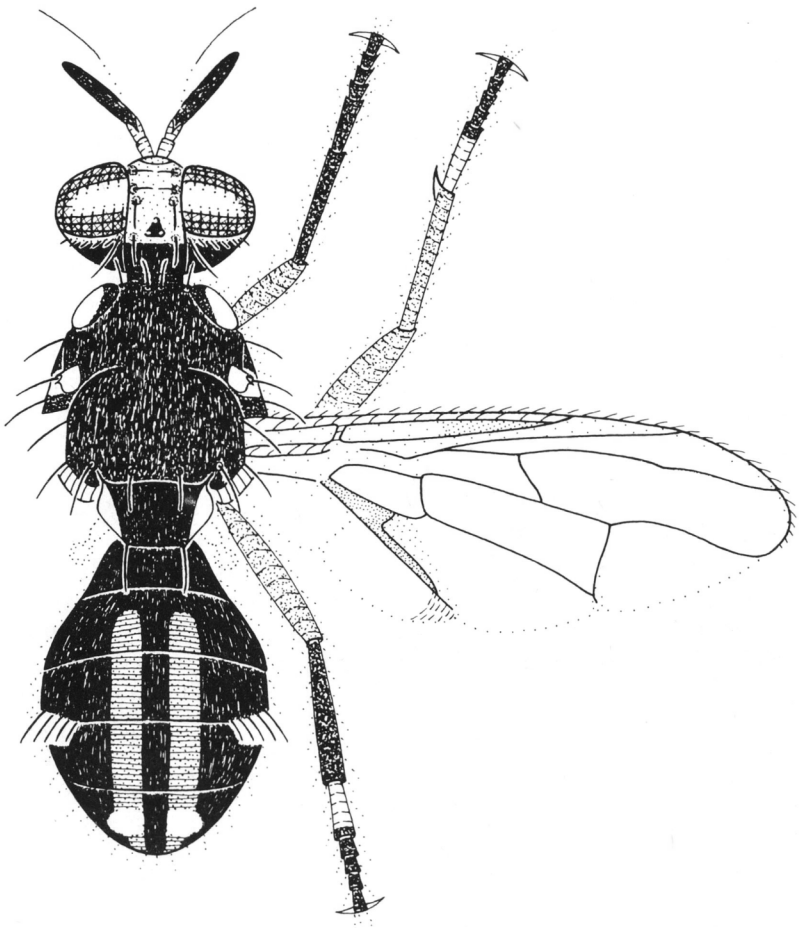

Figure 41—*Dacus (Bactrocera) kirki* Froggatt (X12)

to black (tending paler proximally), mid and hind tarsi with apical four segments and apex of basal segment fuscous (remainder fulvous); fore femora with rows of long dark setae on dorsal surface; middle tibiae with apical black spur. *Wings:* costal cells tinged with extremely pale fuscous, microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except fuscous stigma, narrow pale fuscous costal band confluent with R_{2+3} and ending midway between extremities of R_{4+5} and M_{1+2}, a narrow pale fuscous tinge around r-m and i-m cross veins, a narrow fuscous anal streak becoming paler towards and ending at wing margin. A dense aggregation of microtrichia

around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I glossy black with a pair of orange-brown spots on posterior margin either side of the medial line; terga II to V orange-brown with glossy black markings as follows: a broad transverse band across basal $\frac{1}{3}$ of tergum II; two broad lateral longitudinal bands running from basal band on tergum II to posterior margin of tergum V; a broad medial longitudinal band running from basal band on tergum II and narrowing posteriorly to end at posterior margin of tergum V. A pair of shining spots on tergum V which are red-brown in colour.

Comments—This species has been recorded from Western Samoa, American Samoa, Tonga, Niue Island and Tahiti and has been bred from peach, mango, guava and capsicum.

Dacus (Bactrocera) melanotus Coquillett

(Figure 42)

Material studied: A large series of specimens collected at Mitiaro Island and Rarotonga Island in the Cook Islands.

A medium sized species; facial spots absent; mesonotum glossy black; post-sutural vittae absent; humeral calli yellow; notopleural calli glossy black; mesopleural stripes broad; scutellum glossy black; wing with a narrow pale fuscous costal band; anal streak reduced to a pale tinge in anal cell; costal cells colourless; microtrichia in outer corner of second costal cell; all abdominal tergites glossy black.

Head—Generally dark fulvous. *Frons* narrowing posteriorly; dark fulvous with two broad fuscous bands running along eye margins from vertex to *s.or.* bristles; antero-medial hump with only a few short dark fulvous setae; bristles black; 1 *s.or.*, 2 *i.or.*; lunule dark fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* dark fulvous; facial spots absent. *Genae* dark fulvous; sub-ocular spots absent; bristles black. *Occiput* black dorsally, dark fulvous ventrally and along eye margin; occipital rows with 4-7 well developed black bristles each side. *Antennae* with all segments dark fuscous except dark fulvous on inner basal surface of third segment; a strong black bristle on dorsal surface of second segment; arista dark fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (anterolateral corners black); broad mesopleural stripes each extending to (or nearly to) humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder black). Notopleural calli glossy black. Post-sutural vittae absent. *Postnotum* glossy black. *Scutellum* glossy black. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* fore coxae dark fulvous, mid and hind coxae dark fuscous to black; fore femora dark fuscous (tending dark fulvous basally), mid and hind femora black (tending dark fuscous on basal halves); fore and mid tibiae dark fuscous, hind

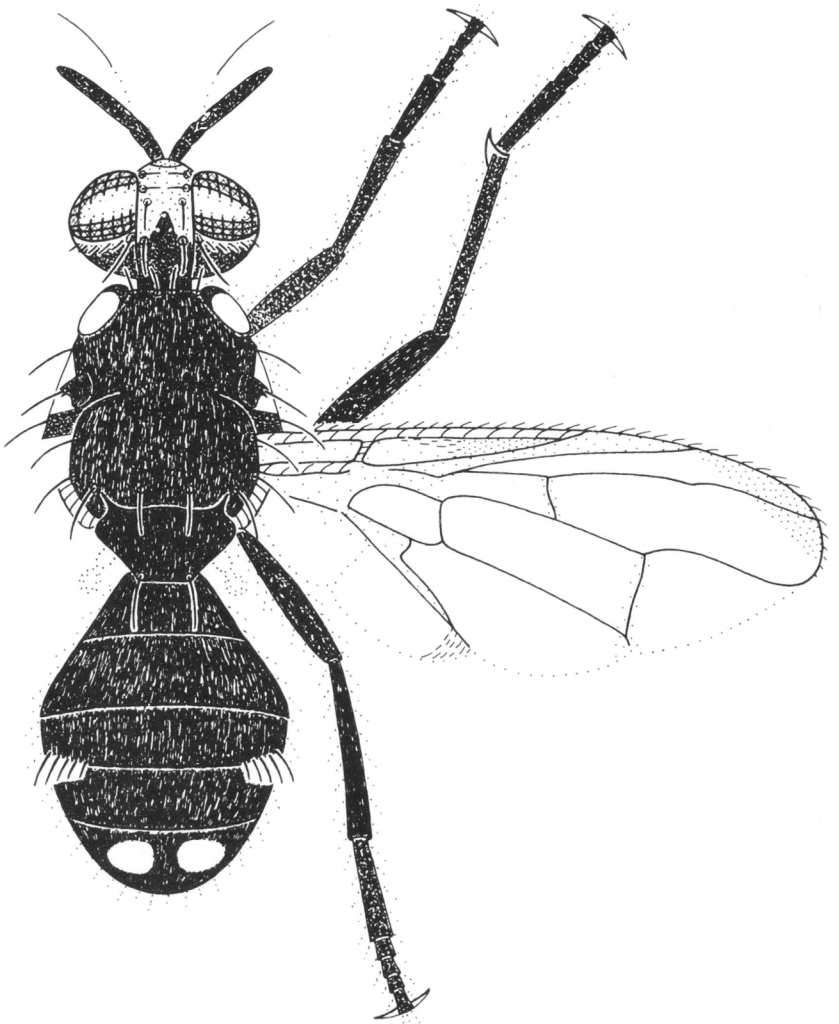

Figure 42 *Dacus (Bactrocera) melanotus* Coquillett (X14)

tibiae black; all tarsal segments dark fuscous to black; rows of long dark setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless or with, at most, a very faint tinge of fuscous colouration, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fuscous stigma, a narrow pale fuscous costal band confluent with R_{2+3} and darkening to fuscous and widening

beyond extremity of R_{2+3} to end midway between extremities of R_{4+5} and M_{1+2}, a narrow fuscous tinge around r-m and i-m cross veins, a narrow fuscous tinge in anal cell and extending to wing margin. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. All terga glossy black. A pair of shining spots on tergum V.

Comments—D. melanotus has been recorded only from the Cook Islands. It is a very serious pest of citrus and has also been found infesting mango and guava.

Dacus (Bactrocera) passiflorae Froggatt

(Figure 43)

Material studied: A series of speciments collected at Fiji, Tonga and Niue Island.

A small species; facial spots absent; mesonotum glossy black; post-sutural vittae absent; humeral calli glossy black; notopleural calli yellow; mesopleural stripes broad; scutellum yellow; wing with narrow fuscous costal band and pale fuscous anal streak; costal cells colourless; microtrichia in outer portion of second costal cell; all abdominal terga glossy black except posterior margin of tergum V dark fuscous.

Head—Generally fulvous. *Frons* of even width; fulvous with fuscous bands on lateral margins running from vertex to base of *s.or.* bristle; antero-medial hump with a few short pale setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous; facial spots absent. *Genae* fulvous; brown sub-ocular spots present; bristles fulvous. *Occiput* black dorsally, fulvous ventrally, yellow along eye margin; occipital rows strong with 5-9 large black bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of the third segment (sometimes pale fuscous on the inner surface of the third segment); a strong dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: notopleural calli; moderately broad mesopleural stripes, each reaching to or beyond anterior *npl.* bristle above, extending onto sternopleuron below as a small transverse spot in only a few specimens, anterior margin markedly convex, upper hypopleural calli (posterior apices glossy black); anterior $\frac{5}{8}$ lower hypopleural calli (remainder glossy black). Humeral calli glossy black. Post-sutural vittae absent. *Postnotum* glossy black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous to black. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous; rows of long dark fulvous setae on dorsal surface of fore femora; middle tibiae with apical black spur. *Wings:* costal cells colourless with microtrichia in outer portion of second costal cell only; remainder of wings colourless except narrow fuscous costal band confluent with R_{2+3}, widening

slightly after crossing extremity of R_{2+3} and extending midway between extremities of R_{4+5} and M_{1+2}, and a narrow pale fuscous anal streak ending at extremity of anal cell extension. A dense aggregation of microtrichia around CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

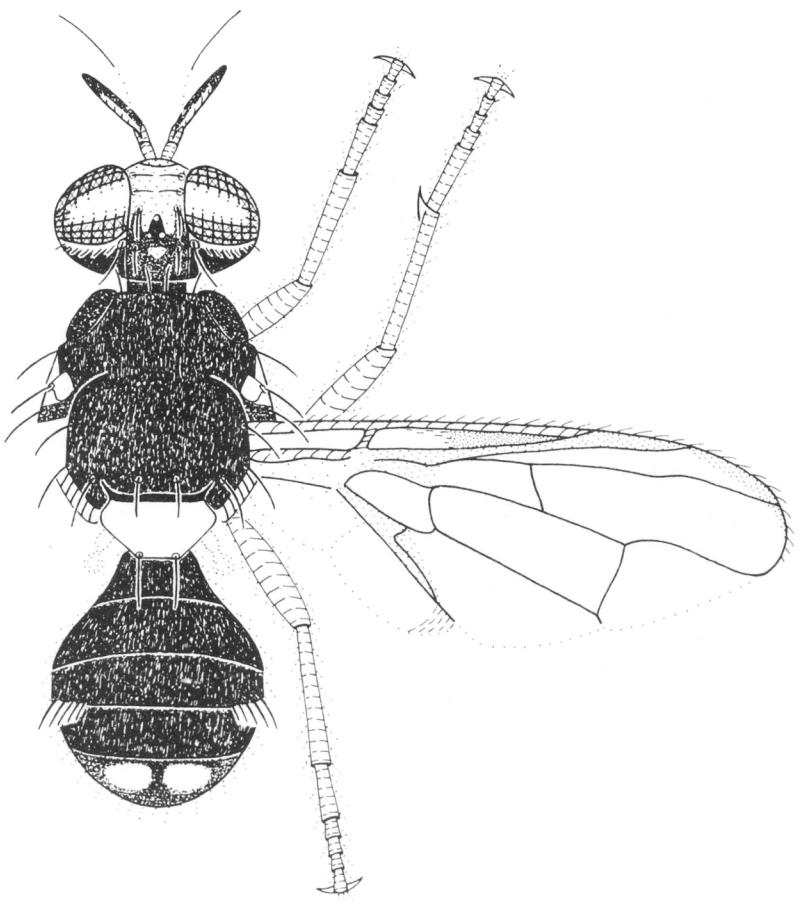

Figure 43—*Dacus (Bactrocera) passiflorae* Froggatt (X16)

Abdomen—Oval; terga free; pecten present on tergum III. Terga I to IV glossy black; tergum V either glossy black with posterior margin dark fuscous or fuscous with a medial longitudinal black band. A pair of large oval shining spots on tergum V.

Comments *D. passiflorae* has been found infesting citrus, passionfruit, mango and granadilla.

This species has been recorded from Fiji, Niuatoputapu Island (Tonga) and Niue Island.

Dacus (Bactrocera) psidii (Froggatt)

(Figure 44)

Material studied: A series of specimens collected at New Caledonia.

A small species; facial spots small and elongate; mesonotum glossy black; lateral post-sutural vittae present; humeral calli yellow (anterodorsal corner black); notopleural calli yellow; mesopleural stripes narrow; scutellum yellow with a broad triangular marking on dorsal surface; wing with costal band

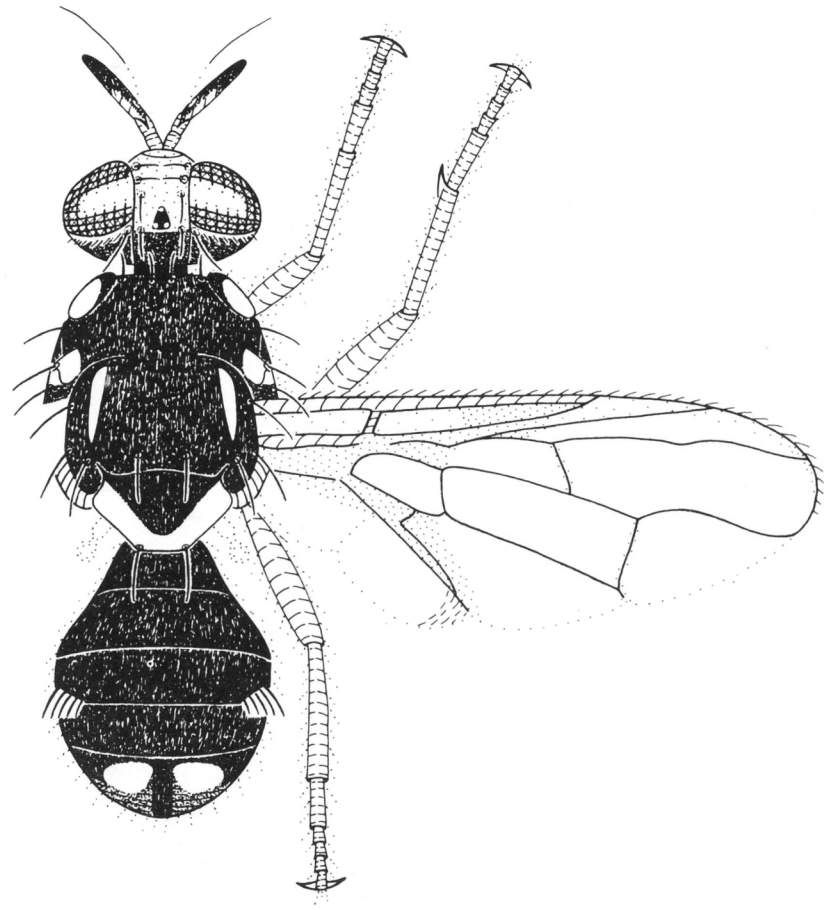

Figure 44—*Dacus (Bactrocera) psidii* (Froggatt) (X15)

reduced to an extremely pale fuscous tinge around costal margin; anal streak narrow and fulvous; costal cells colourless; microtrichia in outer corner of second costal cell; all abdominal terga glossy black.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with no dark markings; antero-medial hump with a small number of short pale setae; bristles dark fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous and generally with small fuscous to dark fuscous elongate spots not reaching epistoma (about 25 per cent of specimens have facial spots absent). *Genae* fulvous; pale brown sub-ocular spots present; bristles dark fulvous. *Occiput* dark fuscous to black dorsally, fulvous ventrally, yellow along eye margin; occipital rows with 5-8 well developed dark fuscous bristles each side. *Antennae* fulvous with fuscous on apex and outer surface of third segment; a strong dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Glossy black with no brown markings. Yellow markings as follows: humeral calli (except anterodorsal corner black); notopleural calli; narrow mesopleural stripes, each equal in width to notopleural callus above, continuing onto sternopleuron below, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{5}{8}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae narrowing slightly posteriorly to end well before upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow with a broad triangular black marking on dorsal surface. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and dark fuscous. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous; fore femora with rows of long pale setae on dorsal surface; middle tibiae with apical black spur. *Wings:* costal cells colourless to extremely pale fulvous, microtrichia in outer portion of second costal cell only; remainder of wings colourless except fulvous stigma, a narrow tinge of extremely pale fuscous colouration around costal margin which ends between extremities of R_{4+5} and M_{1+2} (darker around extremity of R_{4+5}), a narrow tinge of fuscous colouration around r-m and i-m cross veins (darker around r-m cross vein), a narrow fulvous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males, weak in females.

Abdomen –Oval; terga free; pecten present on tergum III. All terga glossy black; in a few specimens tergum V tends to be dark red-brown especially around hind margin and along either side of a broad medial longitudinal black band. A pair of shining spots on tergum V.

Comments—*D. psidii* has been bred from citrus, mango, granadilla and guava.

It has only been recorded from New Caledonia. It has the capacity to become a serious pest of horticultural crops in regions where the above crops are developed. In New Caledonia, however, the introduced *D. tryoni* (Queensland fruit fly) will probably become more important economically that *D. psidii*.

Dacus (Bactrocera) trivialis Drew

(Figure 45)

Material studied: A series of specimens collected at localities throughout Papua New Guinea and West Irian Jaya.

A medium sized species; facial spots pear shaped; mesonotum dull black; lateral post-sutural vittae present; humeral and notopleural calli yellow; mesopleural stripes narrow; scutellum yellow; wing with narrow fuscous costal band and anal streak; costal cells colourless; microtrichia in outer corner of second costal cell; abdominal terga III to V generally dull black to dark fuscous except fulvous on central areas of terga IV and V.

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous except fuscous around orbital bristles and on antero-medial hump; latter covered with short fuscous setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous centrally, fuscous lateral to antennae. *Ocellar triangle* black. *Vertex* fuscous. *Face* fulvous with pear shaped facial spots pointed anteriorly but not reaching epistoma. *Genae* fulvous; large, brown sub-ocular spots present; bristles red-brown to fuscous. *Occiput* fulvous except yellow along eye margin; occipital rows strong with 4-8 well developed fuscous bristles each side. *Antennae* fulvous except fuscous on the apex and outer surface of the third segment; a well developed fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Pleura brown with dark markings as follows: fuscous anterior to mesopleural stripe to a line level with anterior notopleural bristle,

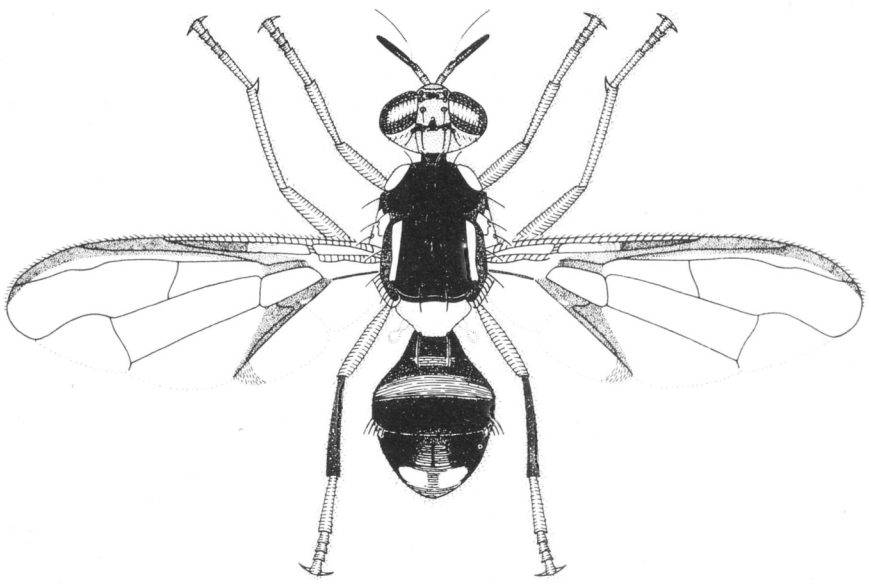

Figure 45 - *Dacus (Bactrocera) trivialis* Drew (X8)

sternopleuron black, dark red-brown to fuscous along posterior margins of mesopleural stripe and above hind coxae; mesonotum dull black, approaching fuscous posteriorly to a line just anterior of prescutellar bristles and with brown markings as follows: below and behind lateral post-sutural vittae, around notopleural calli and above notopleural suture between notopleural and humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripes, each ending midway between anterior margin of notopleural callus and anterior notopleural bristle above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior $\frac{3}{5}$ lower hypopleural calli (remainder fuscous); two moderately broad, laterai post-sutural vittae narrowing slightly posteriorly to end at the upper *p.sa.* bristles. *Postnotum* black except red-brown centrally. *Scutellum* yellow except for narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and red-brown. *Legs:* fore coxae fulvous, mid and hind coxae fuscous; remainder of legs fulvous except for hind tibiae fuscous; rows of long fulvous setae along dorsal surface of fore femora; middle tibiae each with an apical black spur. *Wings:* costal cells colourless, microtrichia in outer portion of second costal cell only; remainder of wings colourless except dark fulvous stigma, narrow fuscous costal band extending over vein R_{2+3} into cell R_{2+3} and crossing vein R_{4+5} at its tip to end between extremities of veins R_{4+5} and M_{1+2}, narrow fuscous anal streak ending before wing margin. A dense aggregation of microtrichia around vein CuA + 1A. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; terga free; pecten present on abdominal tergum III. Tergum I fuscous; tergum II fuscous over most of anterior $\frac{1}{2}$ which extends backwards on lateral margins to posterior margin, fulvous centrally along anterior margin and remainder of tergum whitish; tergum III black, tending brown centrally along posterior margin; tergum IV black except brown centrally along anterior margin, fulvous on central posterior portion and a suggestion of a narrow medial fuscous band on the latter fulvous area; tergum V fulvous except fuscous on anterolateral margins. A pair of brown shining spots on tergum V.

Comments—D. trivialis has been bred from peach and guava. It is very closely related taxonomically to *D. dorsalis* (oriental fruit fly) and could become a pest of horticultural crops if such crops are developed in Papua New Guinea.

Dacus (Bactrocera) umbrosus Fabricius

(Figures 46, 47)

Material studied: A large series of specimens collected at localities from South-East Asia, Papua New Guinea, islands of the Bismarck Archipelago, Solomon Islands, New Hebrides and New Caledonia.

A medium sized species; facial spots present; mesonotum black; lateral post-sutural vittae present; humeral and notopleural calli yellow; mesopleural stripes broad; scutellum yellow; wing with broad fuscous costal band and anal streak and with two broad transverse fuscous bands running from costal band

to hind margin; costal cells fulvous, microtrichia in outer $\frac{1}{2}$ of second costal cell; abdominal terga III to V orange-brown with or without lateral and medial longitudinal dark bands.

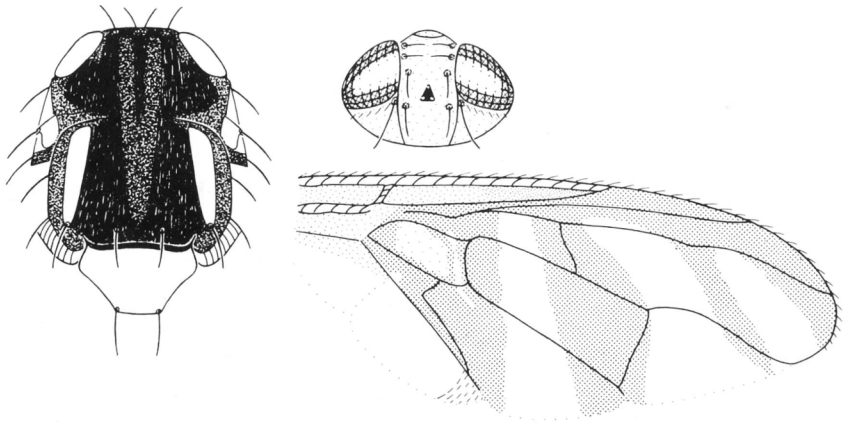

Figure 46—Head. thorax, wing of *Dacus (Bactrocera) umbrosus* Fabricius (X12)

Head—Generally fulvous. *Frons* narrowing slightly posteriorly; fulvous with or without pale fuscous around orbital bristles and on antero-medial hump; latter covered with dark fulvous setae; bristles fuscous: 1 *s.or.*, 2 *i.or.*; lunule fulvous. *Ocellar triangle* black. *Vertex* fulvous. *Face* fulvous with medium sized circular facial spots not reaching epistoma. *Genae* fulvous; subocular spot absent; bristle fuscous. *Occiput* fulvous, tending fuscous dorsolaterally, yellow along eye margin; occipital row with 2-7 well developed fuscous bristles each side. *Antennae* fulvous with fuscous on the apex and outer surface of third segment; a well developed dark fulvous bristle on dorsal surface of second segment; arista fulvous proximally (remainder black).

Thorax—Black with brown markings below humeral calli, above mid coxae, below and behind lateral post-sutural vittae, along mesonotal suture, around notopleural calli, a band between humeral and notopleural calli dorsal to notopleural suture, inside humeral calli, a broad medial longitudinal band running along mesonotum from anterior margin to level of *prsc.* bristles (this band varies in size and is often divided longitudinally into two narrow bands by a narrow black band). The brown markings vary in size and shape usually being larger in specimens from Papua New Guinea and smaller in specimens from New Hebrides and New Caledonia. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, each extending to humeral callus above, continuing onto sternopleuron below as a transverse spot, anterior margin straight; upper hypopleural callus (posterior apices black); anterior $\frac{2}{3}$ lower hypopleural calli (remainder black); two broad lateral post-sutural vittae ending at or just behind the upper *p.sa.* bristles. *Postnotum* black. *Scutellum* yellow with narrow black basal band. *Bristles: sc.* 2, *prsc.* 2, *p.sa.* 2, *a.sa.* 1, *mpl.* 1, *npl.* 2, *scp.* 4; all bristles well developed and black. *Legs:* all segments fulvous; rows of long pale setae on dorsal surface of fore femora;

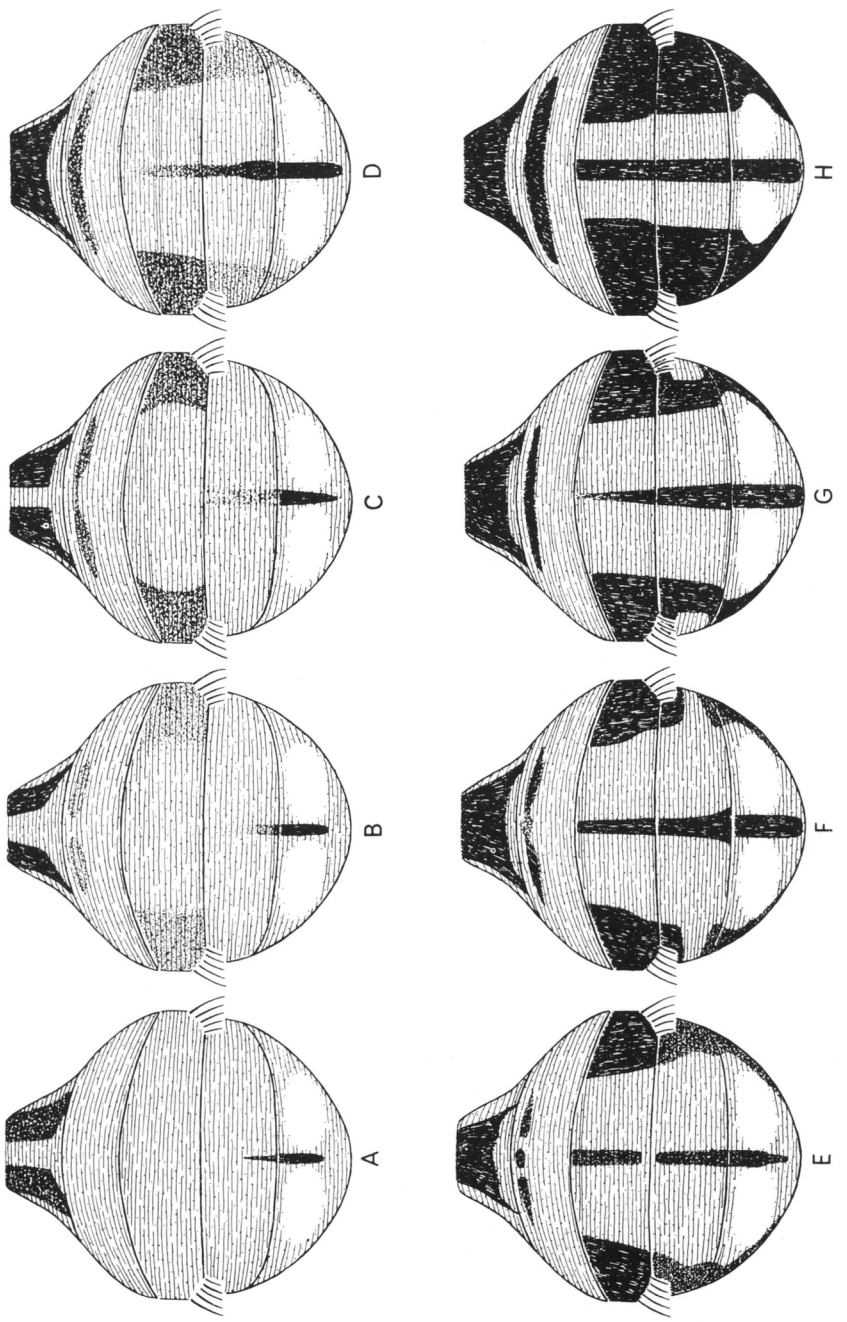

Figure 47—Colour variation in abdomen of *D. umbrosus* (X20)

middle tibiae with apical black spur. *Wings*: costal cells fulvous with microtrichia in outer $\frac{1}{2}$ of second costal cell only; remainder of wings colourless except dark fulvous stigma, broad fuscous costal band confluent with R_{4+5} (except for a small area distal to r-m cross vein in some specimens) and ending between extremities of R_{4+5} and M_{1+2}, a broad transverse fuscous band across centre of wing from costal band to hind margin and enveloping both cross veins, a narrower transverse fuscous band from costal band to hind margin at apex of wing, a broad transverse fuscous band from costal band to anal streak, a broad fuscous anal streak ending at wing margin and continuing onto area covered by dense aggregation of microtrichia. Supernumerary lobe of medium development in males, weak in females.

Abdomen—Oval; terga free; pecten present on tergum III. Tergum I dark fuscous to black with a broad orange-brown basal band centrally. Terga II to V show wide variation in colour pattern. Eight colour forms (Figure 47 A-H) have been selected to show the variation that occurs in the abdominal colour patterns. This variation has been shown to be geographic, representing a gradual change over a geographic range from Papua New Guinea to New Caledonia (Drew, 1974b). The extremes of the colour pattern range have been regarded previously as separate species by some authors, viz., *D. umbrosus* Fabricius with a pale coloured abdomen and *D. frenchi* Froggatt with a dark coloured abdomen.

Comments—D. umbrosus has been bred from citrus and breadfruit and could have the capacity to become a pest of horticultural crops.

It is widely distributed throughout South-East Asia, Papua New Guinea and associated islands, islands of the Bismarck Archipelago, Bougainville Island, Solomon Islands, New Hebrides and New Caledonia.

(5) ASSESSMENT OF ECONOMIC IMPORTANCE AND SUMMARY OF GEOGRAPHIC DISTRIBUTION OF PEST SPECIES

The species discussed in Section I (4) have all been bred from one or more commercial fruit or vegetable hosts.

Quarantine action against fruit fly pest species should be governed, to some extent, by whether or not they are major or minor pests. Recognition of species as being major or minor pests is complicated by the fact that some currently lesser known pest species have the capability to become major pests. To be of maximum value, judgements regarding these potentially major pest species must be made on criteria presently available and before they have attained their pest potential. It is believed that the occurrence of these potentially major pest species should be brought to the attention of quarantine and agriculture officers throughout the world.

The major pest species have a broad host range (both commercial and wild fruits), a wide climatic tolerance and a large geographic distribution. Other species with these characteristics must be regarded as potentially major pest species. In contrast the many non-pest species and minor pest species of Dacinae occupy only one or very few host fruits and have a limited geographic distribution and climatic tolerance.

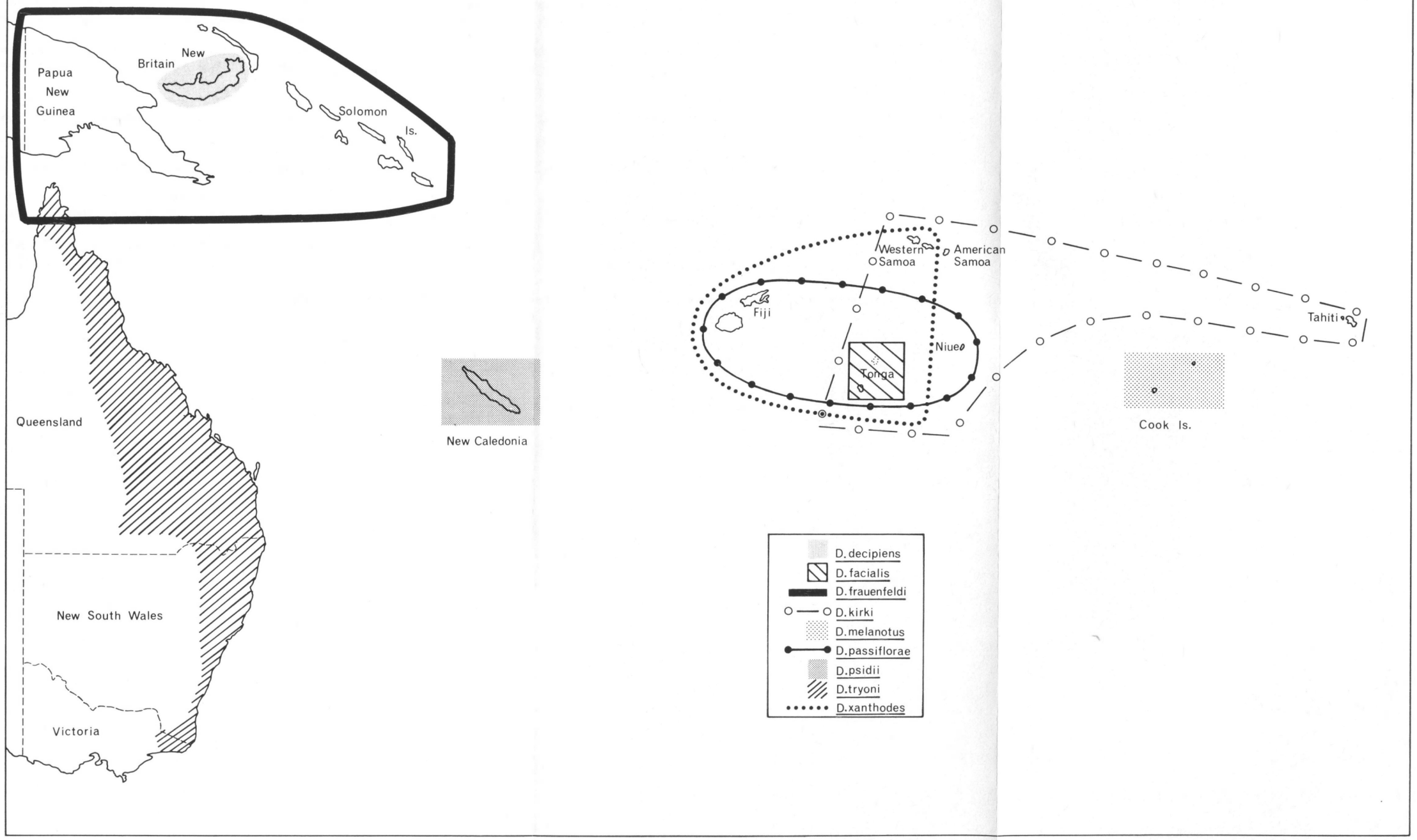

Figure 48—Map of South Pacific region showing distribution of endemic species having economic pest status

The potentially major pest species and their known distributions are as follows:

Dacus decipiens Drew. . . . . .New Britain
Dacus facialis Coquillett . . . . . .Tonga
Dacus frauenfeldi Schiner. . . . . .Papua New Guinea
Dacus kirki Froggatt . . . . . .Western Samoa, American Samoa, Tonga, Niue Is., Tahiti
Dacus melanotus Coquillett . . . . .Cook Islands
Dacus passiflorae Froggatt. . . . . .Fiji, Niue Is., Tonga
Dacus psidii (Froggatt). . . . . .New Caledonia
Dacus xanthodes (Broun) . . . . . .Fiji, Western Samoa, Tonga

Most islands or island groups in the South Pacific each have an endemic fruit fly species which could become of similar pest status to *D. dorsalis*, *D. tryoni* and *D. cucurbitae* (Figure 47). The risk of introduction of these species may be small while horticulture industries in the localities where they occur are in their infancy. However, as these industries develop the fruit fly problem will intensify and cause a greater risk of introduction to major production regions such as Australia and the United States of America (including the Hawaiian Islands).

An example is a recently discovered undescribed species of *Dacus (Zeugodacus)* in the collection of the Wau Ecology Insitute, Papua New Guinea, bred ex vegetable marrow at Wau in 1978.

During 1977-78, staff at the Institute introduced a large number of varieties of cucurbits. These crops were heavily infested by three species of fruit fly, *D. atrisetosus*, *D. cucurbitae* and the undescribed species mentioned above (A. Allison, personal communication).

To date, the recognised major pest species of tropical fruit flies are *D. dorsalis* (oriental fruit fly), *D. tryoni* (Queensland fruit fly) and *D. cucurbitae* (melon fly). *D. tryoni* has been recorded from Papua on one occasion and has been introduced into New Caledonia, Islands of the Tahiti group, Austral Islands and Easter Island (subsequently eradicated from the latter). In Figure 48, only the endemic distribution of *D. tryoni* is shown. *D. cucurbitae* (melon fly) has been introduced into Papua New Guinea, islands of the Bismarck Archipelago and Bougainville Island. This serious pest species must be regarded as a major threat to Australian horticulture in the light of its expanded distribution.

(6) SPECIES WHICH MAY BE CONFUSED WITH *DACUS DORSALIS* HENDEL

Within the *Dacus dorsalis* complex, three species not described in Section I (4), closely related to *D. dorsalis* and very difficult to separate taxonomically are *Dacus (Bactrocera) endiandrae* (Perkins and May), *Dacus (Bactrocera) occipitalis* (Bezzi) and *Dacus (Bactrocera) pedestris* (Bezzi). The pest status of *D. endiandrae* and *D. occipitalis* is unknown, while *D. pedestris* is known to infest commercial fruits. To assist in identifying these species, the following definitions and illustrations are given.

Dacus (Bactrocera) endiandrae (Perkins and May)

(Figure 49)

A medium sized species, facial spots oval, mesonotum black except red-brown around lateral margins, lateral post-sutural vittae present and not reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band overlapping vein R_{2+3} and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen orange-brown with transverse dark fuscous to black band along base of tergum III, a medial longitudinal dark fuscous to black band on terga III to V, moderately broad lateral fuscous to pale fuscous margins on terga III to V.

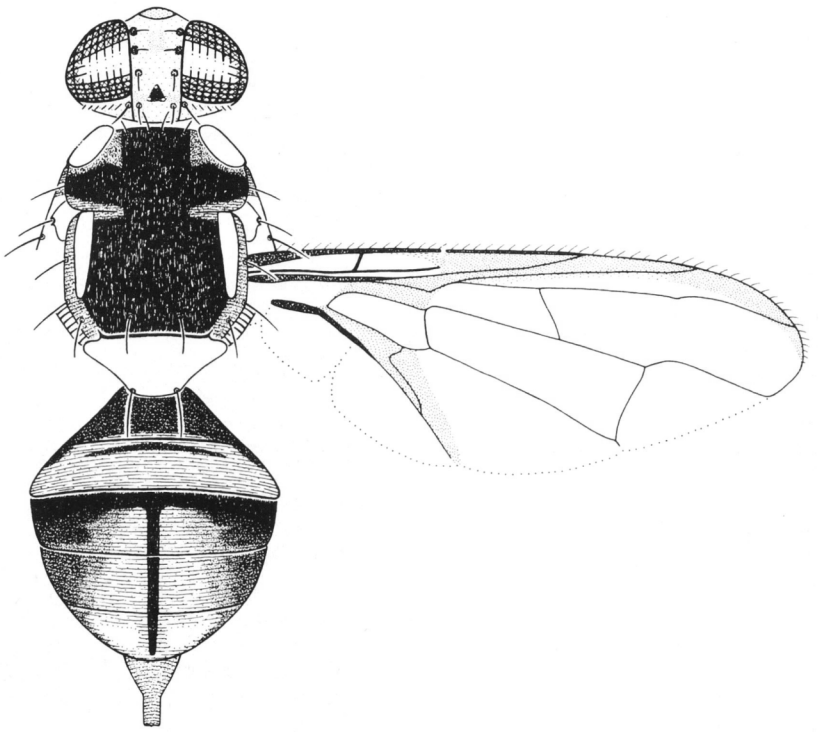

Figure 49 – *Dacus (Bactrocera) endiandrae* (Perkins and May) (X13)

Dacus (Bactrocera) occipitalis (Bezzi)

(Figure 50)

A medium sized species, facial spots large and oval, mesonotum black except brown around lateral and posterior margins, lateral post-sutural vittae present and reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, wing with a narrow fuscous costal band overlapping vein R_{2+3} and widening markedly at apex of wing and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen orange-brown with transverse black band along base of tergum III, a medial longitudinal black band and two broad lateral longitudinal dark fuscous bands on terga III to V.

This definition and illustration is from the lectotype ♂ designated by D. E. Hardy, 1968, received on loan from Museo Civico Di Storia Naturale, Milano, Italy.

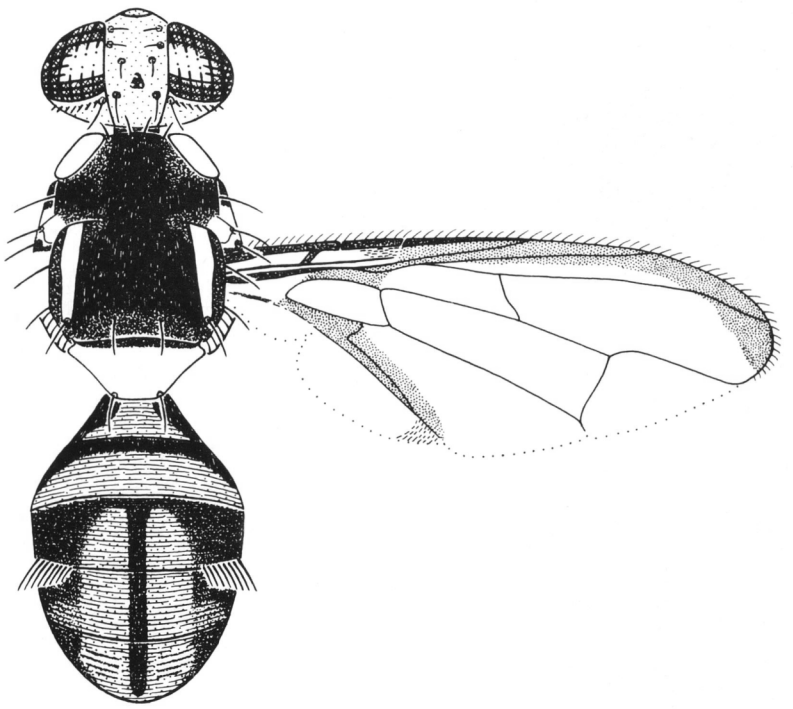

Figure 50—*Dacus (Bactrocera) occipitalis* (Bezzi) (X12)

Dacus (Bactrocera) pedestris (Bezzi)

(Figure 51)

A medium sized species, facial spots large and oval, thorax black except brown around lateral margins, lateral post-sutural vittae present and reaching upper *p.sa.* bristles, mesopleural stripes of medium width, humeral and notopleural calli yellow, scutellum yellow, legs with pale fuscous to fuscous on apical $\frac{1}{3}$ of all femora and with all tibiae pale fuscous to fuscous, wing with a narrow fuscous costal band confluent with vein R_{2+3} and a narrow fuscous anal streak, costal cells colourless, microtrichia in outer portion of second costal cell only, abdomen with terga III to V fulvous to orange-brown except for transverse black band across base of tergum III, and a broad medial longitudinal black band and two broad lateral longitudinal dark fuscous to black bands on terga III to V.

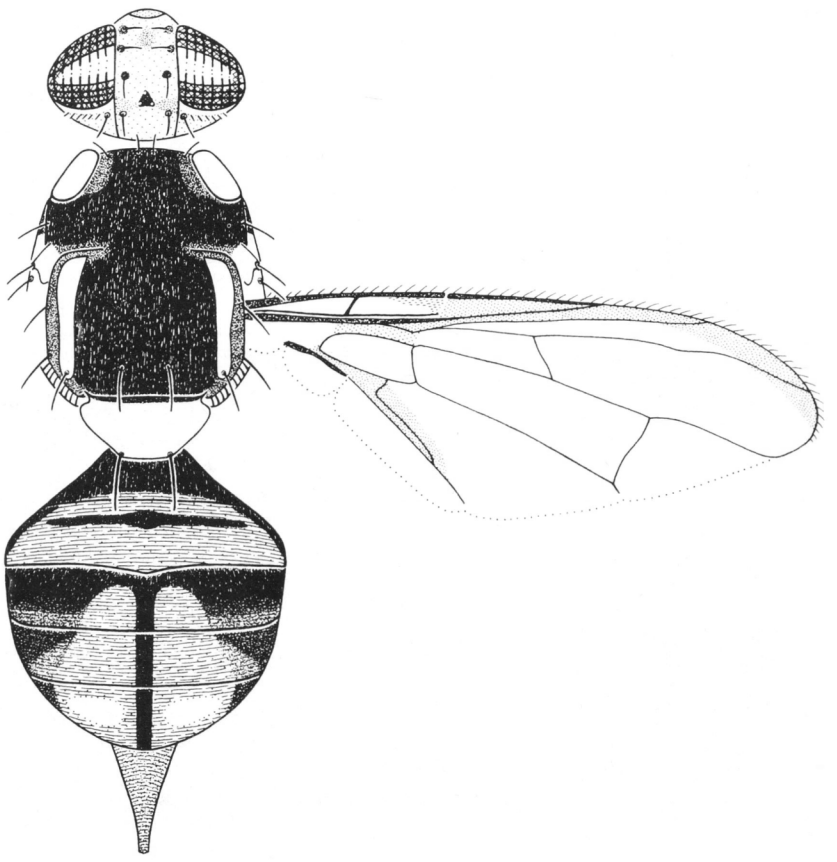

Figure 51—*Dacus (Bactrocera) pedestris* (Bezzi) (X11)

(7) THE RESPONSES OF THE ECONOMIC SPECIES TO MALE ATTRACTANTS

The responses of fruit fly species in the South Pacific area to male attractants has been published previously (Drew, 1974a) and the responses of Australian species is presently being studied and will be published in the near future.

It is important to note that some of the economic pest species do not respond to any of the known male attractants. Consequently, for these species, population monitoring is more difficult and the male annihilation method of eradication can not be used in suppression or eradication programmes.

No species have been found responding to medlure and trimedlure.

Knowing the attractant responses is of assistance in the identification of species, especially in the situation where two similar species are attracted to different lures.

The following table lists the species discussed in Section I (4) and their responses to lures.

Species	Cue-Lure	Methyl Eugenol	No Response
Callantra aequalis (Coquillett)	√		
D. jarvisi (Tryon)			√
D. cucumis French			√
D. breviaculeus Hardy	√		
D. bryoniae (Tryon)	√		
D. cacuminatus (Hering)		√	
D. dorsalis Hendel		√	
D. frauenfeldi Schiner	√		
D. halfordiae Tryon			√
D. mayi Hardy		√	
D. melas (Perkins and May)	√		
D. musae (Tryon)		√	
D. mutabilis (May)			√
D. neohumeralis Hardy	√		
D. tryoni (Froggatt)	√		
D. decipiens Drew			√
D. atrisetosus (Perkins)			√
D. cucurbitae Coquillett	√		
D. xanthodes (Broun)		√	
D. curvipennis Froggatt	√		
D. facialis Coquillett	√		
D. kirki Froggatt	√		
D. melanotus Coquillett		√	
D. passiflorae Froggatt	√		
D. psidii (Froggatt)	√		
D. trivialis Drew	√		
D. umbrosus Fabricius		√	

(8) KEY TO SPECIES OF FRUIT FLIES (TEPHRITIDAE: DACINAE) OCCURRING IN AUSTRALIA (This key includes *D. cucurbitae* (melon fly) which does not occur in Australia; it is reproduced from Drew *et al.*, 1981).

For identification of species occurring in the South Pacific area outside Australia, refer to keys in a previous publication (Drew, 1972b).

The following key is for species collected within Australia. *D. cucurbitae* (melon fly) and *D. dorsalis* (Oriental fruit fly) do not occur in Australia but are included in this key because of the economic importance of these species and because of their high risk of introduction to Australia from adjacent Pacific islands. When using this key, refer to figures 1-7, 52-54 and in Drew *et al.*, 1981 figures 3-7, for assistance in understanding the key characters.

Species-level differences are primarily colour characters which always show some intraspecific variation and change with time in pinned dried specimens in collections. As a result closely related species will be difficult to key out.

When using couplets 13 and 43, note that even when microtrichia are confined to the apical portion of the second costal cell there is still a row of microtrichia along anterior margins of both cells.

1. Antennae elongate, first and second segments approximately of equal length, the second and third segments combined generally about equal to vertical length of head, the combined lengths of all segments thus being greater than vertical length of head; abdomen elongate, strongly clavate and petiolate, segment I approximately parallel-sided or narrower at its posterior margin in dorsal view; abdomen strongly arched posteriorly and with the suture between terga III and IV strongly concave forwards in lateral view; abdomen with sterna I and II generally longer than wide Genus **Callantra** Walker 2

Antennae comparatively short, first segment approximately half as long as second segment, the combined lengths of all segments less than vertical length of head; abdomen elongate oval or oval, not strongly petiolate, segment I much wider across posterior margin than anterior margin in dorsal view; abdomen slightly arched centrally and with the suture between terga III and IV generally straight in lateral view; abdomen with sterna I and II wider than long .. .. Genus **Dacus** Fabricius 5

2(1). Costal band (Figure 52) extended well below vein R_{4+5} for its entire length 3

Costal band confluent with vein R_{4+5} and crossing this vein only at apex of wing .. .. .. **Callantra pusilla** May

3(2). Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein .. **Callantra aequalis** (Coquillett)

Costal band not attaining vein M_{1+2} for its entire length .. 4

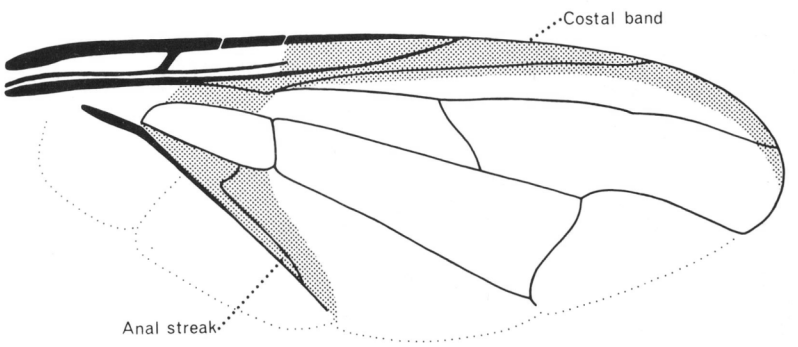

Figure 52—Diagram of wing showing costal band and anal streak

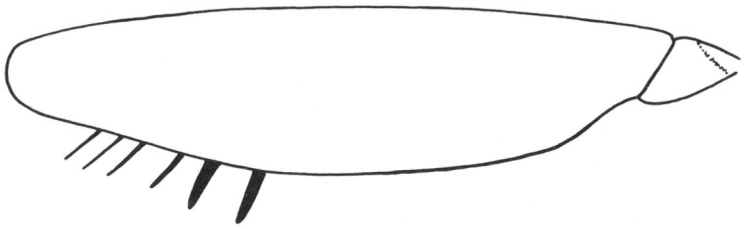

Figure 53 Lateral view of fore femur of *Callantra petioliforma* May showing spines on ventral surface (X41)

4(3). A row of spines present beneath fore femora (Figure 53); black spot on eye margin level with base of antenna; facial spot elongate; oviscape short **Callantra petioliforma** May

No spines beneath fore femora; no spot on eye margin level with base of antenna; facial spot pear-shaped or oval; oviscape elongate .. .. **Callantra smieroides** Walker

5(1). Costal band present 6

Costal band absent .. .. **D. niger** Tryon (some specimens)

6(5). Costal band broken in middle, forming an isolated apical spot 7

Costal band entire 8

7(6). Notopleural callus brown; r-m crossvein infuscated .. .. **D. (Afrodacus) furvus** (May) (males)

Notopleural callus yellow; r-m crossvein not infuscated .. .. **D. (Afrodacus) tigrinus** (May) (males)

8(6). Costal band confluent with vein M_{1+2} for its entire length, not or barely crossing this vein .. .. **D. absonifacies** (May)

Costal band not attaining vein M_{1+2} 9

9(8). Costal band confluent with vein R_{4+5} for its entire length (in *D. visendus* and *D. calophylli* there is a small pale fuscous area distal to r-m crossvein), not or barely crossing this vein except at or beyond r-m crossvein 10

Costal band narrow, not attaining vein R_{4+5} distal to r-m crossvein except on wing margin after crossing extremity of vein R_{2+3} 20

10(9). Infuscation on wing in addition to costal band and anal streak 11

No infuscation on wing other than costal band and anal streak (Figure 52) 15

11(10). Mesopleural stripe broad, attaining humeral callus dorsally 12

Mesopleural stripe not attaining humeral callus dorsally .. 14

12(11). Medial post-sutural vitta present; *a.sa.* bristles absent; *prsc.* bristles absent .. .. **D. (Polistomimetes) visendus** Hardy

Medial post-sutural vitta absent; *a.sa.* bristles present; *prsc.* bristles present (**alyxiae** complex) 13

13(12). Costal cells colourless; microtrichia in apical portion of second costal cell only; no medial dark stripe on abdomen .. .. **D. (Bactrocera) alyxiae** (May)

Costal cells coloured; microtrichia covering most of second costal cell and apical portion of first cell; a medial black stripe present on abdomen . .. . **D. (Bactrocera) recurrens** (Hering)

14(11). Mesopleural stripe broad, extending to anterior *npl.* bristle dorsally; apical third of wing fuscous; lateral post-sutural stripe broad, parallel-sided, ending behind upper *p.sa.* bristle .. .. **D. (Bactrocera) amplexiseta** (May)

Mesopleural stripe narrow, about as wide as notopleural callus; infuscation over central portion of wing only; lateral post-sutural stripe narrow and ending before upper *p.sa.* bristle .. .. ..**D. (Bactrocera) pulcher** (Tryon)

15(10). Mesonotum black; microtrichia in outer portion of second costal cell only 16

Mesonotum red-brown, with or without a pattern of black markings; microtrichia covering most of both costal cells 17

16(15). No pecten of hairs on abdominal tergum III and with supernumerary lobe weak in male; facial spots linear and poorly defined; costal cells pale fulvous .. .. **D. (Gymnodacus) calophylli** (Perkins and May)

Pecten of hairs present on abdominal tergum III and a definite supernumerary lobe on wing in male; facial spots distinct and oval in shape; costal cells fuscous .. .. **D. (Bactrocera) bryoniae** (Tryon)

17(15). Medial yellow vitta present on mesonotum; lateral post-sutural vittae absent.. .. .. **D. (Pacifodacus) salamander** Drew and Hancock

No medial yellow vitta on mesonotum; lateral post-sutural vittae present. 18

18(17). Four scutellar bristles; abdominal terga III-V red-brown except darker laterally and with a thin dark medial band .. .. **D. (Paratridacus) expandens** Walker

Two scutellar bristles; abdominal terga III-V mostly fuscous (**notatagena** complex) 19

19(18). Mesonotum with a medial black pattern; humeral calli entirely yellow; legs with fore and middle femora and hind tibiae fuscous .. .. **D. (Bactrocera) notatagena** (May)

Mesonotum without a medial black pattern; humeral calli with anterior $\frac{1}{3}$ fuscous; legs with all femora, fore and hind tibiae fuscous to dark fuscous.. .. ..**D. (Bactrocera) romigae** Drew and Hancock

20(9). Four scutellar bristles.. 21

Two scutellar bristles 29

21(20). Medial yellow vitta present on mesonotum 22

No medial yellow vitta on mesonotum 27

22(21). Infuscation on i-m crossvein; costal band widening at wing apex 23

No infuscation on i-m crossvein; no widening of costal band at wing apex 24

23(22). Costal band expanded into a distinct dark fuscous spot at apex of wing; usually with a broad dark fuscous band along i-m crossvein; mesonotum mostly red-brown .. ..**D. (Zeugodacus) cucurbitae** Coquillett

Costal band only slightly widened at apex of wing; a narrow pale infuscation along i-m crossvein; mesonotum red-brown with a pattern of small fuscous markings .. ..**D. (Zeugodacus) choristus** (May)

24(22). Prescutellar bristles present 25
Prescutellar bristles absent 26

25(24). Anterior supra-alar bristles absent; supernumerary lobe absent in wing . .. .. **D. (Hemizeugodacus) aglaiae** Hardy
Anterior supra-alar bristles present; supernumerary lobe very strong .. .. **D. (Zeugodacus) fallacis** Drew

26(24). Medial yellow vitta on mesonotum long and narrow, with apex commencing level with posterior borders of humeral calli; facial spots large, tending oval; a medial black oval spot on abdominal tergum V; pecten present on tergum III of male abdomen; strong supernumerary lobe and dense aggregation of microtrichia at extremity of vein CuA + 1A, in male .. .. **D. (Diplodacus) signatifer** Tryon
Medial yellow vitta on mesonotum broadening posteriorly and apex commencing level with mesonotal suture; facial spots small and circular; a medial black stripe present on abdominal tergum V which may extend forward on to tergum IV; no pecten on male abdomen; supernumerary lobe very weak and no microtrichia at extremity of vein CuA + 1A, in male .. .. **D. (Austrodacus) cucumis** French

27(21). Small flies, entirely black on mesonotum; lateral post-sutural stripes absent. .. .. **D. niger** Tryon
Medium to large flies, predominantly red-brown on mesonotum; lateral post-sutural stripes present 28

28(27). Scutellum yellow except for narrow, dark brown, basal band; no infuscation on wing other than costal band and anal streak; weak, brown, medial stripe on posterior half of abdomen; *a.sa.* bristles present .. .. **D. (Paratridacus) expandens** Walker
Scutellum yellow except for brown apical spot and narrow, dark brown, basal band; a band of infuscation on wing embracing r-m crossvein and outer portion of discal cell; broad, medial, fuscous band present over abdominal terga I-V; *a.sa.* bristles absent .. .. **D. (Hemizeugodacus) aureus** (May)

29(20). Prescutellar bristles present 30
Prescutellar bristles absent 80

30(29). Post-sutural yellow vittae absent 31
Post-sutural yellow vittae present 32

31(30). Mesonotum black; without a yellow triangle along mesonotal suture .. .. **D. (Bactrocera) allwoodi** Drew
Mesonotum red-brown; with a yellow triangle along mesonotal suture .. .. . **D. (Bactrocera) mendosus** (May)

32(30). A medial yellow vitta in addition to lateral post-sutural vittae on mesonotum. 33
Only lateral post-sutural vittae on mesonotum 36

33(32). Costal band expanded into a distinct dark fuscous spot in apex of wing .. .. .. **D. (Zeugodacus) cucurbitae** Coquillett
Costal band not expanded at apex 34

34(33). r-m crossvein infuscated; notopleural calli dark brown .. .. **D. (Afrodacus) furvus** (May) (Females)
No infuscation on r-m crossvein: notopleural calli yellow .. 35

35(34). Thorax entirely black (except for yellow calli and vittae); black transverse band or lateral black spots present on abdominal terga I and II .. **D. (Afrodacus) tigrinus** (May) (Females)
Thorax red-brown with fuscous or black markings behind mesonotal suture; abdominal terga I and II entirely fulvous .. .. **D. (Afrodacus) flavinotus** (May) (Females)

36(32). Anterior supra-alar bristle present 37
Anterior supra-alar bristle absent 76

37(36). Infuscation on wing other than costal band and anal streak 38
Wings not infuscated except for costal band and anal streak 41

38(37). A transverse band across wing enclosing both the r-m and i-m crossveins 39
Only one of the crossveins infuscated 40

39(38). Humeral calli black; scutellum yellow with a black triangle; mesonotum black.. **D. (Bactrocera) frauenfeldi** Schiner
Humeral calli yellow; scutellum entirely yellow; mesonotum red-brown .. .. **D. (Bactrocera) strigatus** (Perkins)

40(38). r-m crossvein infuscated; distinct facial spots present; abdominal terga III and IV uniformly black, tergum V uniformly dark fuscous .. **D. (Bactrocera) laticaudus** Hardy
i-m crossvein infuscated; facial spots absent; abdominal terga uniformly orange-brown .**D. (Bactrocera) hispidulus** (May)

41(37). Scutellum entirely brown or with dark markings at apex .. 42
Scutellum yellow on at least apical half 43

42(41). Facial spots absent; scutellum uniformly pale brown; mesopleural stripe broad, almost reaching humeral callus dorsally . .. .. . **D. (Bactrocera) phaleriae** (May)
Facial spots present; scutellum dark brown or black on apical $\frac{1}{3}$; mesopleural stripe narrow, about as wide as notopleural callus . .. **D. (Bactrocera) bancrofti** (Tryon)

43(41). Microtrichia covering most of second costal cell and a portion of first cell 44
Microtrichia confined to apical portion of second costal cell only 49

44(43). Facial spots absent; abdomen uniformly yellow-brown; lateral post-sutural stripe narrow, parallel-sided for part of its length and tapering to end just before the upper *p.sa.* bristle .. .. . **D. (Bactrocera) mutabilis** (May)

Large oval facial spots present; abdomen fuscous or reddish-brown with fuscous markings; lateral post-sutural stripe broad, triangular and ending before upper *p.sa.* bristle or parallel-sided and reaching to *p.sa.* bristle (**tryoni** complex) 45

45(44). Humeral callus brown or dark brown .. .. **D. (Bactrocera) neohumeralis** Hardy

Humeral callus yellow 46

46(45). Mesonotum and abdomen chiefly fuscous with a pattern of darker fuscous to black markings; apical ½ of mid and hind femora fuscous .. .. **D. (Bactrocera) melas** (Perkins and May)

Mesonotum and abdomen chiefly red-brown or fulvous, often with fuscous markings; all femora entirely fulvous .. 47

47(46). Mesonotum and abdomen red-brown with a pattern of fuscous markings 48

Mesonotum pale red-brown and abdomen fulvous, without fuscous markings .. .. **D. (Bactrocera) aquilonis** (May)

48(47). Costal cells fuscous; abdominal terga III-V with broad lateral longitudinal fuscous to dark fuscous bands .. .. **D. (Bactrocera) tryoni** (Froggatt)

Costal cells fulvous; abdominal terga III-V with broad lateral longitudinal fuscous to red-brown bands; a small species .. .. **D. (Bactrocera) humilis** Drew and Hancock

49(43). Mesonotum mostly black (**dorsalis** complex) 50

Mesonotum red-brown, with a distinctive black pattern consisting of a broad medial longitudinal band narrowing to a point anteriorly and with two similar but shorter lateral bands, all arising out of a broad black area on posterior region of mesonotum .. .. **D. (Bactrocera) cacuminatus** (Hering)

Mesonotum orange-brown or red-brown, with or without a pattern of fuscous markings 54

50(49). Abdomen with a pronounced broad medial black vitta on terga III-V 51

Abdomen without a broad medial black vitta on terga III-V (occasionally a faint narrow fuscous line) 53

51(50). Lateral post-sutural stripe not broad, narrowing posteriorly and ending before upper *p.sa.* bristle 52

Lateral post-sutural stripe broad, parallel-sided and ending at or beyond upper *p.sa.* bristle .. .. **D. (Bactrocera) dorsalis** Hendel

52(51). Mesopleural stripe broad, reaching almost to humeral callus .. .. . **D. (Bactrocera) fuliginus** Drew and Hancock

Mesopleural stripe narrow, reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle .. **D. (Bactrocera) endiandrae** (Perkins and May)

53(50). Abdomen uniformly orange-brown, especially on terga III-V; brown spot on apex of scutellum; costal band narrower than stigma beyond extremity of vein R_{2+3}; mesopleural stripe about as wide as notopleural callus ... and with anterior margin straight . . . . . **D. (Bactrocera) bancrofti** (Tryon)

Abdomen orange-brown or reddish brown except tending fuscous on anterior portion of tergum III; without brown spot on apex of scutellum; costal band at least as broad as stigma beyond extremity of vein R_{2+3}; mesopleural stripe slightly wider than notopleural callus and convex on anterior margin . . . . . **D. (Bactrocera) musae** (Tryon)

54(49). Scutellum with broad basal brown band, $\frac{1}{4}$-$\frac{1}{2}$ width of scutellum (**fagraea** complex) 55

Scutellum with narrow basal band 59

55(54). Abdomen with a well defined medial black vitta on terga III-V . . . . . **D. (Bactrocera) rufescens** (May)

Abdomen without a medial black vitta 56

56(55). Abdominal terga III and IV with lateral fuscous markings . . 57

Abdominal terga III and IV uniformly coloured, without fuscous markings 58

57(56). Mesonotum and abdomen uniformly red-brown; rarely with narrow longitudinal fuscous bands on mesonotum; fuscous areas on extreme lateral margins of abdominal terga III and IV only; mesopleural stripe not wider than notopleural callus; lateral post-sutural stripe not broad and narrowing posteriorly . . **D. (Bactrocera) halfordiae** (Tryon)

Mesonotum red-brown with or without a pattern of fuscous markings; abdomen usually fuscous over most of terga III and IV and laterally on tergum V; mesopleural stripe $1\frac{1}{2}$ times width of notopleural callus; lateral post-sutural stripe parallel-sided for most of its length . . . . . **D. (Bactrocera) kraussi** Hardy

58(56). Abdominal tergum V with a pair of dark shining spots; mesonotum red-brown; basal band of scutellum approximately half width of scutellum . . . . . **D. (Bactrocera) russeolus** Drew and Hancock

Abdominal tergum V without dark shining spots; mesonotum orange-brown; basal band of scutellum approximately third width of scutellum . **D. (Bactrocera) fagraea** (Tryon)

59(54). A well defined or indistinct medial dark vitta on abdomen, either as a band on terga III-V or as an elongated spot on one or two of these terga 61

No medial dark vitta on abdomen 60

60(59). Abdominal tergum III with red-brown to very pale fuscous areas on lateral margins . . . . . **D. (Bactrocera) peninsularis** Drew and Hancock (some specimens)

Abdomen with broad lateral longitudinal dark fuscous bands on terga III-V . . . . **D. (Bactrocera) barringtoniae** (Tryon)

61(59). Abdominal terga III-V with broad lateral longitudinal dark band (e.g. see Figure 3 in Drew *et al.*, 1981) (**silvicola** complex) 62

Abdominal terga III-V with narrow, pale lateral longitudinal dark bands (e.g. see Figures 5-7 in Drew *et al.*, 1981) or without dark lateral margins (e.g. see Figure 4 in Drew *et al.*, 1981). 65

62(61). Costal cells colourless 63

Costal cells fulvous or lightly infuscated . . . . . **D. (Bactrocera) absconditus** Drew and Hancock

63(62). Lateral post-sutural vittae ending before upper *p.sa.* bristles; abdominal terga III-V with a broad, well defined medial black stripe. . . . . **D. (Bactrocera) silvicola** (May)

Lateral post-sutural vittae ending at or behind upper *p.sa.* bristles; abdominal terga III-V with a narrow or indistinct medial fuscous stripe 64

64(63). Abdominal tergum V with a pair of fuscous shining spots; costal band of wing extends below R_{2+3} over its entire length; abdominal terga III-V with medial fuscous stripe connected to lateral fuscous bands along anterior margin of tergum III . . . . . **D. (Bactrocera) rufofusculus** Drew and Hancock

Abdominal tergum V without dark shining spots; costal band of wing narrow, not extending below R_{2+3} except at wing apex; abdominal terga III-V with medial fuscous stripe indistinct and separate from lateral fuscous bands at anterior margin of tergum III . . . . . **D. (Bactrocera) breviaculeus** Hardy

65(61). Abdominal terga III-V with distinct, narrow lateral dark colour patterns on at least some terga 66

Abdominal terga III-V without distinct lateral dark colour patterns 71

66(65). Abdominal tergum V with a pair of fuscous to black shining spots . . . . **D. (Bactrocera) perkinsi** Drew and Hancock

Abdominal tergum V without dark shining spots (**quadratus** complex). 67

67(66). Abdominal terga III-V with more or less distinct medial fuscous stripe 68

Abdominal terga IV and V only with distinct medial fuscous stripe 70

68(67). Abdominal terga III-V with broad lateral fuscous patches; medial stripe well defined. . . . . **D. (Bactrocera) antigone** Drew and Hancock

Abdominal tergum III with broad lateral fuscous patches, terga IV and V with patches narrow or absent; medial stripe not well defined 69

69(68). Lateral post-sutural vittae broad, parallel-sided; costal band of wing barely overlaps vein R_{2+3}; hind tibiae

fulvous .. .. **D. (Bactrocera) peninsularis** Drew and Hancock (some specimens)

Lateral post-sutural vittae tapered posteriorly; costal band of wing almost reaches vein R_{4+5}; hind tibiae fuscous on basal two-thirds .. .. **D. (Bactrocera) erubescentis** Drew and Hancock

70(67). Mesonotum orange-brown; abdominal terga III-V with a very narrow lateral fuscous margin; hind tibiae fulvous; femora fulvous .. .. **D. (Bactrocera) aurantiacus** Drew and Hancock

Mesonotum red-brown; abdominal tergum III with lateral fuscous patches, remaining terga dark fulvous; hind tibiae fuscous; femora fuscous at apex .. .. **D. (Bactrocera) quadratus** (May)

71(65). Costal cells colourless; abdominal terga III-V with a distinct medial longitudinal fuscous band (**mayi** complex) 72

Costal cells pale fulvous; abdomen with distinct medial longitudinal fuscous band over terga IV and V only, a trace may be present on tergum III 74

72(71). Anal streak narrow, approximating width of anal cell (or much paler if extending towards base of discoidal cell), with microtrichia never extending over the entire coloured streak (Figure 54a); mesonotum pale red-brown; abdomen pale orange-brown .. .. **D. (Bactrocera) pallidus** (Perkins and May)

Anal streak broad, reaching almost to base of discoidal cell and covered with microtrichia for entire width (Figure 54b); mesonotum and abdomen red-brown or dark red-brown 73

73(72). Lateral post-sutural stripe broad, almost parallel-sided for part of its length; mesonotum and abdomen red-brown; mesonotum seldom marked with fuscous and then only laterally before mesonotal suture and along inner margins of lateral post-sutural stripe .. .. **D. (Bactrocera) tenuifascia** (May)

Lateral post-sutural stripe not broad, narrowing sharply posteriorly; mesonotum and abdomen dark red-brown; mesonotum usually with a pair of longitudinal parallel black bands centrally. .. .. **D. (Bactrocera) mayi** Hardy

74(71). Mesonotum with a pair of longitudinal parallel fuscous stripes; abdominal tergum V with a pair of fuscous to black shining spots .. **D. (Bactrocera) robiginosus** (May)

Mesonotum uniformly reddish brown; abdominal tergum V without fuscous to black shining spots (**bidentatus** complex) 75

75(74). Lateral post-sutural vittae broad, parallel-sided, ending at upper *p.sa.* bristle; hind tibiae fulvous; costal band confluent with R_{2+3} .. .. **D. (Bactrocera) aeroginosus** Drew and Hancock

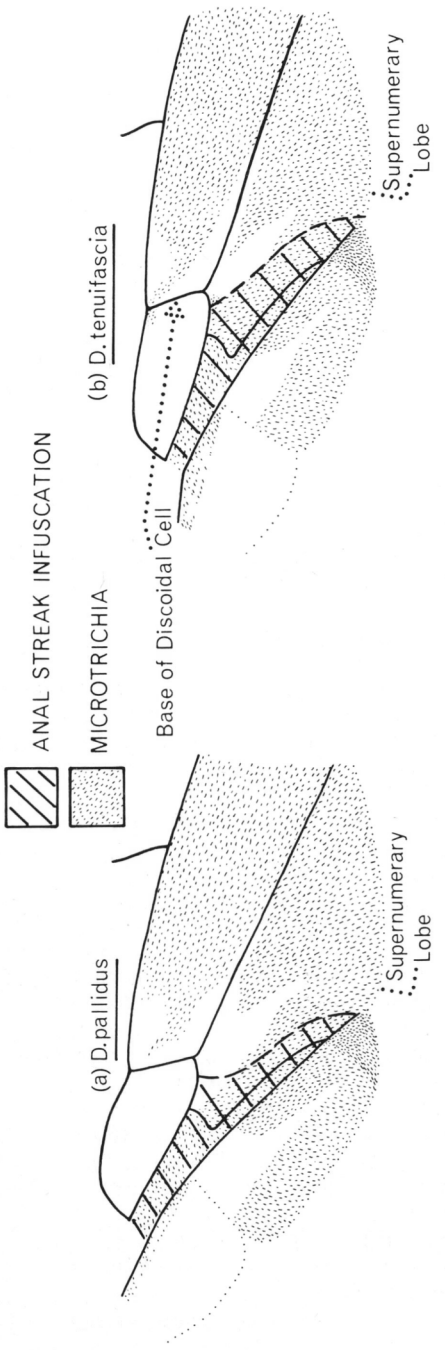

Figure 54—Anal sections of wings of (a) *Dacus pallidus* (Perkins and May) and (b) *Dacus tenuifascia* (May) showing differences in infuscation and microtrichia patterns

Lateral post-sutural vittae narrow, tapered sharply posteriorly and ending before upper *p.sa.* bristle; hind tibiae brown; costal band overlapping R_{2+3} .. .. **D. (Bactrocera) bidentatus** (May)

76(35). r-m crossvein infuscated; mesopleural stripe L-shaped and reaching humeral callus dorsally .. .. **D. (Afrodacus) brunneus** (Perkins and May)

No infuscation on r-m crossvein; mesopleural stripe not attaining humeral callus dorsally 77

77(76) Humeral and notopleural calli joined by a broad yellow band .. .. **D. (Afrodacus) jarvisi** (Tryon)

Humeral and notopleural calli not joined by a broad yellow band 78

78(77). Costal cells brown; microtrichia covering most of second costal cell and a portion of first cell; facial spots absent .. .. **D. (Bactrocera) mutabilis** (May) (some specimens)

Costal cells pale fulvous or colourless; microtrichia in outer portion of second costal cell only; facial spots present 79

79(78). Mesonotum black; abdomen with a narrow fuscous band along anterior margin of tergum III and a fuscous to black medial longitudinal band on terga III-V .. .. **D. (Afrodacus) mesoniger** (May)

Mesonotum red-brown with a pattern of black markings; abdomen with an elongate black spot on tergum V which extends onto tergum IV in some specimens .. .. **D. (Afrodacus) aberrans** Hardy

80(29). Post-sutural yellow vittae on mesonotum present 81

Post-sutural yellow vittae on mesonotum absent (except an elliptical yellow spot in centre of mesonotum in *D. newmani*) 85

81(80). Medial post-sutural yellow marking on mesonotum absent .. 82

Medial post-sutural yellow marking on mesonotum present 83

82(81). Abdomen fulvous with a transverse dark fuscous to dull black band across base of tergum III, narrow fuscous markings on lateral margins of terga III-V, a broad medial longitudinal black band on terga III-V .. .. **D. (Polistomimetes) murrayi** (Perkins)

Abdomen red-brown with a transverse dull black band across base of tergum III, dark lateral markings on terga IV and V usually absent, a narrow medial longitudinal dark band on terga III-V which is interrupted at the intersegmental lines and very pale on tergum III .. .. **D. (Polistomimetes) decurtans** (May)

83(81). Lateral post-sutural vittae present 84

Lateral post-sutural vittae absent; medial vitta very broad .. .. **D. (Didacus) hardyi** Drew

84(83). Humeral and notopleural calli connected by a yellow band; infuscation on i-m crossvein .. .. **D. (Pacifodacus) strigifinis** Walker

Humeral and notopleural calli not connected by a yellow band; no infuscation on i-m crossvein .. .. **D. (Diplodacus) signatifer** Tryon (some specimens)

85(80). r-m crossvein infuscated; broad mesopleural stripe attaining humeral callus dorsally; abdomen fulvous with fuscous markings on first 4 terga .. .. .. **D. exiguus** (May)

r-m crossvein not infuscated; mesopleural stripe not attaining humeral callus dorsally; abdomen uniformly coloured on first 4 terga 86

86(85) Elongate facial spots present; mesopleural stripe broad and attaining anterior notopleural bristle dorsally; mesonotum uniformly red-brown or dark brown 87

No facial spots; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior *npl.* bristle; mesonotum rich chocolate brown with a central elliptical yellow spot posterior to mesonotal suture .. .. .. **D. (Dacus) newmani** (Perkins)

87(86). Facial spots small, narrow (occasionally absent); hind tibiae fulvous; costal band not overlapping vein R_{2+3} .. .. **D. (Dacus) bellulus** Drew and Hancock

Facial spots distinct and elongate; hind tibiae fuscous; costal band overlapping vein R_{2+3} **D. (Dacus) signatifrons** (May)

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SECTION II THE STERILE INSECT RELEASE METHOD FOR SUPPRESSION OR ERADICATION OF FRUIT FLY POPULATIONS

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Introduction

The idea of using sterile insects to suppress or eradicate populations of insect pests was conceived by Knipling (1955) and the validity of his theory was confirmed by the eradication of the screw worm fly *Cochliomyia hominivorax* (Coquerel) from the south-eastern region of the U.S.A. (an area of *ca* 207,000 km²) in 1958-59 (Knipling, 1960). The success of this programme stimulated work with other species and particularly tephritid fruit flies in the U.S.A. and elsewhere. The melon fly, *Dacus cucurbitae* Coquillett, was eradicated from Rota in 1962-63 (Steiner *et al.*, 1965) and from Kume Is. (Japan) in 1976 (Iwahashi, 1977), as was the oriental fruit fly, *Dacus dorsalis* (Hendel), from Guam in 1963 (Steiner *et al.*, 1970). Numerous other field experiments as well as supporting laboratory and developmental work in the areas of mass rearing, irradiation, transportation and release techniques have been, or are being, conducted in many parts of the world with a number of species e.g. the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), in Italy (Nadel and Guerrieri, 1969; Murtas *et al.*, 1970), Spain (Mellado *et al.*, 1974), Nicaragua (Rhode *et al.*, 1971), Hawaii (Harris *et al.*, 1975), Peru (Simon, 1974), Tunisia (Cheikh *et al.*, 1975), Western Australia, Mexico; *D. cucurbitae* in Hawaii and Japan: *D. dorsalis* in Japan (Itô and Iwahashi, 1974), Philippines and U.S.A.; the Queensland fruit fly, *Dacus tryoni* (Froggatt), (Andrewartha *et al.*, 1967; Monro and Osborn, 1967) and the cucumber fly, *Dacus cucumis* French, in Australia (Hooper, 1975a, 1975b, 1976); the olive fly, *Dacus oleae* (Gmelin), in Greece (Tzanakakis, 1974); *Anastrepha* spp. in U.S.A. (Lopez, 1970); and the cherry fly, *Rhagoletis cerasi* L., in Switzerland (Boller, 1974). As a result of these investigations a large body of knowledge has been accumulated which will benefit future programmes.

The suppression or eradication of fruit flies by the sterile insect release method (SIRM) is more difficult than was the case with the screw worm because fruit flies in general have higher population densities and higher

reproductive potential. For example, the density of screw worm flies in the south-eastern U.S.A. was estimated to be less than 0.4-1.9/ha (Anon., 1962), whereas in the Tunisian *C. capitata* programme the adult density varied from 300 to a maximum of 28,000/ha (Cheikh *et al.*, 1975). However, this factor does not invalidate the use of the SIRM against fruit flies. Geier (1969) pointed out that "practical efficacy would be greatest for sterile individuals released in sparse target colonies, whose low densities were already close to entailing dangerous under-population effects". Thus the timing of the start of any SIRM programme should take place when the target population is low and this timing may be either opportunistic, as in the eradication of *D. dorsalis* from Guam following decimation of the wild population by typhoons (Steiner *et al.*, 1970), or planned, for example by prior reduction of the population with insecticides. Either protein-bait sprays or specific male attractants could be employed. With fruit flies the SIRM will usually need to be integrated with other control procedures.

The SIRM involves the following major activities; mass rearing, sterilization, transportation and release, assessment, and ecological studies prior to and during the programme. These will be considered separately.

(1) MASS REARING

Mass production techniques for the major economic species of fruit flies of concern to Australia are now established. Monro and Osborn (1967) successfully reared up to 1 million pupae per week of the Queensland fruit fly, *D. tryoni*, but their carrot-based medium is expensive. This species can be reared on a bran-based medium (Hooper, 1978a) but insecticide contamination of commercial bran creates a serious problem. Mitchell *et al.* (1965) described rearing procedures for *C. capitata*, *D. dorsalis* and *D. cucurbitae*, and Tanaka *et al.* (1969, 1970) described recent modifications to rearing procedures in the U.S.A. In general, rearing procedures in other countries e.g. Italy, Spain, Japan, Philippines, Peru and Mexico, are similar to, or based on, those developed in the U.S.A., but modifications to the larval rearing media are frequently made to utilise local products and so reduce production costs (see Nadel (1970) for a survey of diets for *C. capitata*). Currently material production costs in the U.S.A. are *ca* $20 per million pupae, but when labour and transport costs are added, the cost rises by a factor of 3-4. The U.S.D.A. rearing facility in Hawaii can currently produce 30 million pupae per week, and with automation there would be no impediment to higher production. Peru built a factory for *C. capitata* with a planned maximum output of 375 million pupae per week in 1975 and a factory is now operating in Mexico with a weekly production of 500 million sterilised pupae (Patton, 1980).

Eggs obtained from the oviposition cages are measured volumetrically and placed on the larval medium. Equipment is now available which automatically dispenses known volumes of suspensions of eggs in water on to medium. In some facilities eggs are seeded on to the medium soon after collection, while in others the eggs are pre-incubated in aerated water before seeding.

Two methods of recovering mature larvae from the larval production units have been developed (Tanaka *et al.*, 1970). One involves separating the larvae from the medium by washing the residue through a screen sieve, the larvae then being added to moist vermiculite, bran or sawdust for pupation. The other is referred to as the 'popping' method; mature larvae will leave the medium of their own accord and they fall from the vertically stacked rearing trays and are collected in receptacles containing pupation medium. A further modification is to collect the larvae in receptacles filled with water. Current evaluation procedures indicate that as long as the water is kept at 20°C larvae are unaffected by immersion for periods up to 24 hours. They are then collected and added to pupation medium. This procedure is currently used in Japan and Hawaii.

Control of heat build up during larval development is of critical importance. Towards the end of larval growth, the temperature of the medium can increase markedly, leading to reduced yields and smaller pupae (Hooper, 1978b), and one can presume there are other deleterious effects on fitness. For example, Tanaka *et al.*, (1972) found with *C. capitata* and the SMYGS diet that when the rearing trays were kept in an ambient temperature of 27°C, the temperature of the diet started to increase by the 5th day and reached a maximum of 38-40°C. To overcome this problem, the larval trays were transferred from 27°C to 21°C when the temperature of the medium started to increase. This procedure did not reduce pupal size but gave a higher pupal recovery (72 per cent vs 60 per cent for uncooled diet) and enhanced emergence of adults (92 per cent vs 79 per cent).

Pupae are recovered from the pupation medium by sieving when *ca* 4 days old. Ohinata (1980) discussed unpublished work by Ozaki and Kobayashi which showed that, for *C. capitata*, *D. cucurbitae* and *D. dorsalis* sieving during a certain stage (*ca* 33 per cent development) of pupal development resulted in a high proportion of non-flying adults. They are then stored in thin (1 cm) layers on screen bottomed trays to minimise heat build up until irradiated. Pupal development rate can be manipulated by the temperature at which they are held (Langley *et al.*, 1972) and so the development of pupae produced on different days synchronised. However, problems can result from these procedures (Hooper and Nadel, 1970).

Current rearing procedures are efficient in terms of pupal recovery from eggs (*ca* 60-70 per cent), pupal production per unit of rearing medium, and production costs. However, I have reservations as to the effects of some of the procedures on the 'quality' of the flies produced. For example, cages used to hold adults for egg production are often dimly lit. This reduces fly activity and as a result a higher fly density can be achieved. When this system is maintained over many generations it is likely to affect the quality of the flies. Laboratory culture can result in changes in the colonies e.g. compared with wild *D. dorsalis* the laboratory colony in Hawaii has a shorter premating period and decreased longevity, while the fecundity of colonised *D. dorsalis* in Japan has increased with increasing time in culture. These attributes may be desirable in terms of production but one wonders what undesirable effects have also accumulated which might affect quality. The quality of the released flies is of crucial importance in the SIRM and is undoubtedly a complex phenomenon. There is an urgent need for better ways of estimating quality.

(2) INDUCTION OF STERILITY

In all fruit fly control programmes to date, late stage pupae i.e. within 3 days of emergence, have been irradiated. If younger pupae are irradiated somatic damage is increased with a marked reduction in the fitness of the emerging adults. Either X or γ-radiation or neutrons can be used to induce sterility, but in practice, γ-radiation from ^{60}Co or ^{137}Cs sources are used. Dose rates usually are in the range of 3-9 krad per min.

Ionising radiation induces dominant lethal mutations (DLM) in the chromosomes. The DLM involve chromosome breakage with loss of fragments and/or formation of bridges, which ultimately results in chromosomal imbalance in the zygote leading to embryonic death.

The relationship between male sterility, expressed as per cent hatch of eggs of the cross I♂ × U♀(I = irradiated, U = untreated) and dose for the cucumber fly, *D. cucumis*, is shown in Figure 55 (Hooper, 1975a) and this curve is typical of the dose response curves for other tephritids. The important point is that while sterility initially increases rapidly the curves tend to become exponential beyond *ca* 95 per cent sterility. Thus relatively high doses are required to produce total sterility.

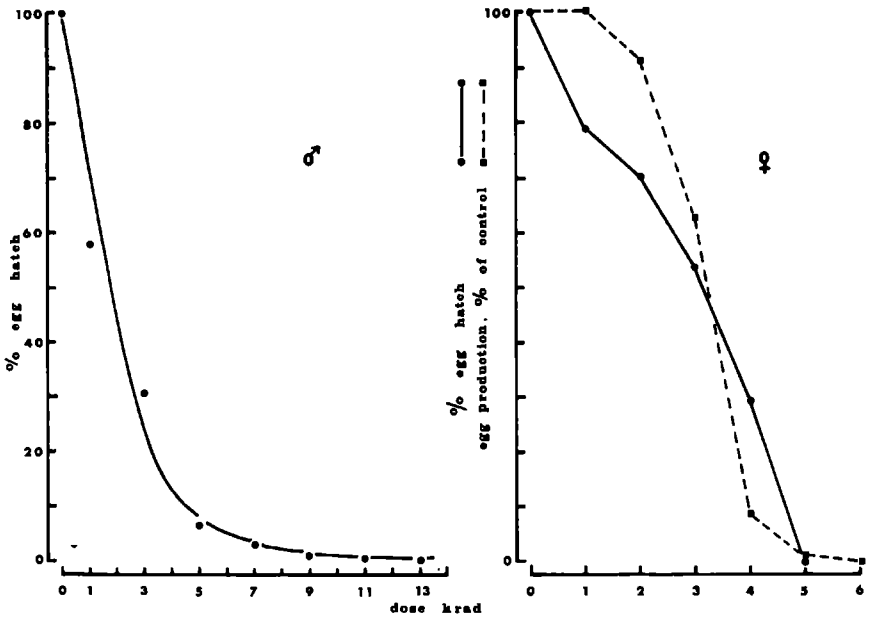

Figure 55—Dose-response curves for the induction of sterility in male and female *D. cucumis*. Data have been corrected for the control hatch (84.5 per cent)

In females, sterility can occur either by DLM or through infecundity (Figure 55). Generally total female sterility is achieved at a lower dose than is total male sterility e.g. in *D. cucumis* 6 krad causes total sterility in females, while 9 krad causes *ca* 99 per cent sterility in males (Hooper, 1975a).

With doses giving 95-98 per cent sterility in males (up to 9 krad) survival of the flies is usually not lowered to any significant extent. However, competitiveness of the irradiated males in comparison with untreated males is lowered, and this factor is crucial to the success of the SIRM. Competitiveness of irradiated males is inversely proportional to the dose given, and directly proportional to the age of the pupae when irradiated.

Competitiveness can be measured in different ways e.g. (a) by comparing the number of observed matings of irradiated and untreated males, (b) by comparing the number of females inseminated, (c) by comparing the egg hatch obtained when irradiated and untreated males are confined in various ratios with untreated females. I believe that the latter approach i.e. ratio tests, provides the best overall estimate of mating competitiveness since it reflects the total interplay within the experimental conditions of such factors as mating drive, mating ability, sperm complement, sperm competitiveness and the impact of multiple mating of females. Other factors such as delayed peak mating response, as shown to occur in *C. capitata* (Holbrook and Fujimoto, 1970), which contribute to reduced competitiveness may not operate in small cage experiments.

For many years the competitiveness of irradiated males based on ratio tests simply involved comparing the observed egg hatch with that which would be expected on the basis of full competitiveness. If the observed egg hatch was higher than the expected, then reduced competitiveness was indicated. The expected egg hatch (E) can be calculated as follows

$$E = \frac{N.Hn + S.Hs}{N + S}$$

where N = number of untreated males
S = number of irradiated males
Hn = hatch of the cross U♂ × U♀
Hs = hatch of the cross I♂ × U♀

Fried (1970) proposed a precedure for quantifying the competitiveness of the irradiated males. If we assume that the competitiveness of the irradiated males is C then the above equation can be modified to

$$\text{Observed egg hatch } O = \frac{N.Hn + C.S.Hs}{N + CS}$$

and solving for C we obtain

$$C = \frac{N}{S} \times \frac{Hn - O}{O - Hs}$$

A procedure has now been devised to calculate the variance of C and so permit detection of significant differences between competitiveness values (Hooper and Horton, 1981).

Returning to the question of the timing of irradiation, the closer the pupae are to eclosion the more competitive are the males although the degree of sterility declines. Data for *C. capitata* (Hooper, 1971a) illustrate this point (Table 1).

Table 1. Sterility and competitiveness of male *C. capitata* irradiated 1, 2 and 3 days before adult emergence (from Hooper, 1971a).

Dose (krad)	Cage population I♂ : U♂ : U♀	Corrected % hatch from males irradiated at indicated days before emergence[1] 1	2	3
5	25 : 0 : 25	14.0 a	12.7 a	9.4 b
7	25 : 0 : 25	6.7 a	7.6 a	5.3 b
9	25 : 0 : 25	3.9 a	3.1 ab	2.3 b
9	16 : 16 : 16	66.4 a	78.1 b	83.1 b
	Expected egg hatch	48.9	48.6	48.2
	Competitiveness value	0.44	0.21	0.14

[1] Means characterised by same letter are not significantly different at the 5% level of probability. Comparisons of means must be made only within each treatment.

Table 2. Sterility and competitiveness of male *C. capitata* irradiated 48 hr before or 2-6 hr after adult eclosion (from Hooper, 1971b).

Dose (krad): stage irradiated	Sterility test Corr. % egg hatch of cross 25 I♂ × 25 U♀	Competition test Corr. % egg hatch of ratio 36 I♂ : 12 U♂ : 12 U♀	Exp. % egg hatch	Competitiveness value
7 : pupal	5.1	53.4	28.8	0.32
7 : adult	6.3	39.8	29.7	0.59
9 : pupal	2.1	58.5	26.6	0.24
9 : adult	1.9	44.9	26.4	0.43
11 : pupal	0.6	56.7	25.4	0.29
11 : adult	0.8	50.1	25.6	0.35

With *C. capitata* irradiation of young adults gives more competitive males than does irradiation of the pupal stage. This is shown in Table 2 (Hooper, 1971b) and these findings are confirmed by the data of Ohinata *et al.* (1971). Similarly, with *D. cucurbitae* irradiation of adults rather than mature pupae yielded more competitive males (Anwar *et al.*, 1975). Irradiation of young adults raises problems in handling which are not present with pupal irradiation and females will produce a few eggs of low viability. However, Harris *et al.* (1975) successfully used this technique experimentally in a pilot test against *C. capitata* on the island of Lanai, Hawaiian Islands, U.S.A.

It was stated earlier that competitiveness is inversely proportional to dose, while sterility of course is directly proportional to dose. These two antagonistically acting forces operate to determine egg hatch in a competitive mating situation. The data in Table 3 obtained with *C. capitata* clearly illustrate this phenomenon (Hooper and Katiyar, 1971). As the dose increased from 5 to 13 krad, the degree of sterility increased and of course the egg hatch from a 5I: 1U ratio was expected to decrease. However, while the observed egg hatch did not change significantly from 3-11 krad, it increased significantly at higher doses. Clearly some factor was operating antagonistically to the increasing sterility of the males and this factor was the competitiveness of the males, which declined from 0.93 to 0.16. Similar results have been obtained with *D. cucumis* (Hooper, 1975a) and the phenomenon can be accepted as general.

Table 3. Sterility and competitiveness of male *C. capitata* irradiated in the pupal stage two days before eclosion. Caged with untreated males and females in a 5 : 1 : 1 ratio (from Hooper and Katiyar, 1971).

Dose (krad)	Sterility test	Competitiveness test		
	Corr. % egg hatch[1]	Mean % egg hatch Observed[1]	Expected	Competitiveness value
3	26.1 a	35.9 a	38.4	0.93
5	12.5 b	33.6 a	27.1	0.52
7	4.3 c	39.2 a	20.2	0.30
9	1.9 d	36.4 a	17.8	0.31
11	0.42 e	41.0 a	17.0	0.25
13	0.06 f	51.0 b	16.7	0.16
15	—	60.6 c	—	—
17	—	67.8 c	—	—

[1] Means characterised by same letter are not significantly different at the 5% level of probability.

The data discussed above are of great practical importance. In the *C. capitata* experiments in Italy and Nicaragua (Hooper and Nadel, 1970, Murtas *et al.*, 1970, Rhode, 1970) a sterilising dose of 9 krad was used. Based on the extensive data of Hooper (1972), the competitiveness of these males assessed against untreated laboratory males—not wild males—and under optimum conditions, was of the order of 0.26. In the Italian programme the radiation dose was increased from 7.5 krad in 1967 to 9 krad in 1969 (Nadel and Guerrieri, 1969, Hooper and Nadel, 1970). The decision to increase the dose in 1969 was based on the premise that the more sterile the insect, the better, and this notion has been widespread for many years. However, because of the counteracting factor of competitiveness, Hooper and Katiyar (1971) and Hooper (1972) argued that a dose of 7 krad, at least in the early stages of a suppression programme for *C. capitata*, rather than 9 krad may be superior and warranted field testing. It is accepted that as suppression is achieved and the wild population declines, an increase in dose to lower the level of residual fertility from *ca* 5 per cent to 1 per cent may be required. However, at this point, assuming sustained release of high numbers of flies, increased overflooding ratios will compensate for the reduced competitiveness of the flies.

Fortunately, a simple procedure which reduces the loss of competitiveness of irradiated males has been found (Hooper, 1971b). If pupae prior to treatment are maintained for 5-10 min in an atmosphere of nitrogen, and then irradiated in nitrogen, a protective effect is obtained. To achieve a given degree of sterility, the dose must be increased but even so competitiveness is enhanced. Table 4 gives data for *C. capitata*. While a dose of 11 krad in nitrogen was required to induce the same level of sterility as 9 krad in air, the competitiveness of the nitrogen treated males was 3.3 times greater than that of the males treated in air. The nitrogen treatment does not adversely affect survival. This phenomenon has been confirmed in *Rhodnius prolixus* (Stål) (Baldwin and Chant, 1971), *D. cucumis* (French) (Hooper, 1976), *Aedes aegypti* (L.) (Halliman and Rai, 1973), *Musca domestica* L. (La Chance and Richard, 1974) and *D. cucurbitae* (Ashraf *et al.*, 1975) and so can be presumed to be of wide application. This finding has already been used in a practical programme; the sterile *C. capitata* used in the 1975-76 eradication campaign in Los Angeles, U.S.A., were irradiated in nitrogen (Ohinata *et al.*, 1978, Cunningham *et al.*, 1980).

Since at present there is no practicable method for separating the sexes of fruit flies in either the pupal or the adult stages, sterile flies of both sexes have been released in all SIRM programmes. Therefore the impact of the sterile females is of some interest. Work by Ohinata *et al.* (1971) with *C. capitata* showed that in 29 : 1 : 1 ratio tests (i.e. 29 irradiated males or females : 1 untreated male : 1 untreated female) the use of irradiated females alone gave much lower control than did the use of irradiated males alone, regardless of whether the flies were irradiated in the pupal or adult stages. With the same insect Hooper (1972) found that, when irradiation was given to late stage pupae, females neither augmented, nor detracted from, the control given solely by irradiated males. Similar work with *D. cucurbitae* suggests that the presence of both irradiated sexes may give somewhat lower control than that given by irradiated males alone (Anwar *et al.*, 1975).

Table 4. Effect of irradiating pupae of *C. capitata* (2 days before eclosion) in an atmosphere of nitrogen on sterility and competitiveness of males (from Hooper, 1971b).

Dose (krad): irradiation atmosphere	Sterility test	Competitiveness test[1]		
	Corr. % egg hatch[2]	Observed corr. % egg hatch[2]	Exp. % egg hatch	Competitiveness value
5 : air	11.7 a	40.1 a	34.4	0.66
7 : nitrogen	11.4 a	30.2 a	34.1	1.13
9 : air	2.0 b	56.1 a	26.6	0.24
11 : nitrogen	2.8 b	36.5 b	27.2	0.79

[1] Ratio of 36 I♂ : 12 U♂ : 12 U♀
[2] Means of each pair of treatments which are followd by the same letters are not significantly different at the 5% level of probability

(3) TRANSPORTATION OF IRRADIATED FLIES

Since the mass production/irradiation facility is almost invariably remote from the release site, the irradiated pupae must be packaged and transported. In addition, so that evidence of the ratio of irradiated to wild flies can be gathered, the pupae are usually coated with dyes so that the irradiated flies will be marked and distinguishable from wild flies.

A number of dyes, some fluorescent, are available (Steiner, 1965, Holbrook *et al.*, 1970). However, some dyes have been found to lower the competitiveness of the flies (Mellado *et al.*, 1974) and each dye should be checked experimentally. Chambers *et al.* (1970) found with *C. capitata* that although the dye used (Day-Glo red) was only slightly detrimental, such small effects can be cumulative and must be considered.

In the latter stage of pupal development the metabolic heat produced by the pupae can increase significantly the temperature of the mass of pupae and lead to premature emergence, high mortality and mutilation of flies; e.g. Tanaka *et al.* (1972) reported that in a mass of pupae of *D. cucurbitae* held at 27°C, the temperature rose to almost 40°C in one day and this heat rise reduced emergence by *ca* 97 per cent. Consequently the early transportation procedure was to pack pupae in shallow trays in a large container to ensure adequate ventilation and allow for dissipation of heat (Kamasaki *et al.*, 1969; Hooper and Nadel, 1970). Nevertheless problems still resulted. Tanaka *et al.* (1972) reported that pupae could be packed in long polyethylene bags from which the air was withdrawn before sealing. The semi-anaerobic conditions thus obtained inhibited development of the pupae and eliminated any heat rise. Adult eclosion was greater than 90 per cent after 5 days storage in the bags at 20°C or after 2 days at 27°C. Emergence of flies usually began 2 days after the pupae were removed from the bags. This technique has several advantages; it reduces costs (by a factor of 20 over the carton technique); because pupal development is inhibited, short delays in transport are not

critical; escape of flies en route is avoided. This method of transporting pupae was used in the 1975-76 *C. capitata* eradication campaign in Los Angeles, U.S.A. (Ohinata *et al.*, 1980).

(4) RELEASE OF IRRADIATED FLIES

Several techniques have been used.

1. Placement of pupae in specially designed containers in the field to permit emergence of flies. One widely used container was designed in Hawaii and is referred to as the "Lanai Bucket". This technique is being used in Japan for *D. cucurbitae* (Iwahashi, 1977) and was also used in the Los Angeles *C. capitata* programme (Cunningham *et al.*, 1980).
2. Flies are allowed to emerge in the laboratory and are then released from the ground. The *C. capitata* programme in Italy utilised this approach (Murtas *et al.*, 1970). Harris *et al.* (1975) found with *C. capitata* that the recovery rate of flies placed in the field as adults was double that of flies which emerged in the field in plastic buckets.

These two approaches are only feasible when ground access is available to the entire release area. However, they can also be used to supplement aerial releases. If the release area is extensive, or the terrain is inaccessible, then aerial distribution is the only approach possible.

3. Some work has been carried out with the aerial distribution of pupae. *C. capitata* pupae reached a constant terminal velocity within the first 3 m of fall and emergence rates of pupae so dropped was acceptable if they fell on grassy fields. Emergence was reduced when they landed on rocky ground or forests (Cunningham *et al.*, 1971). Solar heating and predation would also be potentially serious problems with this technique. Nevertheless, Harris *et al.* (1975), in small scale tests on the island of Lanai, U.S.A. with *C. capitata*, obtained recoveries of adults from this technique equal to those from flies which emerged from pupae in plastic buckets.
4. Release of cold immobilised adults directly from aircraft. This technique was used in the Los Angeles *C. capitata* programme (Cunningham *et al.*, 1980). In a pilot test against *C. capitata* on the island of Lanai, U.S.A., recovery rates of adults distributed from the air as refrigerated adults were much higher than recoveries of adults resulting from the distribution of pupae (Harris *et al.*, 1975).
5. Flies packaged in cardboard boxes, or paper bags, have been released from aircraft (Steiner *et al.*, 1965; Nadel *et al.*, 1967). A problem with this technique is that many flies are damaged as a result of confinement in the containers and as they enter the air stream from fast moving fixed wing aircraft (Harris *et al.*, 1968). In an attempt to overcome these problems, Howell *et al.* (1975) devised a technique in which flies, immobilised by cold, were packed into paper tubes to which small plastic parachutes were attached. The tubes opened automatically *ca* 20 m behind the aircraft at which point they were beginning free fall. Compared with ground release this technique gave better distribution and equal or better survival of flies.

When release of adults is utilised, emergence of adults from irradiated pupae requires a fairly large space and temperature control. Methods of coping with this problem are being investigated.

(5) OVERFLOODING RATIO

Despite the field programmes which have been carried out, there is no precise information available on the magnitude of the overflooding ratio i.e. the released: wild (R : W) fly ratio, required for suppression or eradication of tephritid fruit flies. In the eradication of *D. cucurbitae* from Rota (Steiner *et al.*, 1965) the R : W ratio was initially 14 : 1, rose to 90 : 1 and towards the end of the programme declined to 30 : 1. During the eradication of *D. dorsalis* from Guam, the average R : W ratio was 130 : 1. Eradication of *D. dorsalis* was not obtained with the SIRM on Saipan with an average R : W of 27 : 1 and a maximum ratio of 64 : 1, nor on Tinian where apart from one occasion when the R : W was 322 : 1, the average ratio for the remainder of the programme was 39 : 1 (Steiner *et al.*, 1970). In Tunisia the suppression programme for *C. capitata* reduced populations at least 82 per cent, gave complete control on early maturing fruits (stone fruit and figs), and reduced, but did not control, infestations in preferred summer fruits (peaches and figs). Here the lowest R : W ratio was 49 : 1, the highest was 1740 : 1 and the average was 430 : 1. However, sterile flies were not evenly distributed and this in part explains the reduced late season control (Cheikh *et al.*, 1975). In Nicaragua, control of *C. capitata* in excess of 90 per cent resulted from R : W ratios which were generally in excess of 1000 : 1 (Rhode *et al.*, 1971).

On the evidence to date an average minimum R : W ratio of 100 : 1 should be the objective for medfly eradication. A marked (sterile): unmarked (wild) male fly ratio of *ca* 10 : 1 caused a decline in the egg hatch of *D. curcurbitae* on Kume Is., and eradication was obtained when the ratio exceeded 45 : 1 (Iwahashi, 1977).

(6) ASSESSMENT OF FIELD PROGRAMMES

It is evident that the progress of any field programme utilising the SIRM must be monitored so that adjustments to the release strategy can be made and other problems delineated rapidly. Marking the released flies permits estimation of the R : W fly ratio from trap data, as well as defining trends in the wild fly population density. While the former data by themselves do not permit predictions on the outcome of the programme, since we have no accurate knowledge of the overflooding ratios required, they are essential for correlation with fruit infestation data and for checking distribution and field survival of the released flies. In the recent *C. capitata* suppression programme in Tunisia (Cheikh *et al.*, 1975) R : W fly ratios were generally in excess of 100 : 1, but these data also showed that certain zones of the experimental area were not receiving adequate numbers of released flies. The efficiency of the pupal marking procedure must be considered here; if we assume a 99.5 per cent marking efficiency, 5 flies in every 1000 will be unmarked, which would give an apparent R : W ratio of 199 : 1 from the released flies alone. Thus the upper R :

W ratio which can be accepted as real is set by the marking efficiency which is consequently a factor which must be determined.

Trap data can be used to compare the wild population density in the experimental area with those in nearby, similar untreated areas or with data for the same area in years prior to the programme. In the Tunisian programme the wild fly population was reduced by 84-99 per cent compared with that of the previous year (Cheikh *et al.*, 1975).

Fruit infestation data provide the best estimate of the progress of the suppression/eradication programme. Such data have been used in several programmes e.g. Rhode (1970), Cheikh *et al.* (1975). In some instances eggs have been dissected from fruit to provide egg hatch data and so allow a direct estimate of the impact of the released sterile males on the wild population (Rhode, 1970; Murtas *et al.*, 1970). Such data, while extremely useful, require much manpower, and this assessment is really only practicable in the early stages of the programme when wild females, and therefore eggs, are in reasonable numbers.

(7) ECOLOGICAL STUDIES

Prior to the actual release of sterile flies, ecological studies are essential. Such studies should include the following:

1. A survey of the areas to establish all potential hosts of the target fruit fly and their fruiting sequence (i.e. establishment of a fruit calendar). Concentrations of favoured hosts should be delineated as these could serve as areas for rapid increase in wild populations and such 'hot spots' may require additional special control measures. An example from the Italian programme with *C. capitata* illustrates the importance of these host fruit studies. Work began in 1967 on the island of Capri and continued on Procida in 1968 and 1969. However, it was not until 1969 that the importance of the inedible sour orange, which is preferred to the common orange for oviposition, was recognised as an important overwintering host for this fruit fly. Thus sour oranges provided foci of *C. capitata* infestation (Murtas *et al.*, 1970).
2. Extensive trapping and fruit infestation data for at least 1 year prior to the implementation of the SIRM to elucidate seasonal fluctuations in the population.
3. Estimation of the size of the fruit fly population is essential either (a) to allow the establishment of an appropriately sized mass production facility or (b) if the size of the production facility is fixed to indicate the area which can be treated with the available numbers of sterile flies.

The size of the population can be estimated by classical mark-recapture techniques. These were used to estimate populations of *D. cucurbitae* in the Ryukyu Islands of Japan (Itô *et al.*, 1974). Steiner (1969a, b) has discussed this problem and given an alternative procedure for estimating the size of populations of *D. dorsalis*, *D. cucurbitae* and *C. capitata* based on male lure trap catches.

(8) CONCLUSIONS

The past 15 years have seen significant advances in many aspects of the SIRM as applied to fruit flies. In the field of mass production Steiner (1969c) indicated that the yield of *C. capitata* pupae had increased to 18,000 per litre of medium, possibly close to maximum yield. He stated that material costs of production had declined from $45 to $10 per million pupae in 18 months, while material plus labour costs had fallen from $350 to $20 per million pupae. In large rearing facilities, labour costs could probably be reduced further with appropriate automation. Irradiation techniques have improved so that flies of higher competitiveness are now produced and there have been important advances in transportation and aerial release techniques.

Inevitably there are areas still requiring research.

These include:

1. Better methods for evaluating 'fitness' of the flies bred and sterilised for release. Only when these are available will it be possible to modify rearing, irradiation, handling and release procedures to optimise 'fitness'. Boller and Chambers (1977) discussed this problem and advocated the use of statistical quality control procedures (Grant and Leavenworth, 1980) which have been widely used in industry. Limited experience with these procedures in my laboratory has indicated their usefulness. However, there still remains the question as to which biological characteristics and behaviours should be monitored to give a meaningful estimate of 'fitness'. Boller *et al.* (in press) have established, for *C. capitata*, a set of laboratory tests (referred to as the RAPID quality control system) which measures a number of performance characteristics. This system can serve as a model for the development of quality control systems for other species.
2. It would be of great benefit if genetic markers could be obtained for the major fruit fly species. This would eliminate the tedious and possibly deleterious procedure of marking pupae with dyes. Early experiments on Rota utilised white-marked *D. dorsalis* (Steiner *et al.*, 1962). However, Steiner (1969c) reported that work with markers in *C. capitata* was disappointing, since all genetically marked strains investigated had reduced fecundity and fitness.
3. Much remains to be done on techniques for the release of irradiated flies. Past experiments have shown that a number of factors e.g. weather, can seriously affect the impact of released flies. In an experiment in Spain which involved placement of *C. capitata* pupae in the field, low temperatures and/or rain consistently reduced emergence from a normal 70-80 per cent to as little as 28 per cent but frequently to 45-50 per cent (Mellado *et al.*, 1974). The fitness of the flies that did emerge under adverse weather conditions must also be questioned. Release of adult flies may obviate this difficulty to some extent.
4. In order to achieve optimal and predictable production of flies, rearing must be carried out under controlled conditions of temperature and humidity, and the flies are then expected to survive and compete with their counterparts in the, relatively speaking, hostile field environment. Procedures to reduce the trauma of the transition from optimal laboratory conditions to the field situation and thus yield 'fitter' flies would be of great

value. Selection for increased ability to withstand food and water stresses was successfully accomplished with the screw worm fly (Baumhover and Spates, 1956).

The role of the sterile insect release method, appropriately integrated with other ecologically acceptable control approaches, in the suppression of established fruit fly populations and/or in the eradication of introductions of exotic species has now been established. I believe the future will see increasing interest in this approach.

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SECTION III CHEMICAL METHODS FOR SUPPRESSION OR ERADICATION OF FRUIT FLY POPULATIONS

M. A. BATEMAN

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Introduction

The purpose of this section is to set down the latest information on chemical methods of dealing with the common pest species of fruit flies in Australia. The only practicable non-chemical method, the sterile insect release method, is described elsewhere in this publication.

Three terms relating to the purpose and intensity of attacks on fruit flies are used throughout this section and need to be defined:

(i) *Control*: This term is used to describe procedures aimed directly at the protection of individual commercial or domestic orchards. Such local procedures usually have very little effect on the breeding population of fruit flies inhabiting the general area.

(ii) *Suppression*: Measures aimed at an entire breeding population (e.g. in a relatively isolated country town) or at a substantial segment of a very large population. The object is to reduce the level of fruit infestation below the economic threshold, in an orchard area, or below the "nuisance threshold" in an urban area. Wide-scale suppression programmes are usually appropriate only in areas where fly is likely to recur each year and therefore they must be normally repeated in successive fruiting seasons.

(iii) *Eradication*: Measures aimed at the destruction of every individual in a breeding population. Usually eradication is undertaken only in areas where the subject species is not endemic, and then only if it is expected that the area can be protected against re-establishment for an acceptable period.

In Australia control procedures appropriate to each State are published by the respective Departments of Agriculture and it is not proposed to discuss them in detail here. In recent years there has been a pronounced reduction in the use of cover sprays with broad spectrum residual insecticides (especially

since DDT fell into disfavour) and a growing reliance on either systemic insecticides or attractants.

Usually, in single orchards or in backyard situations, the main problem is to protect the ripening fruit against gravid fertilised females which fly in from surrounding areas. Attractants are rarely efficient enough to ensure that all these females are killed before some eggs are laid and for this reason many small growers, especially those in severely infested districts, prefer to use insecticides such an fenthion or dimethoate, which have some systemic effect. When thoroughly applied as cover sprays (on fruit as well as foliage) these materials not only kill all adult flies in an orchard and offer some residual protection against them, but also kill larvae which may already be present in the fruit. Their main disadvantages are their extremely deleterious effects on most beneficial insects and their relatively high mammalian toxicities, which necessitate strict precautions during application and a time delay between final spray and consumption.

For suppression and eradication we rely heavily on attractants, although cover sprays with fenthion are sometimes used in a supplementary role. Fruit flies have long been recognised as peculiarly susceptible to attractants and a great variety of substances have been tested against them over the years. It was not until the protein lures were developed in the early 1950's, however, (Steiner, 1952) that attractant/insecticide systems began to compare favourably, in effectiveness, with cover sprays of long-lasting insecticides such as DDT. Protein hydrolysate-insecticide formulations are now used against most species of pest tephritids throughout the world. A most important feature is that they can be used in a way which reduces to a very low level their contribution to the insecticide load of the environment and their impact on non-target organisms.

Attractants of a different type, the specific male lures, have so far found their greatest usefulness in detection systems. It is clear, however, that they also have an important role in suppression systems (Bateman *et al.*,1966b) and in eradication systems (Steiner *et al.*, 1965; Itô and Iwahashi, 1974; Bateman *et al.*,1973; Chambers *et al.*,1974).

(1) SUPPRESSION PROCEDURES

Protein bait sprays are particularly suitable for "area" application techniques aimed at the suppression of entire breeding populations. The protein/insecticide mixture can be applied as a cover spray (Steiner, 1952), a "mist" spray (Jones & Skepper, 1965) or as a "spot" spray (Bateman *et al.*,1966b). Cover sprays and mist sprays (while they may be desirable under some circumstances) have the common disadvantage that they react harshly against beneficial insects. I prefer the spot spray technique, because its effects are restricted almost entirely to the few species of insects which are strongly attracted to the protein solutions.

The spot spray technique depends on the simple concept that if "spots" or "squirts" of a protein/insecticide mixture, each about 100 ml in volume, are dispersed (on foliage) at sufficient density and with adequate uniformity over

the entire area occupied by a breeding population, then *all* of the winged adults in the population will be killed. Further, if the procedure is repeated a number of times, so that the time between applications is less than that required for the sexual maturation of newly emerged adults, then the population will be effectively destroyed.

In practice, if the infested area includes urban districts, or covers more than a few square kilometres, it is quite difficult to achieve the density and uniformity of protein/insecticide "spots" necessary to kill every adult fly. Frequently it is also difficult to encompass the *entire* area occupied by a large population. The result is that a residual breeding population usually manages to persist and hence we have suppression rather than eradication. In an urban area, reduction of the population to the point where the proportion of fruit infested is consistently below 10 per cent constitutes a satisfactory degree of success, since experience has shown that infestations of this order are below the nuisance level.

Observations on a population of *D. tryoni* inhabiting an orchard have indicated that "trivial" or "non-dispersive" movements of mature females as they search for food or oviposition sites, normally exceed 10 metres in a day. A grid of bait spots 15 metres apart should therefore be adequate to ensure that at least one spot is within the daily wandering range of each female. Such a grid would have approximately 50 spots per hectare (20 per acre). In an urban area with normally abundant vegetation, an average application rate of this order of density can be achieved by depositing spots of bait on foliage on *both* sides of all roads and laneways and in public parks, vacant allotments etc., at intervals of approximately six metres (20 feet). The resultant distribution of spots is far less uniform than the theoretical 15-metre grid, but the cost (in terms of time and labour) of increasing the uniformity would be excessive.

Bait spray applications of this kind can be applied most conveniently by means of power sprayers mounted on small utility trucks. A spray pump driven by a 2.25 kW (3 h.p.) petrol engine, capable of maintaining approximately 1378kPa (200 lbs. per sq. in.) pressure is adequate. It should be linked to a tank of at least 227 litre (50 gal.) capacity, fitted with some type of continuously operating agitator. The hand-piece should be a "quick-trigger" type, with a nozzle designed to produce a solid jet of liquid rather than a dispersed spray. Nozzle bore and pump pressure should be adjusted so that a single rapid depression of the trigger produces a "squirt" of about 100ml of solution.

A suitable formulation for the bait spray is 20 g protein "solids" + 10 g malathion (active ingredient) per litre of solution. An alternative insecticide is naled (Steiner, 1969) but I prefer malathion because not only does it have lower mammalian toxicity and longer residual activity, but recent experiments (Bateman, unpublished) have also shown that it is less repellent than naled (at least to *D. tryoni*) when mixed with protein solutions. Similar experiments have produced evidence that the attractancy of protein hydrolysates is reduced less by strong emulsifiable concentrates of malathion (103 per cent and 114 per cent Malathion*) than by comparable formulations of 25 per cent wettable powder.

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*Supplied by Mr. John Berryman, Cyanamid (Aust.) Ltd.

For adequate long term suppression of a population, bait sprays must be applied at regular intervals throughout the period of the year when flies are active. A yearly schedule of applications should be tailored to suit the local climatic pattern, with sprays at weekly intervals during the warmer period (particularly if this coincides with the major fruiting season), sprays every two weeks during periods when the risk is lower and no sprays during periods when the flies are largely inactive. Recent work indicates that in cooler southern regions *D. tryoni* females lose much of their attraction to hydrolysed protein lures as they become physiologically adapted to winter temperatures (Bateman, unpublished).

A typical yearly schedule for a "high-risk" area with a warm summer and an average summer rainfall (October to March) of say 500 mm, might be made up of a total of 23 sprays. It would commence with a group of six applications at two-weekly intervals between early September and mid November, aimed at destroying overwintering adults and preventing oviposition in the earliest fruits. This would be followed by about 15 sprays at weekly intervals from mid November to early March, covering the main summer fruiting period. Sprays could then revert to two-week intervals in autumn to reduce any survivors or immigrants from other areas before they become relatively inaccessible in overwintering sites.

The ease with which suppression can be achieved is related to the degree of stress being imposed on the population by the environment. A population thriving in a warm area with moderate or high rainfall will require more sprays per year and perhaps also a greater concentration of the active chemicals in each spray, than a population in a cool or dry area. Environmental moisture is of particular importance for *D. tryoni* (Bateman, 1967). A population of this species inhabiting an area where summer rainfall (October to March) is less than 180 mm (7 in.) is under considerable stress. It will succumb to suppression procedures much more readily than one which is inhabiting an area with summer rainfall above say 300 mm.

(2) ERADICATION PROCEDURES

Three major eradication techniques are available: (a) protein hydrolysate bait sprays, (b) male annihilation using specific male attractants, (c) the sterile insect release method (SIRM).

Only the protein-insecticide system is of *general* application—i.e. able to be used against any species at short notice. It is capable of eradicating small incipient outbreaks (e.g. such as those which occur fairly regularly in the metropolitan area of Adelaide) or larger established outbreaks such as the medfly invasion of Florida in 1956, which covered more than 3000 km^2 (Steiner *et al.*, 1961). At the present time this system must be regarded as our primary weapon for emergency eradication, since it is the only one which is available for immediate use against any species, in any situation.

As mentioned earlier, the male attractants are widely used in detection systems in areas which are exposed to the risk of invasions by fruit flies, but they have also been used quite effectively against certain species for

eradication by male annihilation. As a general rule, I favour their retention for detection purposes and for the assessment of the progress of suppression or eradication programmes based on protein/malathion or SIRM. However, if an infestation covers a particularly extensive area, or if it does not respond readily to a protein/malathion campaign, or perhaps if eradication is required more urgently than usual, (e.g. if the invader is established in an area where it threatens a prime fruit-growing district) then the male attractant can be committed as a supplementary eradication procedure. Under these circumstances, of course, a detection system based on the same male lure will become largely ineffectual, since the numbers of males trapped in the survey traps will no longer bear any relationship to the number of females present. Monitoring must therefore be done by fruit sampling or by cumbersome and inefficient liquid traps baited with lures which attract both sexes (e.g. protein hydrolysates).

D. dorsalis infestations are a special case where the protein/malathion system may not be the preferred initial form of attack. The attraction of methyl eugenol for males of this species is so extraordinarily high that it is tempting to rely on male annihilation alone for eradication. This in fact has been the policy adopted by the U.S. Department of Agriculture in recent years for dealing with outbreaks of *D. dorsalis* in Los Angeles (Chambers *et al.*, 1974) and it has been entirely successful. The situation might be different where an extensive established population of *D. dorsalis* is to be eradicated. In that case protein/malathion would probably be used to reduce females as well as males in known breeding populations in particularly favourable areas and this would be followed up with either male annihilation or the SIRM, or perhaps a combination of the two.

The SIRM would seem, at first sight, to be of little use for "emergency" type eradication programmes because of the time involved in establishing (or upgrading) breeding colonies and mass producing the immense number of individuals required. However, there may be circumstances (e.g. if an invading species is firmly established in deep rainforest or some other inaccessible area) in which SIRM is the only sensible weapon to use. Furthermore, it is likely that in the long term we will come to rely more and more on autocidal methods (including, perhaps, "genetic" methods as discussed by Whitten, 1971) because of their species selectivity and environmental acceptability. The establishment in a remote part of Australia of a multi-species rearing facility where economically important species can be continuously cultured and mass produced for release at short notice has already been suggested (Bateman and Hooper; 4th Meeting of Exotic fruit fly Working Party, Brisbane, 1976).

The eradication procedures discussed here can be applied either from the ground or from the air. The appropriate method in each specific instance will be determined primarily by the topography and vegetation of the site of the infestation and the total area involved. In an urban area, treatment from the ground is virtually mandatory in Australia; few communities would tolerate spraying from the air. Small outbreaks in rural areas may also be better treated from the ground because of the closer control obtainable over the distribution of insecticides. Application from the air would be far more appropriate against large infestations in extensive agricultural districts (e.g. in prime orcharding areas) or in sparsely settled rural districts and it may be the

only feasible method in areas with inaccessible vegetation or terrain (e.g. in rainforests or mountainous regions).

(A) The protein/malathion system of eradication

(i) *Ground applications*

The series of steps set out below is recommended for the eradication of relatively small outbreaks which have been detected in urban or general farming/orchard areas which are normally free of fly.

1. As soon as the first discovery is made (i.e. larvae in fruit or adults in traps) a circular area of approximately 4 km diameter with the outbreak at its centre should be proclaimed a "quarantine" area and the movement of fruit or soil out of it strictly prohibited.
2. A spraying team should be sent immediately to the point of initial discovery (the "outbreak centre") to commence an intensive spot-spray with protein/malathion. At least one squirt (approximately 100 ml) of the spray should be placed on each tree or shrub, with larger trees receiving proportionatley more. This extremely thorough application should be extended over a zone (called the "outbreak zone") of about 400 metres diameter surrounding the outbreak centre. It should be done twice per week for the first six weeks and continued at that rate as long as flies continue to be found within that zone. When flies cease to appear, this very thorough spraying in the outbreak zone should be reduced to once per week and continued at that rate until at least 12 weeks have elapsed since the last live individual was seen.
3. As soon as possible after the initial discovery, spot-spraying with protein/malathion should also be commenced at the outer edge of the proclaimed quarantine area and extended inwards as far as the periphery of the outbreak zone. (Note that this is "eradication" spot-spraying and the desired density of spots is approximately 100 per ha. as opposed to 50 per ha. for "suppression" spot-spraying. It is possible, however, that such a high density of spots may not be feasible in built-up areas because of lack of foliage.) This spraying of the "outer zone" (i.e. the area outside the outbreak zone) should be repeated at weekly intervals until 12 weeks have elapsed since the last live fly was seen.
4. All fallen hosts should be collected from the outbreak zone and destroyed, preferably with heat. Very ripe hosts can also be taken from the trees and vines at this time, but green and ripening fruit should be allowed to remain. Complete stripping of fruit must be avoided (especially in the outbreak zone) because it will result in the migration to other areas of any adult flies which may be present.
5. A survey should be commenced immediately throughout the proclaimed quarantine area and in surrounding districts with the object of delineating the extent of the infestation. Additional male lure traps should be distributed and if possible should be supplemented with McPhail type traps (invaginated glass or plastic) or

the more efficient Nakagawa type (Nakagawa *et al.*, 1975) baited with protein hydrolysate (1.5 per cent protein solids in aqueous solution). This is important because trapped females can yield useful information about the age and progress of an outbreak. If skilled fruit inspectors are available they should search for larvae in ripe fruit and a publicity campaign should be initiated to enlist the help of the public in locating any additional outbreak centres. If new outbreak centres are discoverd, the extent of the quarantine area must be continually adjusted to maintain the surrounding spot-sprayed buffer area of 2 km radius. Each new outbreak centre should be treated in exactly the same way as the first—especially with respect to the extremely intensive spraying within the outbreak zone.

6. The entire programme should be continued for 12 weeks after the last live fly (larva in fruit or adult in trap) is seen, if a good male attractant is available, or for 18 weeks (3 generations) if detection depends on less efficient lures or fruit sampling.

This system was adopted by the South Australian Department of Agriculture in 1975 as a replacement for the "fenthion cover spray" technique and it has now been used quite successfully against numerous outbreaks of Queensland fruit fly. Its record of effectiveness against Medfly outbreaks is not as convincing and limited cover sprays of fenthion have been used in certain areas as a supplementary treatment. The technique has also been accepted by the Victorian Department of Agriculture in recent years as their standard method of eradication (O'Loughlin, 1975). In both States it has considerably reduced the costs of eradication and in South Australia it has also removed the objections of militant environmentalist groups, who were strongly opposed to fenthion cover sprays.

(ii) *Aerial applications*

Protein/malathion bait sprays are well suited to application from the air, provided care is taken to avoid human habitations. Because of the spraying technique used, the malathion is unlikely to affect humans even if they are exposed to it, but some pets such as fish or caged birds may suffer. In addition, certain types of car paints are susceptible to damage (Ohinata & Steiner, 1967). The protein solution is harmless to vegetation provided a type with low salinity is chosen. Preparations with salinities even as low as 6 per cent may cause damage to sensitive foliage, especially in tropical areas (R. Drew, personal communication). In using protein bait spray from the air there is a strong temptation to adopt a "cover spray" approach, in order to maximise the impact on the target fruit fly species. However, the material is a good attractant—it will certainly lure individuals from at least five metres or so and probably from much greater distances in time—and cover spraying, therefore, is wasteful of aircraft time and spray materials. It is also quite undesirable because of its effects on non-target organisms. A primary goal of an aerial spray programme should be the placement of a comprehensive mosaic of bait swathes over the entire infested area while at the same time leaving ample unsprayed places for the survival of beneficial and other non-target species. The following suggestions are intended as a guide towards an effective procedure:—

1. Use a high viscosity spray mixture by mixing malathion concentrate directly into the hydrolysed protein solution without adding water. This technique was suggested by Steiner (1969) and has been used successfully in many parts of the world. I recommend two parts protein (i.e. protein solids) to one part malathion (active ingredient). Steiner recommended technical malathion, but a small amount of emulsifier (5-10 per cent w/v) may help to "hold" the solution. A mechanical mixer and very efficient agitators in storage and spray vats are necessary.
2. Increase droplet size as much as possible by using wide bore spray nozzles and removing the swirl plates. Large droplets of viscous bait are more attractive to fruit flies, longer lasting and less hazardous to non-target organisms. They also permit spraying to be done from a greater (and therefore safer) height without many of the problems associated with evaporation and excessive wind drift.
3. Apply the spray in single swathes leaving 10 metre unsprayed strips between them and spray directly up or down-wind to reduce lateral drift. This technique makes full use of the attractant powers of the bait and saves both materials and aircraft time.

As with ground spraying, the timing of the applications should be determined according to the weather. In warm conditions when ovarian development is rapid, weekly spraying will be necessary. Ten-day or two-weekly applications will suffice in cooler conditions. Re-spraying will be required if more than 12 mm of rain falls within a few hours after application. When dealing with a "discrete" outbreak in an area normally free of flies, a buffer area of at least 2 km surrounding the known infested zone should also be sprayed. Applications should be continued for two or three generation times, depending on the efficiency of the detection system available.

(B) The use of male attractants in eradication systems

Because they are available for only a limited number of pest species of fruit flies (none of the temperate species respond to male lures) and because their primary attraction is for males only, the male attractants are of far less general usefulness in eradication systems than the protein attractants. The latter are effective for both sexes of all species so far tested. With existing technology the male lures are of little use for ordinary control purposes (i.e. the protection of individual orchards in an area where flies are endemic) because they provide no defence against itinerant gravid females. They are more efficient when used over the full extent of an isolated population, but must be used at a very high density of baits per unit area if they are to reduce the population of males so drastically that all or most of the females remain unmated. Bateman *et al.* (1966a) found only minimal evidence of suppression of *D. tryoni* in an urban area in which cue-lure baits had been distributed at a rate of only one per hectare. Significant suppression was achieved when the rate was increased to 8-9 per hectare, but only when the target populations were already under considerable environmental stress (Bateman *et al.*, 1966b). However, methyl eugenol, the most efficient of the lures at present available,

had been used to eradicate island populations of *D. dorsalis* by Steiner *et al.* (1965). It has also been used in recent years to eradicate small "incipient" outbreaks of *D. dorsalis* in California (Chambers *et al.*,1974).

Cue-lure (and its hydroxy derivative sometimes known as Willison's lure) is effective for two of the major tropical pest species, *D. cucurbitae* and *D. tryoni*. Its reduced efficiency relative to methyl eugenol may be partly due to its relatively poor attractancy for juvenile males. Iwahashi (personal communication) has found that the percentage of males of *D. cucurbitae* coming to cue-lure increases with age in sigmoid fashion, until a maximum of 80 per cent is reached at about 14 days—i.e. approximately the average age at sexual maturity. Thus in a field situation, some individuals are likely to achieve sexual maturity and have an opportunity to mate before their response to cue-lure is fully expressed. As far as I am aware, male annihilation with cue-lure has not yet been used successfully for the eradication of a population, without simultaneous use of a supplementary system.

The possibility that persistent and widespread use of male lure might lead to the development of resistant or "insensitive" strains has been raised by Itô and Iwahashi (1974). In laboratory selection experiments they have shown that this is theoretically possible, but suggestions that such a strain actually developed in the field during experiments on the eradication of *D. dorsalis* in the southern islands of Japan (Itô and Iwahashi, 1974) have not yet been fully substantiated.

Both methyl eugenol and cue-lure are extremely long-lasting, under suitable conditions. Cue-lure is probably superior in this respect and in mixtures with malathion has been shown to remain active after more than two years of continuous exposure. Because of their durability, these lures are normally applied absorbed into some type of long-lasting solid carrier which can be distributed throughout an infested area. Blocks of porous fibre-board are ideal, but other absorbent materials such as cotton dental wicks and cigarette filter tips (R. T. Cunningham, personal communication) have also been used. Pieces of thick cotton string ("cordelitos") make excellent carriers (Bateman *et al.*, 1973). They absorb the chemicals extremely well and have the advantage that in appropriate lengths (say 25-30 cm) they are very easily applied from the ground by tying to vegetation. They can also be dropped from the air, in which case many catch in the branches of trees where they remain effective for longer periods than when lying on the ground, where they may become covered with mud or leaves.

Cordelitos made from twisted 6-ply caulking cotton have ideal characteristics for this purpose and are relatively cheap (0.6-0.8 cents per 30 cm length at 1978 prices). Malathion is a suitable insecticide and a 1:1 mixture of the lure and technical malathion is an effective formulation. The mixture can be absorbed directly into the carrier, or ethyl alcohol can be used as a solvent to assist uniform dispersion of the active ingredients. This can be done by soaking the carriers in a solution containing the active ingredients at the rate of their required weights (per carrier) in sufficient ethanol to saturate one carrier. On exposure in the field the ethanol will quickly evaporate, leaving the appropriate lure/insecticide mixture dispersed evenly throughout the carrier. Cordelitos 30 cm long prepared in this way, impregnated with 2 g cue-lure and

2 g malathion, have been found to be highly effective (Bateman *et al.*, 1973) and to retain some ability to attract and kill for more than six months. At 1978 prices they would cost approximately four cents (Aust.) each (materials only).

Cordelitos similar to those described above but impregnated with methyl eugenol and malathion (3:1) have been tested by Cunningham (personal communication) for use against *D. dorsalis*. Cunningham found them satisfactory in both performance and lasting qualities but recommends 6 g methyl eugenol per 30 cm cordelito.

A technique involving the blending of the male lures with thixotropic materials (e.g. Thixin E^R) has also been developed in Hawaii (Ohinata *et al.*, 1971) and has been used successfully (e.g. in eradication of *D. dorsalis* in Los Angeles; W. Routhier, personal communication). The thixotrope + lure + insecticide forms a highly viscous deposit as it thickens, which adheres well to solid surfaces (e.g. foliage) and retains its attracting and killing properties for considerable periods.

(C) Eradication with combined treatments—protein hydrolysates plus male attractants

Perhaps the most powerful technique for the eradication of tephritid populations is the simultaneous use of the protein/malathion system and male annihilation. In experiments on isolated populations of *D. tryoni* in western New South Wales (Bateman *et al.*, 1966b) it was found that this "double attack" method was consistently more effective than either technique applied alone. The reason for this may lie in the behaviour of virgin females. When a breeding population is attacked with the protein/malathion system, the total number of adults will be progressively reduced, but the ratio of males to females will remain approximately constant. However, if male attractant baits are also added to the environment at high density (say 30 per hectare), the number of males will become extremely small relative to the number of females and may even approach zero. It is well established (Steiner *et al.*, 1965; Fletcher, 1969; Nakagawa *et al.*, 1970; Nadel & Peleg, 1965) that under these circumstances virgin females (and perhaps also "sperm depleted" older females—Steiner *et al.*, 1965) become attracted to the male lure baits. The mortality of the young females will therefore be increased and the decline of the population will be considerably accelerated.

An opportunity to test the capacity of the combined technique to eradicate a field population arose in 1971 when a thriving infestation of Queensland fruit fly was discovered on Easter Island, an isolated oceanic island about midway between Tahiti and the west coast of South America. The threat to Chile and indeed to the entire South American continent, was such that the Chilean government asked Australia for assistance in an urgent eradication campaign. Rapid and certain eradication was essential and it was achieved with (i) protein/malathion, applied from the ground (as a spot spray) in inhabited areas and from the air elsewhere and (ii) 25 cm cordelitos loaded with cue-lure and malathion, also applied from the ground and from the air, at an average density of 30 per hectare of standing vegetation. The population of *D. tryoni*, which was extremely large and vigorous prior to the commencement

of the campaign, collapsed dramatically and disappeared within five weeks (Bateman *et al.*, 1973). The island remained free of fruit flies for almost two years, but then *D. tryoni* was again introduced (from Tahiti). Again it was eradicated, but only after a long and very difficult campaign. The same techniques were used, but on the second occasion no aircraft was available and all treatments were applied from the ground.

(3) DETECTION SYSTEMS

Early detection of incipient outbreaks is one of the most crucial aspects of fruit fly eradication. If a new infestation can be detected in its early stages and attacked with the full weight of modern techniques, rapid eradication can be virtually guaranteed. Failure to detect an outbreak for more than one or two generations, or failure to attack vigorously and swiftly once an outbreak is detected, can result in a disproportionate escalation of the problem.

An efficient detection system is essential in any area where a determined effort is being made to prevent fruit flies from becoming established. Extensive systems are permanently maintained in many parts of the world, especially in California, Florida and other parts of the southern United States, where there is a perpetual threat of introduction of medfly and Mexican fruit fly (*Anastrepha ludens* (Loew)) from Central America and both oriental fruit fly and melon fly from Asia and the Pacific. In Australia, detection systems are used widely in southern and south-eastern parts of the continent, to guard against the introduction to those areas, of Queensland fruit fly from eastern Australia and medfly from Western Australia. In addition, a discontinuous but vitally important detection line has been installed along parts of the northern coastline, including the Kimberly region of Western Australia, the north coast of the Northern Territory and the Cape York-Torres Strait area of Queensland. The purpose of this is to provide some degree of early warning in the event of invasion by species such as *D. dorsalis* and *D. cucurbitae* which now occur in islands immediately to the north of Australia.

Current detection systems rely almost exclusively on the attraction of adult flies to traps. The only feasible alternative, searching for larvae in fruit, is too time consuming and inefficient except under special circumstances.

The most widely used lures for adults of the tropical fruit flies are the synthetic male lures and solutions of hydrolysed proteins. Liquid lures based on ammonium salts are still used in some areas, but protein solutions seem at least as effective for most species and are more convenient to prepare and use. Bright colours, especially fluorescent yellows, are surprisingly effective attractants for many of the temperate species. Sex pheromones, also are known to exist, especially in tropical species, but none has yet been developed as a useful lure.

The principal male lures and the species which respond to them have been discussed in Section I (7). These lures are extremely well suited for use in detection systems since they are highly effective, have good species specificity and can be used in simple traps which require very little servicing. Their effective life is quite variable. Cue-lure which is the most stable of the three,

retains sone attractancy for as long as three years when absorbed into fibreboard and protected from direct weathering by sun and rain (A. H. Friend, personal communication). Methyl eugenol exposed in a similar manner maintained undiminished effectiveness for up to seven months (Cunningham and Steiner, 1972) and retained some attractancy for two years (R. T. Cunningham, personal communication). Trimedlure has a much shorter residual effectiveness and normally lasts only a few weeks.

The useful life of the lures can be prolonged in various ways. Glycerides of lard have been used as "extenders" with some success (Hart *et al.*, 1966; Cunningham *et al.*, 1970) and thixotropic compounds such as Thixin E^R have also proved effective (Ohinata *et al.*, 1971). More recently Keiser *et al.* (1976) have tested several of the fixatives commonly used in the perfume industry and have found that one of these, Phantolid, is especially promising. In field tests, blends of Phantolid and trimedlure retained some attractiveness for as long as four months, relative to a few weeks for trimedlure alone (I. Keiser, personal communication). Microencapsulation also significantly extends the residual effectiveness of the lures. Methyl eugenol, cue-lure and trimedlure have all been encapsulated successfully and Keiser *et al.* (1976) found that encapsulated methyl eugenol, at least, lasted significantly longer than Thixin blends of the same lure.

It seems to be characteristic of the species that are attracted to either methyl eugenol or cue-lure that the males feed avidly on the male lures. This means that they can be killed rapidly with an insecticide which has contact or stomach poison properties (e.g. malathion or naled). Trimedlure, however, is not readily eaten by medfly males and an insecticide with fumigant action (e.g. dichlorvos) is preferable. It can either be mixed with the lure or when a relatively enclosed trap is being used, it can be added separately.

Methyl eugenol is by far the most effective of the three attractants. Steiner (1969) states that it will draw *D. dorsalis* males from approximately 1 km. He also considers that methyl eugenol traps at a density of one per km^2 are roughly equivalent to trimedlure traps at 20 per km^2. The attraction of cue-lure to either melon fly or Queensland fruit fly is between these extremes, probably towards the trimedlure end of the scale.

The detection system for *D. dorsalis* adopted by U.S. authorities in Southern California is a 1.5 km grid of methyl eugenol traps (Chambers *et al.*, 1974). In Los Angeles such a grid detected incipient outbreaks of *D. dorsalis* on five occasions in the 12 years 1961-70. Each of these outbreaks was small enough, at the time of detection, for eradication to be achieved relatively easily, which indicates that the detection system is reasonably efficient.

Detection of *D. tryoni* is more difficult and the generally accepted standard in Australia is a grid of cue-lure traps at 400 m intervals. The efficiency of such a system for the detection of *D. tryoni* has been measured by Monro and Richardson (1969) who recaptured 4.1 per cent of newly emerged males and 9.0 per cent of mature males released in the centre of a square 400 m grid covering 2.5 km^2.

The implication of these results is that a population of *D. tryoni* which exceeded a density of about five males per km^2 (a very low density indeed for a breeding population of this species) would have a high probability of

detection in a grid of this kind. The South Australian Department of Agriculture has operated a 400 m grid of cue-lure traps in the suburbs of Adelaide since 1960. Male *D. tryoni* were found in those traps in 14 of the 17 years from 1960 to 1976. Larvae in fruit were found in only six of those years. A similar 400 m grid of trimedlure traps has been operated simultaneously in Adelaide and male medfly have been detected on five occasions. Medfly larvae in fruit were also found on five occasions. With both species the trapped males and the larval infestations were not always related (P. Madge, personal communication).

Detection systems using liquid lures are cumbersome and difficult to maintain and are considerably less efficient than systems using male attractants. The normal trap is the invaginated glass "McPhail" type (Baker *et al.*, 1944) which is expensive to purchase, difficult to transport and easily broken. Nakagawa *et al.* (1975), however, have recently developed a plastic trap which certainly overcomes some of these problems and which has proved to be a suitable alternative to the McPhail trap.

Liquid traps are usually baited with the same protein hydrolysates that are used in bait spray operations. Solutions containing as little as 1.5 per cent protein solids are adequate. Insecticides are not used in the McPhail trap since the trapped flies drown in the protein solutions, but Nakagawa *et al.* (1975) recommend that a piece of dichlorvos plastic strip be suspended in their trap to provide a fumigant action.

Liquid lures are used in detection systems when the threatening species do not respond to any of the male attractants. Examples of major pest species which fall into this category include Mexican fly (*Anastrepha ludens* (Loew)), Caribbean fly (*A. suspensa* (Loew)) and South American fruit fly (*A. fraterculus* (Wiedemann)) from the American region; Olive fly(*D. oleae* (Gmelin)) from the Mediterranean region, and the *Rhagoletis* species from temperate Europe and North America. In Australia the only serious pest species for which we have no male lures are *D. jarvisi* and *D. cucumis* (See Section I (7)).

Liquid traps are also valuable for monitoring the progress of suppression or eradication campaigns. Information from trapped females on ovarian maturation, presence or absence of "yellow bodies" in oviducts (denoting whether or not eggs have been laid) and the presence or absence of sperm in spermathecae, can provide early warning of the development of "hot spots" in a treated area and perhaps suggest necessary modifications in the conduct of a campaign.

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SECTION IV FRUIT FLY COLLECTING

R. A. I. DREW

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Introduction

Fruit flies are usually collected by lure trapping (Steiner, 1957; Farias and Nakagawa, 1970; Drew, 1974), by rearing from infested hosts (May, 1953, 1957, 1960) and occasionally by individual captures (Sonleitner and Bateman, 1963; Bateman and Sonleitner, 1967). Clearly the purpose of the particular project and the resources available determine the nature and extent of the collection to be undertaken. Consideration must be given to factors such as the species to be collected, the prevailing environmental conditions, population density, presence of predators which devour insects in traps, accessibility of the collection area and the availability of host fruit.

The current section is based on extensive experience in the collection of fruit flies in Australia and the South West Pacific Area. It is presented as a practical guide to those who may become involved in similar programmes.

(1) TRAP TYPES

(a) *STEINER TRAP*—The Steiner trap (Steiner, 1957) essentially consists of a horizontal cylinder with a large opening at each end. A mixture of attractant and insecticide is impregnated into a cotton wick suspended within the trap. A slight taper in the main cylinder allows the traps to be nested together into a small volume for transport.

Comments—Significant features are the large surface area provided by the wick for evaporation of the attractant and the large open area at each end which facilitates distribution of the attractant vapour. Good catches of flies are achieved under most climatic conditions and population densities. Because of its relatively large volume it is particularly effective in the tropical and sub-tropical areas where large numbers of flies are often taken in short periods of time. When baited with dichlorvos insecticide, it successfully kills large insect predators which otherwise enter the trap and consume the flies.

Queensland Modification (Figure 56)

A modification of the Steiner trap has been developed at the Department of Primary Industries laboratories in Brisbane and now includes improvements suggested as a result of field testing by Dr. G. B. Monteith, Queensland Museum (previously of the Department of Entomology, University of Queensland). The modified trap has a soft clip-on lid and a readily accessible and removable wick suspension mechanism.

Comments—Field experiments in Queensland have shown that two features of the original Steiner trap are important, i.e., more flies are collected in the Steiner trap when funnels are placed at each opening and when one half of each opening is covered with gauze. The modified trap is relatively inexpensive and can be assembled in the laboratory with a minimum of labour. Samples can be forwarded upon request.

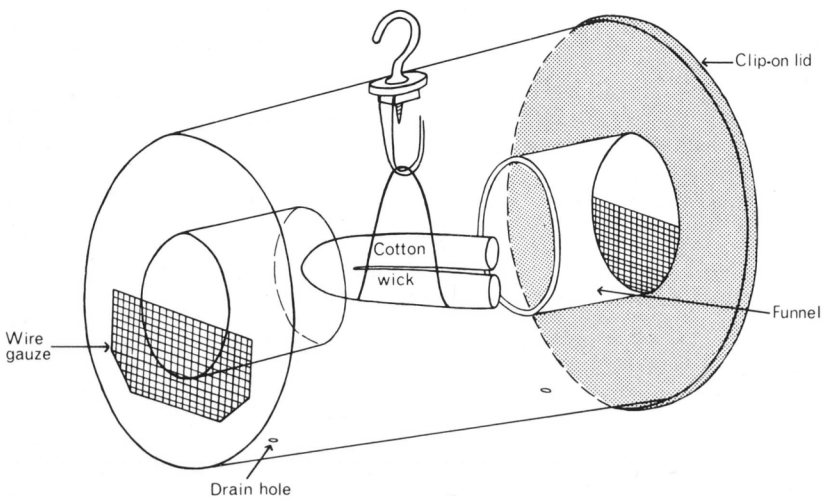


Figure 56—Steiner trap (Queensland modification)

(b) *ISRAELI TRAP* (Figure 57)—This trap is designed on the same basic principle as the Steiner Trap, being shaped as a horizontal cylinder. Approximately 7 ml of the attractant/insecticide mixture is held in a small plastic container positioned between two ribs on the floor of the trap. The attractant vapour escapes from the container via a pore 2 mm in diameter and this, together with the small opening (6 mm in diameter) at each end of the trap, allows emission of only a small amount of attractant vapour from the trap.

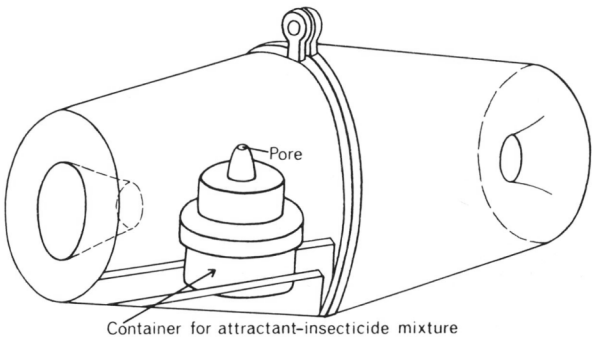


Figure 57—Israeli trap

Comments—This trap has higher efficiency than the Steiner trap for *C. capitata* but lower efficiency for *Dacus* species. The smaller openings would probably exclude some of the larger predatory insects, but the smaller volume of the trap would not accommodate some of the larger catches experienced in tropical areas. This trap is easily transported in large numbers.

(c) *BATEMAN TRAP* (Figure 58)—This trap was developed by M. A. Bateman, Division of Entomology, C.S.I.R.O., Sydney. The body of the trap consists of two primary components—(i) a plastic cannister which acts as a hood over (ii) a yellow plastic funnel. A receptacle for holding collected flies is made from soft plastic tubing and placed on the stem of the funnel. The attractant/insecticide mixture is placed on a cotton wick or fibre-board block which is suspended within the hood of the trap.

Comments—The most important aspect of the design of this trap is that it utilises two characteristics of fruit fly behaviour apart from attraction to the lure; that of negative geotropism (i.e. the flies walk vertically into the trap) and a visual response to the yellow colour. This trap could prove more suitable in the temperate areas where there are fewer problems with predatory Arthropods. In a field test in a tropical area, large crickets became lodged in the neck of the funnel and spiders spun webs across the neck, preventing the flies from falling into the receptacle below. This receptacle is removable and so provides a quick method of removing the flies, i.e. simply by taking off and stoppering the receptacle containing the flies and replacing it with a new one. This trap is more difficult to recharge than in the modified Steiner trap and would have to be dismantled in order to transport in the smallest possible volume. It can be assembled in the laboratory as readily as the modified Steiner trap and for a similar cost of materials. The Steiner trap (Queensland modification) caught significantly more male flies than the Bateman trap in an experiment designed to compare their efficiency (Hooper and Drew, 1978).

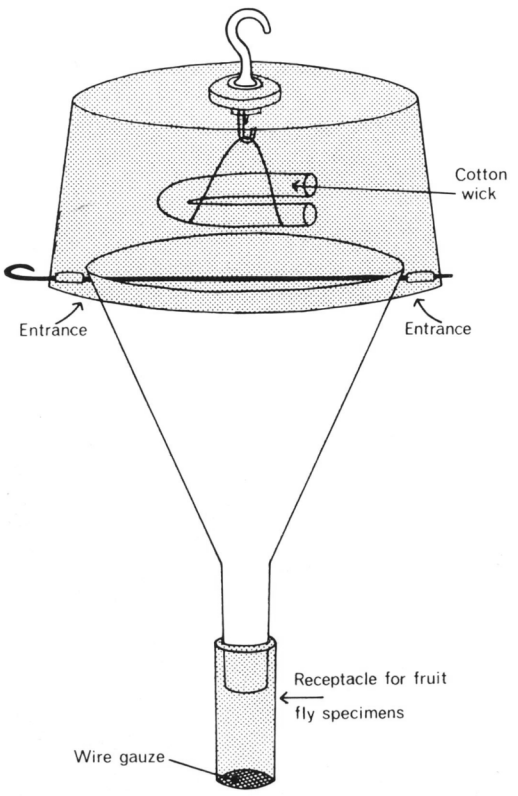


Figure 58—Bateman trap

(d) *JACKSON TRAP or STICKY TRAP*—Harris *et al.* (1971) experimented with a variety of sticky traps. Basically the traps consist of either a cardboard container folded flat for transportation and expanded into a cylinder open at two opposite ends when in use, or of various shapes of flat cardboard suspended on a string. The inside surface is lined with a non-drying adhesive which traps the flies when they approach the cotton wick charged with attractant. An alternative is to insert a removable cardboard tray coated with non-drying adhesive. No insecticide is required.

Comments—Flies collected in this trap are of little value for permanent collection purposes due to damage by the adhesive, but are in good enough condition for identification. The sticky traps have the advantages of being cheap, easy to use and the simplest of all to transport. They would probably be the most convenient trap for quarantine purposes around airports and towns but do not weather well enough for survey work under wet tropical conditions. A commercially available sticky trap is the Sectar 1 trap, manufactured by the 3M Corporation, St. Paul, Minnesota 55101, U.S.A. In this trap, the adhesive is impregnated with the attractant.

(e) *McPHAIL TRAP* (Figure 59)—This is a glass or pastic flask-shaped trap with an invaginated entrance at the base. It measures approximately 140 mm high, 160 mm diameter across the widest line, with the entrance 45 mm in diameter. Nakagawa *et al.* (1975) designed a trap based on a gallon plastic tub as a substitute for the McPhail trap.
Comments—The McPhail trap was designed for use with liquid attractants such as fermenting fruit juice solutions and proteinaceous solutions. These lures attract both sexes of fruit flies and also species which do not respond to male lures. The McPhail trap is expensive and attracts only small numbers of flies compared with the male lure traps. It appears to be of limited value for survey and detection programmes.

The Nakagawa modification proved as effective as the McPhail trap for collecting *D. dorsalis* and *D. cucurbitae* but not for collecting *C. capitata.*

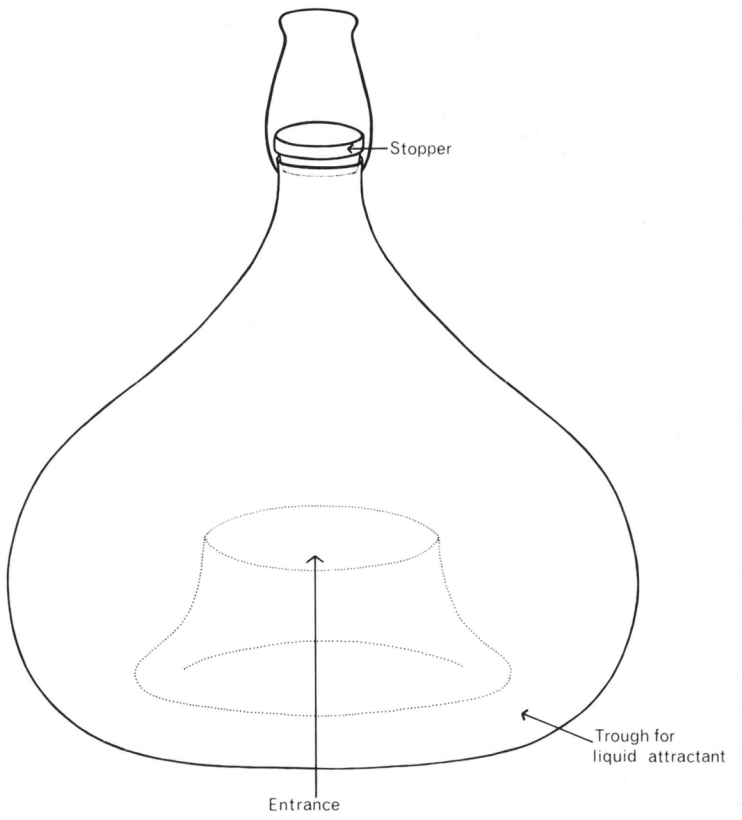


Figure 59—McPhail trap

(2) FRUIT FLY ATTRACTANTS

Attractants or lures have long been used in association with fruit fly traps. The first attractants were essentially food lures based on combinations of natural plant products, flavouring essences and ammonia (Perkins and Hines, 1934; Caldwell and May, 1943). Ammonia is a product of decomposing organic matter and probably represents a source of food. A major advantage of food lures is that both sexes of many species respond to them. May (1958) developed an effective food lure termed the orange-ammonia lure with which he carried out an extensive collecting programme throughout Queensland. The recipe for this lure is 280 g pulped orange, 25 g ammonium carbonate, 600 ml water and 1 g of mercuric chloride preservative. This mixture should be allowed to stand a minimum of 24 hours before use and will keep for several months. For use the stock solution is diluted with water at a ratio of 1 part to 10 parts of water and used in McPhail traps. This lure has proved valuable in trapping female specimens for ecological and taxonomic studies and in determining the optimum time to apply control measures in orchards.

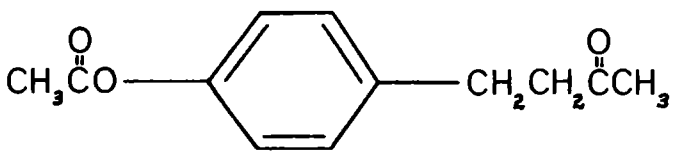
The most powerful attractants are chemicals which attract male tephritids and they can be referred to as parapheromones. However, the flies feed vigorously on cue-lure and methyl eugenol when attracted and in this regard they behave like a food lure. These parapheromones attract flies over larger distances than do the food lures. Beroza and Jacobson (1963) suggest distances up to 0.8 km in the case of methyl eugenol.

The male lures can be divided into three basic groups:
(a) *Cue-lure group*—cue-lure, anisylacetone, Willison's lure;
(b) *Methyl eugenol group*—citronella oil, huon pine oil, methyl eugenol;
(c) *Med-lure group*—siglure, med-lure, trimedlure.

Drew (1974) showed that in the South Pacific area the fruit fly species can be divided into two groups on the basis of the compounds to which they are attracted: (a) cue-lure group and (b) methyl eugenol group. It was found that closely related species all responded to the one attractant. No species from the South Pacific area was recorded as responding to the med-lure group.

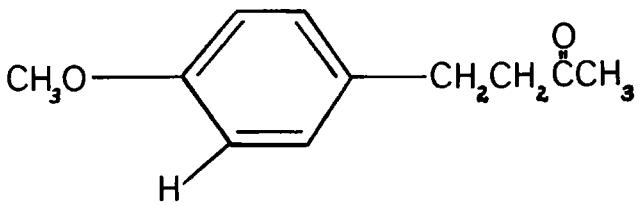
The chemical formulae of some of the attractants are as follows:—

Cue-lure: 4-(*p*-acetoxyphenyl)-2-butanone

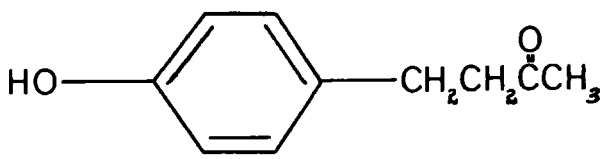


Cue-lure is the *p*-acetoxy derivative of benzylacetone. It attracts teneral specimens of melon fly in addition to mature specimens.

Anisylacetone: 4-(*p*-methoxyphenyl)-2-butanone

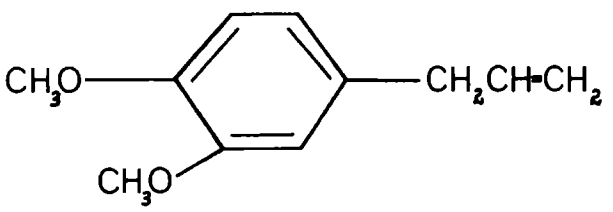


Willison's lure: 4-(*p*-hydroxyphenyl)-2-butanone

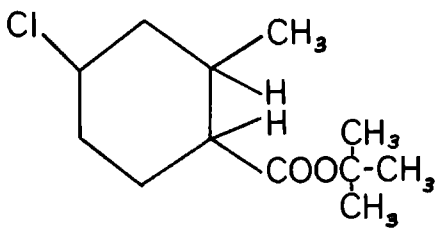


Willison's lure, cue-lure and anisylacetone are similar in molecular structure and are all ketoesters. The acetoxy derivative (cue-lure) is not very stable and is thought to be transformed to the hydroxy derivative (Willison's lure) as a result of hydrolytic degradation when exposed in the field.

Methyl eugenol: O-methyl eugenol (an ether)



Trimedlure: t-butyl-4 (or 5)-chloro-2-methyl cyclohexane carboxylate



Trimedlure is the best attractant available for the Mediterranean fruit fly. It exists in eight different isomeric forms and commercial preparations of the attractant are mixtures of these isomers.

The most readily available attractants are cue-lure, Willison's lure, methyl eugenol and trimedlure. Some suppliers of these attractants are as follows:—

Cue-lure	International Pheromones Ltd., Norway House, 21-24 Cockspur Street, London SWIY 5BZ. England.
Willison's lure	Union Carbide Australia, Sydney.
Methyl eugenol	Fritzsche, Dodge & Olcott Inc., 148 South Creek Road, Dee Why, Sydney, 2099 New South Wales, Australia.
Trimedlure	UOP Chemical Division, State Highway 17, East Rutherford, New Jersey, 07073, U.S.A.

When charging a trap with male attractant, a mixture of 4 ml attractant and 1 ml of 50 per cent w/v concentrate of malathion or dichlorvos has been found most suitable in Queensland. Malathion persists longer than dichlorvos, but when predacious insects enter the trap dichlorvos is more suitable because of its more rapid killing action.

Identification procedures can take a considerable amount of time when large numbers of flies are collected. Identifications can be expedited by keeping separate the flies that respond to each attractant. In setting the traps therefore, place only one attractant in a trap and avoid contamination with other attractants. The attractants impregnate the plastic and so it is best to use each trap for only one particular attractant throughout its period of use. Small quantities of attractant on the outside surface of traps frequently will attract flies and prevent them from entering the traps. Even minute amounts of attractant such as that carried on hands of personnel servicing the traps have been shown to cause contamination. It has been found valuable, therefore, to carry a plastic washbottle of ethanol to rinse hands after each trap is serviced. The removable wick mechanism in the Queensland Steiner trap has assisted in avoiding contamination during servicing of traps.

Trapping with male attractants is the best method for quarantine detection surveys and compounds are now available for attracting most major fruit fly pest species. It is important to note that some economic pest species of fruit fly do not respond to male attractants. The species with which we are most likely to be concerned in Australia and the attractants to which they respond, are listed in Section I (7). Also high concentrations of an attractant will often have a repellency action. This is the case with trimedlure (Beroza *et al.*, 1961).

(3) STRATEGY OF TRAP DISTRIBUTION FOR DETECTION PROGRAMMES IN QUEENSLAND

The optimum strategy for trap distribution will clearly depend on the purpose of the particular detection programme and on the nature and extent of available resources. Steiner (1969) estimated that for an effective programme for detection of oriental fruit fly, it is necessary to set approximately one methyl eugenol trap per km^2. For quarantine programmes in Queensland such a high trap density is impractical despite the high risk of introduction of exotic fruit fly species. The length of coastline to be surveyed is large and many areas are inaccessible during the wet spring-summer season each year. In Cape York trapping is therefore concentrated firstly at towns, settlements and areas known to be visited by people from outside the mainland and secondly in areas of rainforest along the eastern coast which have a large number of fruit fly host plants.

(4) PLACEMENT OF INDIVIDUAL TRAPS

Within the areas of concern the placement of individual traps is important. Traps are best set along wet gullies, water courses, endemic forests and where possible in known host fruit trees. Farias and Nakagawa (1970) showed that for maximum trap catches in a detection programme the traps should be set in host trees wherever possible. The traps should be hung in shady positions as high as is practicable. In tropical rainforest, captures of fruit flies in Steiner traps charged with cue-lure and methyl eugenol increased as the height of the trap above ground was increased. However, this same effect did not occur in open forest, a citrus orchard and suburban gardens (Hooper and Drew, 1979).

In many areas, particularly in the tropics, ants often pose a problem by entering the traps and eating the dead fruit flies. To counter this problem an insecticide or sticky barrier should be placed on the string supporting the trap. A good non-toxic sticky barrier is provided by using Bird Tanglefoot. This can be obtained from: The Tanglefoot Company, 314 Straight Ave., S.W., Grand Rapids, Michigan, 49504, U.S.A.

(5) REARING FROM INFESTED FRUIT

Rearing adults from infested fruit provides valuable information on distribution, hosts and seasonal activity. When flies are bred from field collected fruit they will die at an immature stage unless suitable conditions are provided. Such premature death makes identification of the specimens difficult and sometimes impossible. Colour characters on the thorax and abdomen, necessary for identification, are not developed until the fly is at least three to four days old.

Essential features in rearing are that collected fruit be held in a container which has a gauze cover to allow aeration. Pupae must be allowed to develop in a dry medium such as sawdust or sand and for efficient sieving of pupae the fruit juices must not wet the pupation medium. Emerging flies must have access to water and sugar for survival. After three to four days the flies can be collected, killed and prepared for taxonomic study.

(6) INDIVIDUAL CAPTURES

Some studies demand the capture of live individual fruit flies. Sonleitner and Bateman (1963) and Bateman and Sonleitner (1967) successfully collected *D. tryoni* adults for mark-recapture sampling of the population in an orchard, using sweep nets.

In the Department of Primary Industries two methods have been used to obtain gravid females (for isolining) and also live adults of both sexes (for cytology and gel electrophoresis).

Flies were either aspirated directly from leaves and fruit or they were attracted to Steiner traps containing pieces of sponge cloth (200 mm × 100 mm) soaked with protein hydrolysate, fresh orange or apple juice. Large numbers of both sexes were attracted and the flies fed on the juice in the sponge cloth and so remained in a healthy condition.

(7) PRESERVATION AND SHIPMENT OF SPECIMENS

Preservation of fruit fly specimens is of vital importance and appropriate steps must be taken as soon as the specimens are obtained. Specimens are often damaged in transit and by bacterial and fungal growth after collection. Such damage may render the fruit flies useless for identification, thus invalidating an entire detection programme.

Wherever possible, place flies in *glass* bottles or tubes, between two firm layers of cotton wool or soft tissue. Beneath the bottom layer of cotton wool, place a few crystals of thymol or chlorocresol preservative. Glass containers are recommended because these preservatives dissolve common plastics.

Liquid preservatives such as ethanol must not be used for adult fruit flies as these liquids dissolve out the body colours which are important taxonomic characters.

Inside the bottle or tube place a small label clearly marked with the following details of the specimens—district in which collected, date collected, collector's name, attractant used in trap and host fruit if specimens have been bred from larvae.

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(9) ACKNOWLEDGEMENTS

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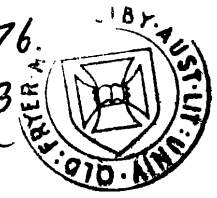

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STUDIES ON TROPICAL FRUIT FLIES
(DIPTERA: TEPHRITIDAE: DACINAE)

Volume III - Taxonomy (Part B) - (Publication No.38)

by

RICHARD ARTHUR IAN DREW

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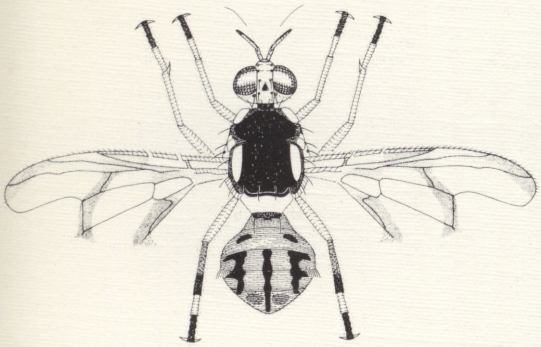

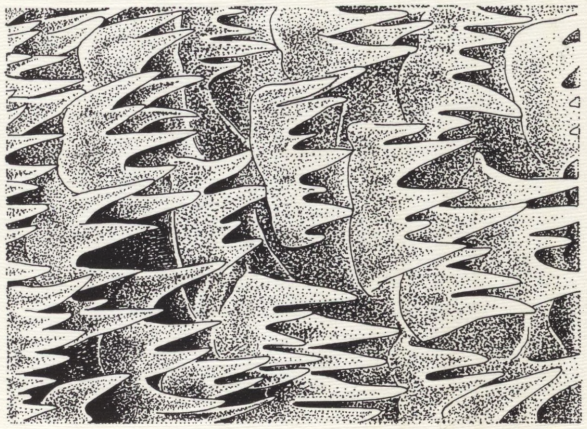

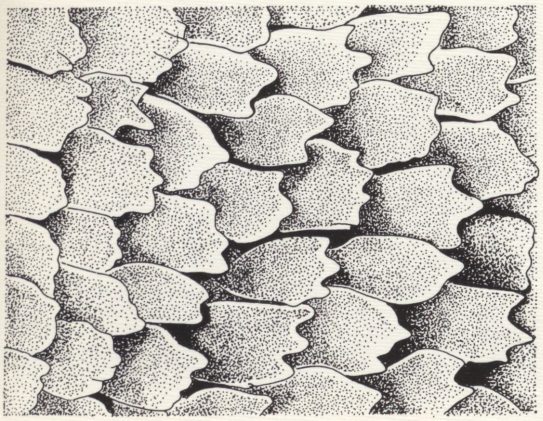

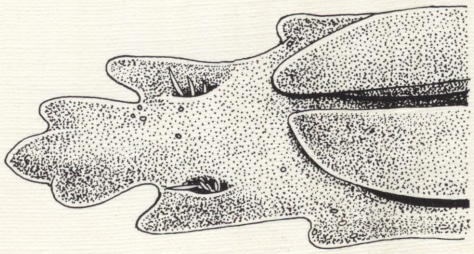

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ERRATA

Page 9. Line 9, paragraph 2, for (9) insert (10)

Page 20. Line 8, paragraph 3, for cross-vein insert crossvein

Page 31. for **Bactrocera) trivialis** insert **Bactrocera (Bactrocera) trivialis**

Page 43. Line 7, paragraph 4, for extremitiles insert extremities

Page 50. Insert: between **quadrisetosus** Drew

Page 51. Insert: between **varipes** Drew

Page 62. Insert: between **unifasciatus** Drew

Page 88. Under **Bactrocera (Bactrocera) pallida**, LOCATION OF TYPES should read

Lectotype ♀ (T. 5254) and paralectotype ♂ (T. 5253) In QM;

Page 102. Insert: between **atramentatus** Drew

Page 176. Insert: between **pagdeni** Drew

Insert: between **toxopeusi** Drew

Insert: between **visendus** May

Insert: between **visendus** Drew

Page 184. Last line of paragraph 1 should read

(1 male, 1 female and the sex of 1 cannot be determined).

Page 294. The reference Smith *et al.* should read

SMITH, E.S.C., CHIN, D., ALLWOOD, A.J. and COLLINS, S., 1988.

A revised host list of fruit flies (Diptera: Tephritidae) from the Northern Territory of Australia. *Qd J. agric. amin. Sci.* **45**: 19-28.

Page 295. **FIG. 1. Caption**, for A1 insert A_1

Page 521. **Line 14**, for ***trivalis*** insert *trivialis*

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THE TROPICAL FRUIT FLIES (DIPTERA: TEPHRITIDAE: DACINAE) OF THE AUSTRALASIAN AND OCEANIAN REGIONS

RICHARD A.I. DREW

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The Australasian and Oceanian Dacinae (290 species) are treated within a revised generic classification comprising only 2 genera, *Bactrocera* Macquart (with 21 subgenera) and *Dacus* Fabricius (with 4 subgenera). Seven new subgenera are described: *Heminotodacus*, *Hemiparatridacus*, *Hemisurstylus*, *Niuginidacus*, *Queenslandacus*, *Semicallantra*, *Trypetidacus*. 109 new species are described: *Bactrocera abdoaurantiaca*, *B. abdominingra*, *B. absidata*, *B. abundans*, *B. aemula*, *B. aithogaster*, *B. alampeta*, *B. anchitrichota*, *B. anfracta*, *B. angusticostata*, *B. angustifasciata*, *B. assita*, *B. atriliniellata*, *B. aurantiventer*, *B. batemani*, *B. buinensis*, *B. bullata*, *B. buloloensis*, *B. buvittata*, *B. caledoniensis*, *B. cinnamea*, *B. circamusae*, *B. citroides*, *B. commina*, *B. congener*, *B. consectorata*, *B. contermina*, *B. contigua*, *B. curreyi*, *B. dapsiles*, *B. daruensis*, *B. daula*, *B. diallagma*, *B. diospyri*, *B. dissidens*, *B. eximia*, *B. fergussoniensis*, *B. finitima*, *B. furfurosa*, *B. furvilineata*, *B. furvescens*, *B. fuscalata*, *B. honiarae*, *B. hypomelaina*, *B. inconstans*, *B. invisitata*, *B. ismayi*, *B. kelaena*, *B. laticosta*, *B. latilineata*, *B. latissima*, *B. macrovittata*, *B. melanogaster*, *B. melanoscutata*, *B. melanothoracica*, *B. mesonotaitha*, *B. mesonotochra*, *B. mimulus*, *B. morobiensis*, *B. morula*, *B. neocheesmanae*, *B. neopagdeni*, *B. nigrovittata*, *B. obfuscata*, *B. oblineata*, *B. ochracea*, *B. propedistincta*, *B. parafrauenfeldi*, *B. paramusae*, *B. paulula*, *B. penefurva*, *B. petila*, *B. pisinna*, *B. popondettiensis*, *B. prolixa*, *B. quasisilvicola*, *B. reclinata*, *B. repanda*, *B. retrorsa*, *B. rhabdota*, *B. robertsi*, *B. samoae*, *B. sandaracina*, *B. sepikae*, *B. singularis*, *B. surrufula*, *B. terminaliae*, *B. thistletoni*, *B. tinomiscii*, *B. turneri*, *B. unichromata*, *B. unilateralis*, *B. unilineata*, *B. unirufa*, *B. ustulata*, *Dacus alarifumidus*, *D. alulapictus*, *D. aquilus*, *D. badius*, *D. concolor*, *D. discors*, *D. dissimilis*, *D. impar*, *D. maprikensis*, *D. melanohumeralis*, *D. memnonius*, *D. nigriculus*, *D. palmerensis*, *D. secamoneae*. Three new names (*B. neonigrita*, *B. neopallescentis*, *B. trilineola*) are proposed for preoccupied ones. In the subgenus *Bactrocera*, 20 species complexes are defined. Five new synonymies are established: *Afrodacus flavinotus* May = *Bactrocera tigrina* (May), *Afrodacus furvus* May = *Bactrocera tigrina* (May), *Afrodacus mesoniger* May = *Bactrocera aberrans* (Hardy), *Neodacus strigifinis atritus* May = *Bactrocera strigifinis* (Walker), *Pacifodacus* Drew = *Sinodacus* Zia. Lectotypes are designated for 29 taxa: *Afrodacus brunneus* Perkins and May, *Asiadacus calophylli* Perkins and May, *Chaetodacus bancroftii* Tryon, *Chaetodacus barringtoniae* Tryon, *Chaetodacus bryoniae* Tryon, *Chaetodacus fagraea* Tryon, *Chaetodacus halfordiae* Tryon, *Chaetodacus humeralis* Perkins, *Chaetodacus musae* Tryon, *Chaetodacus tryoni* var. *sarcocephali* Tryon, *Dacus aequalis* Coquillett, *Dacus cucurbitae* Coquillett, *Dacus curvipennis* Froggatt, *Dacus kirki* Froggatt, *Dacus melanotus* Coquillett, *Dacus niger* Tryon, *Dacus ornatissimus* Froggatt, *Dacus passiflorae* Froggatt, *Dacus signatifer* Tryon, *Melanodacus satanellus* Hering, *Neodacus newmani* Perkins, *Strumeta bilineata* Perkins and May, *Strumeta cacuminata* Hering, *Strumeta endiandrae* Perkins and May, *Strumeta fuscatus* Perkins and May, *Strumeta lineata* Perkins, *Strumeta manskii* Perkins and May, *Strumeta melas* Perkins and May, *Strumeta pallidus* Perkins and May. Keys to genera, subgenera and species are provided. Information is given on location of type specimens, host plants, attractant records, geographic distribution and taxonomic relationships.

☐ *Fruit flies, Dacinae, Australasian, Oceanian, revision, generic classification, keys, host plants, attractants.*

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INTRODUCTION

Tropical fruit flies (Tephritidae: Dacinae) are major pests of fruit and vegetable crops throughout most of the tropical and subtropical world and their taxonomy, biology and control have been much researched. This study includes species east of Weber's Line (plus *B. timorensis* (Perkins) from Timor) to the Society Islands and south of the equator. In Oceania, Dacinae are absent from New Zealand and Norfolk Island. Following the introduction of pest species of fruit fly into various countries (e.g. *Dacus dorsalis* Hendel into Hawaii), plant quarantine authorities recognised the importance both of restricting transport of fresh fruits and vegetables within and between countries (Stout, 1982) and of accurate identification of species. In Australia, Plant Quarantine has maintained an extensive surveillance programme since 1976 for the detection of introduced exotic fruit flies, and surveys in neighbouring areas assessed their fruit fly fauna and the distribution and pest status of the species. Many resulting specimens and data were used in this study. Bateman (1972), Prokopy (1977) and Fletcher (1987) have reviewed the ecological information.

The first taxonomy on Australian fruit flies was the description of *Dacus expandens* Walker (1859) and *D. strigifinis* Walker (1861). The type specimens however, were collected at Aru Island and the Moluccas respectively. The earliest work within Australia was Froggatt's (1897) description of *D. tryoni*, followed by studies of French (1907) and Coquillett (1909). Tryon (1927) was the first to describe a series of species (9) within a generic classification using *Bactrocera* Macquart, *Chaetodacus* Bezzi and *Dacus* Fabricius. Perkins (1934, 1937, 1939) described a number of genera and species and included the Australian fauna in *Austrodacus* Perkins, *Callantra* Walker, *Chaetodacus* Bezzi, *Daculus* Speiser, *Melanodacus* Perkins, *Neodacus* Perkins and *Strumeta* Walker. Hering (1941a) described 1 species while Perkins and May (1949) described 9. Hardy's (1951) revision of Australian fruit flies treated 32 species in 2 genera (*Callantra* Walker and *Dacus* Fabricius) and 12 subgenera of *Dacus* (*Afrodacus* Bezzi, *Asiadacus* Perkins, *Austrodacus, Daculus, Gymnodacus* Munro, *Hemizeugodacus* Hardy, *Heterodaculus* Hardy, *Melanodacus, Neodacus, Paratridacus* Shiraki, *Strumeta, Zeugodacus* Hendel). May (1951, 1952, 1953, 1955, 1957b, 1962a, 1962b, 1963, 1965, 1967) described 26 species and placed the fauna in 12 genera (*Callantra* plus 11 of the subgenera of Hardy, 1951). Drew (1972a, 1972b, 1979) and Drew et al. (1981) described additional species in 2 genera (*Callantra* and *Dacus*). Drew and Hardy (1981), using electrophoretic and biological data, described 1 of the many sibling species now known to occur in the Dacinae.

For non-Australian Dacinae, Macquart (1835) and Walker (1859, 1860, 1861, 1862, 1864, 1865) published the first species from material collected on the voyages of Alfred Russel Wallace. Schiner (1868), Coquillett (1899, 1910), Broun (1905), Froggatt (1899, 1909, 1910), Hendel (1927b), Bezzi (1928) and Aubertin (1929) described additional species. Malloch (1931, 1932, 1938, 1939a, 1939b) presented species descriptions and keys to species in 4 subgenera of *Dacus* (*Callantra, Chaetodacus, Zeugodacus* and *Bactrocera*). Perkins (1939) published descriptions of genera and species and keys to species in 8 genera (*Apodacus* Perkins, *Daculus, Neodacus, Notodacus* Perkins, *Paradacus* Perkins, *Paratridacus, Strumeta* and Zeugodacus). Hering's (1938, 1939, 1941a, 1941b, 1941c, 1953) species descriptions and key to genera were followed by Hardy (1954, 1955a, 1970) who described new species and revised species in 3 subgenera (*Afrodacus, Gymnodacus* and *Neodacus*) of *Dacus*. May (1962a) described 1 species from Papua New Guinea. Drew's work (1968a, 1968b, 1971, 1972a, 1972b, 1973, 1974) culminated in a new generic/subgeneric classification based on characters not previously used (shape of male surstylus and abdominal sternum V).

Scanning electron microscopy of ovipositors has enabled the identification of many sibling species complexes. These, together with new species, are described within a revised generic/subgeneric classification.

Comparative data on the African Dacinae (D.L. Hancock, Zimbabwe, pers. comm.) have provided a new understanding of the supraspecific classification and relationships of African and Pacific species.

METHODS AND ABBREVIATIONS

Ovipositors for scanning were soaked in 10% potassium hydroxide, and dehydrated in ethyl alcohol solutions of increasing concentration before critical point drying. They were then coated with platinum and examined in a Philips 505 Scanning Electron Microscope.

Many fruit flies were collected in Steiner-type fruit fly traps baited with either cue lure or methyl eugenol. This provided valuable attractant records.

Host records were obtained by placing infested fruit on trays above fine sawdust in which mature

larvae pupated. Puparia were sieved from the sawdust and held in cages. The emerging adults were fed on sugar, protein hydrolysate and water until fully coloured and then killed, pinned and labelled.

For detailed definitions of morphological characters see Drew (1982). Nomenclature has been modified to conform with McAlpine (1981). The following abbreviations have been used:

Head — i.or. = inferior fronto-orbital bristles, s.or. = superior fronto-orbital bristles.

Thorax — mpl. = mesopleural bristles, npl. = notopleural bristles, pa. = postalar bristle, prsc. = prescutellar bristles, sa. = supra-alar bristle, sc. = scutellar bristles, scp. = scapular bristles.

Terminology of wing venation and cells is illustrated in Fig. 1.

Specimens studied have been deposited in or received on loan from many institutions whose names are abbreviated in the text as follows:

ANIC	Australian National Insect Collection, CSIRO, Canberra
APQS	Animal and Plant Quarantine Service, Guangzhou, China
BMNH	British Museum (Natural History), London, U.K.
BPBM	Bernice P. Bishop Museum, Honolulu, U.S.A.
DEI	Institut für Pfanzenschutzforschung (formerly Deutsches Entomologisches Institut), Kleinmachnow, Eberswalde, D.D.R.
DPI	Queensland Department of Primary Industries, Brisbane
DPI (PNG)	Department of Primary Industry, Port Moresby, P.N.G.
HNHM	Hungarian Natural History Museum, Budapest, Hungary
HUS	Entomological Institute, Hokkaido University, Sapporo, Japan
MNHN	Museum Nationale d'Histoire Naturelle, Paris, France
NHMV	Naturhistorisches Museum, Vienna, Austria
NMND	National Museum of Natural History, New Delhi, India
NMNH	National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A.
NMV	Museum of Victoria, Melbourne
NSW	New South Wales Department of Agriculture, Sydney
NTU	National Taiwan University, Taipei, Taiwan
QM	Queensland Museum, Brisbane
RNH	Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands
SAM	South Australian Museum, Adelaide
UH	University of Hawaii, Honolulu, U.S.A.
UQ	University of Queensland Insect Collection, Brisbane
WEI	Wau, Ecology Institute, Wau, P.N.G.
ZMB	Zoologisches Museum Berlin, Berlin, D.D.R.
ZMC	Zoological Museum Copenhagen, Copenhagen, Denmark

GENERIC AND SUBGENERIC CLASSIFICATION

The supraspecific classification of the subfamily Dacinae has remained in an unsettled state since the first species were described. Differences of opinion have occurred as to whether the fauna should be divided into either (a) a number of genera or (b) subgenera of 2 basic genera. Perkins (1937, 1939), Hering (1941c) and May (1963) arranged species in genera. Perkins (1937) stated "the Dacinae contains so many species, is so widely distributed, and is so important, that it is necessary to divide it into clearly defined genera." However, he gave no other reasons for his classification. Although May (1963) never developed a classification, he believed that one based on subgeneric division created phylogenetic problems, because the subfamily was naturally divided into 2 groups on the basis of fusion or non-fusion of abdominal terga, i.e. an African group and an Oriental/Pacific group. Others used these taxa as subgenera of *Dacus* s.l. (e.g. Hardy, 1951; Drew, 1972a). Hardy (1951) stated "The basing of genera upon single chaetotaxic characters and upon secondary sexual characters does not appear to be a sound practice. Unless supported by other characters of generic value, these complexes should probably be considered as subgenera."

The generic/subgeneric classification of Drew (1972a) was found satisfactory in revisions of the South East Asian Dacinae by Hardy (1973, 1974). While these classifications were workable and appeared to be heading the development in the right direction, it is now necessary to revise and further develop the arrangement of species so that the 109 new species described in this monograph can be included. Consequently, the classification presented below is based on a knowledge of 290 South Pacific species and increased data on their biology (especially host plant records). It also includes information on the African fauna and the known host records of these species.

Considerable confusion remains about the

supraspecific classification of the African fauna. Munro's (1984) monograph has caused problems, especially as it is difficult to define species from this work. The raising of the Dacinae to family status and the defining of 50 genera is unsatisfactory and does not apply to the South East Asian and South Pacific fauna. Munro (1984) does not indicate how the family definition fits into the accepted classifications of the Diptera (Hennig, 1973; Colless and McAlpine, 1970). In the absence of data on the similarities to and differences from closely related families, it is difficult to accept the Dacinae at family level. As a consequence of starting with a higher taxon, Munro (1984) utilises important characters at levels above genera (subfamily and tribe) that should be used at the generic level. Consequently many characters used at the generic level, e.g. wing, leg and face colour patterns, presence or absence of yellow vittae on the mesonotum, presence or absence of yellow mesopleural stripes and yellow markings on the notopleural calli, and presence or absence of microtrichia in basal cell 2 (basal medial) of wing are, at best, only suitable in defining species. The use of secondary sex characters (pecten on male abdomen), wing and face colour patterns, to define tribes is also unsatisfactory for similar reasons. Munro also ignored characters (length of posterior surstylus lobe and concavity size on posterior margin of abdominal sternum V of male) that are important in the basic division of the Dacini (Drew, 1972a; Hardy, 1973, 1974). When the African fauna is better understood, many of his genera will be synonymised.

Hardy (1954, 1955b) classed *Callantra* as a genus on antennal size and abdominal shape. Drew (1972a) supported this and stated that in *Callantra* abdominal sterna I and II are longer than wide and that most species possess a short posterior surstylus lobe and slight concavity on the posterior margin of abdominal sternum V.

Callantra smieroides Walker, the type species of *Callantra*, has a petiolate abdomen (tergum I longer than wide) and the antennae longer than the vertical length of the head. Twenty-seven species in the South Pacific region have fused abdominal terga (28 species are listed under contents but *C. smieroides* (South East Asian) has been included because of synonymies and misidentifications with South Pacific species). Within this group there is a gradual change in abdominal shape from strongly petiolate and clubbed as in *C. smieroides*, through elongate-oval as in *Dacus armatus* Fabricius to oval as in *Dacus newmani* (Perkins). Consequently, these species cannot be grouped on abdominal shape alone. Ten species have the antennal size as in *C. smieroides*, sa. bristles present and prsc. bristles absent (except *D. capillaris* with sa. present or absent). Of the remaining 17 species, some possess sa. and others lack them. Similar variation occurs with the prsc. bristles. All 27 species (except 3) have a slight concavity on the posterior margin of abdominal sternum V, but the posterior lobe of the male surstylus varies from short to long. Consequently any grouping on surstylus length would contain species with variable abdominal shape and antennal lengths. Likewise, any grouping on antennal size would contain species with varying abdominal shapes.

The irregular distribution of the important taxonomic characters in the 27 fused terga species, i.e. antennal length, abdominal shape, surstylus length, shape of abdominal sternum V and presence or absence of sa. and prsc. bristles, makes the generic status of *Callantra* questionable. Based on the type species (*C. smieroides*), the only characters satisfactory for separating *Callantra* are: Dacini with antennae longer than vertical length of head, and abdomen strongly petiolate (tergum I at least as long as wide). Only 9 South Pacific species available for study (specimens of *D. unicolor* were not seen) fall into this group, i.e. *D. axanus*, *D. capillaris*, *D. discors*, *D. impar*, *D. mayi*, *D. melanohumeralis*, *D. petioliforma*, *D. pusillus*, *D. solomonensis*.

Of the remaining 17 species, 9 fit in subgenus *Dacus*, 5 in subgenus *Didacus* Collart and 3 in subgenus *Semicallantra*. The most logical way to classify these species is to place all 27 in the genus *Dacus* and make *Callantra* a subgenus of *Dacus*.

The genus *Dacus* would then contain only those species with fused abdominal terga. All species with abdominal terga free would then be placed in another genus, *Bactrocera*. It is also difficult to justify the use of *Callantra* as a genus to contain only a small number of South Pacific and South East Asian species when all endemic African species (except 9) have fused abdominal terga and none fits into *Callantra* (Hancock pers. comm.).

Therefore, in this classification the tribe Dacini is split into 2 genera, *Bactrocera* and *Dacus*. Hancock (1986) also noted that the African fauna can be divided into these 2 basic groups.

This classification also has some biological significance. The South Pacific species now placed in *Callantra* breed in rainforest fruits of the family Cucurbitaceae (where the hosts are known), while the other fused terga species breed in fruits of the family Asclepiadaceae in open forests in drier habitats. The African Dacinae also breed primarily in fruits or pods of Cucurbitaceae and

Asclepiadaceae (Hancock, 1986), suggesting a relationship between the African dacine fauna and the South Pacific species with fused abdominal terga. The habitat of most African species is open woodland or savannah with only a few species occurring in rainforests (Hancock, 1986). In the South Pacific region, most species are endemic to rainforest habitats, with only the few fused abdominal terga species that breed in Asclepiadaceae occurring in the drier open forests.

In comparing the responses of African and South Pacific species to male attractants (cue lure and methyl eugenol), no African species has been recorded at methyl eugenol while most species attracted have responded to cue lure (Hancock, 1985). All Australian species with fused abdominal terga that have responded to lures have been attracted to cue lure (except *D. pusillus* which responds to methyl eugenol).

Discussion of Genera and Subgenera

Genus **Bactrocera** Macquart

Bactrocera Macquart, 1835: 452. Type species *Bactrocera longicornis* Macquart, 1835 (by monotypy).

This genus is divided into 4 groups of subgenera: *Bactrocera, Melanodacus, Queenslandacus* and *Zeugodacus* groups.

Bactrocera Group of Subgenera

Species in the *Bactrocera* group (previously called the *Strumeta* group) possess a short posterior surstylus lobe and abdominal sternum V of male deeply concave on posterior margin. Most species have an oval abdomen and 1 pair of sc. bristles, but some species of the subgenus *Polistomimetes* Enderlein have elongate-oval abdomens.

Four species possess a bulla in the wing of the male: *B. bullata* n. sp., *B. eximia* n. sp., *B. penefurva* n. sp. and *B. tigrina* (May).

Subgenus **Afrodacus** Bezzi

Afrodacus Bezzi, 1924: 469; Perkins, 1937: 55; Hardy, 1951: 117–8, 1955a: 3, 1955b: 427–8 (as subgenus of *Dacus*); May, 1963: 37–8; Drew, 1972a: 17 (as subgenus of *Dacus*). Type species *Chaetodacus biguttulus* Bezzi, 1922 (by original designation).

Eight South Pacific species are placed in this subgenus. As *B. aenigmatica* (Malloch) is only known from the type female, its placement in this subgenus is provisional. *B. aberrans* (Hardy), previously in this subgenus, is now placed in subgenus *Javadacus* Hardy.

Definition: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; sa. bristles absent; prsc. bristles present; 1 pair of sc. bristles present.

Subgenus **Bactrocera** Macquart

Bactrocera Macquart, 1835: 452; Hardy, 1976: 245–9 (as subgenus of *Dacus*); Drew et al., 1981: 54 (as subgenus of *Dacus*). Type species *Bactrocera longicornis* Macquart, 1835 (by monotypy).

Strumeta Walker, 1857: 33. Type species *Dacus conformis* Walker, 1857 = *Dacus umbrosus* Fabricius, 1805 (by original designation).

Apodacus Perkins, 1939: 26; May, 1963: 37 (syn. of *Strumeta* Walker); Drew, 1972a: 19 (syn. of *Strumeta* Walker). Type species *Apodacus cheesemani* Perkins, 1939 (by original designation).

This subgenus contains the majority of species of South Pacific Dacini. Most of these species have previously been placed in subgenus *Strumeta* Walker but Hardy (1976) showed that this is a junior synonym of *Bactrocera*. Four species placed in this subgenus are unusual in having a medial postsutural vitta: *B. cheesmanae* (Perkins), *B. eximia* n. sp., *B. neocheesmanae* n. sp. and *B. penefurva* n. sp. Reliable characters are not available to place *B. cheesmanae* (and consequently *B. neocheesmanae* n. sp.) in another subgenus (Drew 1972a). Similarly *B. eximia* n. sp. and *B. penefurva* n. sp. must be placed in this subgenus although their general appearance suggests otherwise.

Some species placed in the subgenus *Bactrocera* show variation in the presence of prsc. bristles, but because of the unreliability of this character it is unwise to establish another subgenus for these species (Drew 1972a).

Definition: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; sa. bristles present; prsc. bristles usually present; 1 pair of sc. bristles present.

Subgenus **Gymnodacus** Munro

Dacus (*Gymnodacus*) Munro, 1938: 117; Hardy, 1954: 15–16, 1955b: 430; Drew, 1972a: 18. Type species *Dacus mesomelas* Bezzi, 1908 (by original designation).

Gymnodacus Munro. May, 1963: 42.

Only 2 South Pacific species are placed in this subgenus. It is similar to subgenus *Bactrocera* and differs in the absence of a pecten of cilia on abdominal tergum III of the male.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles present; 1 pair of sc. bristles present.

Subgenus **Notodacus** Perkins

Notodacus Perkins, 1937: 56. Type species *Tephrites* (*Dacus*) *xanthodes* Broun, 1905 (by original designation).
Dacus (*Notodacus*) Perkins. Hardy, 1955b: 434; Drew, 1972a: 18–19.

Only 1 species is placed in this subgenus.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles present; prsc. and sa. bristles present; 1 pair of sc. bristles present.

Subgenus **Polistomimetes** Enderlein

Polistomimetes Enderlein, 1920: 358. Type species *Polistomimetes minax* Enderlein, 1920 (by original designation).
Daculus Speiser, 1924: 140; May, 1963: 40–1. Type species *Musca oleae* Gmelin, 1788 (by original designation).
Dacus (*Daculus*) Speiser. Hardy, 1951: 125; Drew, 1972a: 17–18 and 1979: 76 (syn.).
Dacus (*Heterodaculus*) Hardy, 1951: 134; May, 1963: 40 (syn. of *Daculus* Speiser). Type species *Dacus* (*Heterodaculus*) *visendus* Hardy, 1951 (by original designation).

Eight South Pacific species are placed in this subgenus. A trend with these species, except *B. decurtans* (May) and *B. murrayi* (Perkins), is towards an elongate-oval abdomen similar to that in the type species *B. minax* (Enderlein). It is possible that *B. decurtans* and *B. murrayi* are not true *Polistomimetes* but aberrant *Bactrocera* species with prsc. and sa. bristles absent.

Munro (1984) stated that Drew (1979) "placed the African genus *Daculus* as a synonym of *Polistomimetes* based on his having drawn up the same limited diagnosis for both without any consideration of any other characters." However, all available characters were compared during a thorough study of *D.* (*Daculus*) *oleae* (Gmelin), the type species of *Daculus* Speiser (Drew, 1972a) and an extensive description of *Polistomimetes minax* Enderlein, the type species of *Polistomimetes* (Drew, 1979). The latter description was based on 2 males and 1 female from the type series of *B. minax*. Munro (1984) also stated that the concavity on the posterior margin of the male abdominal sternum V is shallow in *Daculus*. In *D. oleae* (the type species) it is deep, and together with the short posterior lobe of the male surstylus and free abdominal terga, places *Daculus* and *Polistomimetes* in the same group of subgenera.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles absent; 1 pair of sc. bristles present.

Trypetidacus, n. subgen.

TYPE SPECIES: *Bactrocera invisitata*, n. sp.

This subgenus takes in 1 South Pacific species, *B. invisitata*. It is close to subgenus *Gymnodacus* in having the surstylus lobe short, abdominal sternum V with a deep concavity, pecten of cilia absent from abdominal tergum III of male and 1 pair of sc. bristles present. It differs from *Gymnodacus* in having prsc. and sa. bristles absent and is unique in possessing a short anal cell extension in the wing similar to that in the subfamily Trypetinae.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; prsc. and sa. bristles absent; 1 pair of sc. bristles present.

Melanodacus Group of Subgenera

Species in the *Melanodacus* group possess a short posterior surstylus lobe and abdominal sternum V of male slightly concave on posterior margin. All species in this group have 4 sc. bristles (as do most species in the *Zeugodacus* group of subgenera), but the male surstylus lacks the long posterior lobe present in the latter.

Hemisurstylus, n. subgen.

TYPE SPECIES: *Bactrocera melanoscutata*, n. sp.

This subgenus takes in 1 South Pacific species, *B. melanoscutata*. It differs from the other subgenera in the group in lacking prsc. bristles.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; prsc. bristles absent; sa. bristles present; 2 pairs of sc. bristles present.

Subgenus **Hemizeugodacus** Hardy

Dacus (*Hemizeugodacus*) Hardy, 1951: 131; Drew, 1972a: 18. Type species *Dacus* (*Hemizeugodacus*) *aglaiae* Hardy, 1951 (by original designation).

Hemizeugodacus Hardy. May, 1953: 48 (as synonym of *Neozeugodacus* May).

Neozeugodacus May, 1951: 6; Hardy, 1955b: 430, 1956: 70–1 (syn.). Type species *Neozeugodacus aureus* May, 1951 (by original designation).

Three South Pacific species are placed in this subgenus. Previously it was defined as possessing a deeply concave posterior margin of abdominal sternum V of male (Drew, 1972a). Additional material of each species shows that the concavity is slight. Consequently the subgenus has been withdrawn from the *Bactrocera* group of subgenera.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. bristles present; sa. bristles absent; 2 pairs of sc. bristles present.

Subgenus **Melanodacus** Perkins

Melanodacus Perkins, 1937: 57; May, 1963: 42 (as synonym of *Paratridacus* Shiraki). Type species *Dacus niger* Tryon, 1927 (by original designation).

Dacus (*Melanodacus*) Perkins. Hardy, 1951: 138.

May (1963) made *Melanodacus* a synonym of *Paratridacus* Shiraki. A large series of specimens of the type species of *Melanodacus*, *B. nigra* (Tryon), show that the male surstylus and abdominal sternum V characters are different from those of *Paratridacus* which is now placed in the *Zeugodacus* group of subgenera. It is necessary therefore to retain *Melanodacus* for *B. nigra* and *B. satanellus* (Hering).

DEFINITION: *Bactrocera* with posterior lobe of male surstylus short; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles present; 2 pairs of sc. bristles present.

Queenslandacus Group of Subgenera

Species in the *Queenslandacus* group possess a long posterior surstylus lobe and abdominal sternum V of male with a deeply concave posterior margin.

Queenslandacus, n. subgen.

TYPE SPECIES: *Bactrocera exigua* (May).

This subgenus takes in 1 South Pacific species, *B. exigua*. Previously, specimens of this species were not available for study and consequently it was left provisionally in subgenus *Daculus* Speiser (Drew, 1972a). This species does not fit into the other 3 groups of subgenera on male surstylus and abdominal sternum V characters.

DEFINITION: *Bactrocera* with posterior lobe of male surstylus long; abdominal sternum V of male deeply concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles absent; 1 pair of sc. bristles present.

Zeugodacus Group of Subgenera

Species placed in the *Zeugodacus* group of subgenera possess a long posterior surstylus lobe and abdominal sternum V of male slightly concave on posterior margin. This group was called the *Dacus* group of subgenera (Drew, 1972a). Most species have 4 scutellar bristles.

Subgenus **Austrodacus** Perkins

Austrodacus Perkins, 1937: 56; Hardy, 1951: 122 (as subgenus of *Dacus*); May, 1963: 39; Drew, 1972a: 11 (as subgenus of *Dacus*). Type species *Dacus cucumis* French, 1907 (by original designation).

This monotypic subgenus appears to be distinct and worth retaining for *B. cucumis* (French).

DEFINITION: *Bactrocera* with posterior surstylus lobe long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles absent; 2 pairs of sc. bristles present.

Subgenus **Diplodacus** May

Diplodacus May, 1951: 8, 1953: 12, 1963: 42; Drew, 1972a: 12 (as subgenus of *Dacus*). Type species *Dacus signatifer* Tryon, 1927 (by original designation).

Dacus (*Daculus*) Speiser (partim) of Hardy, 1955b: 428.

This subgenus is monotypic for *B. signatifera* (Tryon). Although Drew (1972a) reported intraspecific variation in the number of sc. bristles in *B. signatifera*, *Diplodacus* is being retained. Munro (1984) stated that Drew (1972a) placed *Diplodacus* "as a subgenus of *Dacus* because of the very long posterior lobe of the surstylus". However, it was placed in the *Dacus* group of subgenera (now the *Zeugodacus* group of subgenera) on the combination of two characters: the length of surstylus lobe and size of concavity on posterior margin of abdominal sternum V of male. Munro also stated that Drew accepted *Diplodacus* as a genus. This is incorrect as it was accepted as a subgenus of *Dacus* (Drew, 1972a).

DEFINITION: *Bactrocera* with posterior surstylus lobe long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles absent; generally with 2 pairs of sc. bristles present.

Heminotodacus, n. subgen.

TYPE SPECIES: *Bactrocera dissidens*, n. sp.

This subgenus takes in 1 South Pacific species, *B. dissidens*. It is similar to *Papuodacus* Drew but differs in possessing 1 pair of well developed humeral bristles.

DEFINITION: *Bactrocera* with posterior surstylus lobe long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles present; prsc. bristles present; sa. bristles absent; 2 pairs of sc. bristles present.

Hemiparatridacus, n. subgen.

TYPE SPECIES: *Bactrocera abdoaurantiaca*, n. sp.

This subgenus takes in 1 South Pacific species, *B. abdoaurantiaca*. It is similar to *Paratridacus* but differs in having the prsc. bristles absent.

DEFINITION: *Bactrocera* with posterior surstylus lobe long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral and prsc. bristles absent; sa. bristles present; 2 pairs of sc. bristles present.

Subgenus **Javadacus** Hardy

Dacus (*Javadacus*) Hardy, 1983: 26–7. Type species *Dacus* (*Javadacus*) *montanus* Hardy, 1983 (by original designation).

This subgenus is similar to *Afrodacus* Bezzi in chaetotaxy but differs in the male surstylus and abdominal sternum V characters. It differs from *Asiadacus* Perkins in possessing prsc. bristles. *B. aberrans* (Hardy), previously placed in *Afrodacus*, fits in this subgenus.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. bristles present; sa. bristles absent; 1 pair of sc. bristles present.

Niuginidacus, n. subgen.

TYPE SPECIES: *Bactrocera singularis*, n. sp.

This subgenus takes in 1 South Pacific species, *B. singularis*. It is similar to *Sinodacus* Zia and *Hemigymnodacus* Hardy but differs from *Sinodacus* in the absence of the abdominal pecten in males and from *Hemigymnodacus* in lacking prsc. bristles.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. bristles absent; sa. bristles present; 1 pair of sc. bristles present.

Subgenus **Papuodacus** Drew

Dacus (*Papuodacus*) Drew, 1972a: 13. Type species *Dacus* (*Papuodacus*) *pallescentis* Drew, 1971 (by original designation).

This subgenus takes in 1 South Pacific species, *D. pallescentis* Drew, now called *Bactrocera neopallescentis* n. nom. (see discussion on *B. neopallescentis*). All the type series plus 14 of an additional 20 specimens of *B. pallescentis* possess prsc. bristles. The remaining 6 lack these bristles and fit into the monotypic subgenus *Diplodacus*. However, since *Diplodacus* is accepted above, despite intraspecific variation in the number of sc. bristles in its type species, *B. signatifera*, *Papuodacus* is similarly retained.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. bristles generally present; sa. bristles absent; 2 pairs of sc. bristles present.

Subgenus **Paradacus** Perkins

Paradacus Perkins, 1938: 143; Hardy and Adachi, 1954: 155 (as subgenus of *Dacus*); Drew, 1972a: 13 (as subgenus of *Dacus*). Type species *Paradacus fulvipes* Perkins, 1938 (by original designation).

This subgenus is used to contain 4 South Pacific species. It is close to *Zeugodacus* Hendel, differing in the absence of prsc. bristles.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. bristles absent; sa. bristles present; 2 pairs of sc. bristles present.

Subgenus **Paratridacus** Shiraki

Paratridacus Shiraki, 1933: 109; May, 1963: 42; Hardy, 1951: 140 (as subgenus of *Dacus*); Drew, 1972a: 15–16 (as subgenus of *Dacus*). Type species *Dacus yayeyamanus* Matsumura, 1916 (by original designation) = *Dacus expandens* Walker, 1859 (synonymised by Hardy, 1951).

Paratridacus appears to be a good subgenus, differing from *Zeugodacus* in the absence of a pecten of cilia on abdominal tergum III of males. Seven South Pacific species are placed in this subgenus.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia absent from abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles present; 2 pairs of sc. bristles present.

Subgenus **Sinodacus** Zia

Sinodacus Zia, 1936: 157; Hardy, 1977: 47 (as subgenus of *Callantra* Walker). Type species *Sinodacus hochii* Zia, 1936 (by original designation).

Dacus (*Pacifodacus*) Drew, 1972a: 12 (new synonymy based on a comparison of type species). Type species *Asiadacus triangularis* Drew, 1968 (by original designation).

Pacifodacus Drew, established for a group of South Pacific species previously placed in *Asiadacus* Perkins and *Neodacus* Perkins (Drew, 1972a), cannot be separated generically from specimens of *S. hochii* Zia, the type species of *Sinodacus,* kindly donated by Liang Guang-qin, APQS.

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. bristles absent; sa. bristles present; 1 pair of sc. bristles present.

Subgenus **Zeugodacus** Hendel

Dacus (*Zeugodacus*) Hendel, 1927a: 26; Hardy, 1955b: 436–7; Drew, 1972a: 16. Type species *Dacus caudatus* Fabricius, 1805 (by original designation).

Zeugodacus Hendel. Shiraki, 1933: 78; Perkins, 1937: 55, 1938: 137; May, 1963: 50.

Zeugodacus is a large subgenus in the South Pacific region, containing 20 species. *B. fulvifacies* (Perkins) and *B. terminifera* (Walker) are placed provisionally in this subgenus (Drew, 1972a).

DEFINITION: *Bactrocera* with posterior lobe of surstylus long; abdominal sternum V of male slightly concave on posterior margin; pecten of cilia present on abdominal tergum III of male; humeral bristles absent; prsc. and sa. bristles present; generally with 2 pairs of sc. bristles present.

Genus **Dacus** Fabricius

Dacus Fabricius, 1805: 272. Type species *Dacus armatus* Fabricius, 1805 (by subsequent designation of Speiser, 1924: 140 and confirmed by Hendel, 1927a: 25).

Subgenus **Callantra** Walker

Callantra Walker, 1860: 153; Hendel, 1914: 74 (as *Calantra*, lapsus); Hardy and Adachi, 1954: 149; Hardy, 1955b: 426–7; May, 1963: 40; Drew, 1972a: 9. Type species *Callantra smieroides* Walker, 1860 (by monotypy).

Mellesis Bezzi, 1916: 114; Hendel, 1927b: 58 (syn.). Type species *Monacrostichus crabroniformis* Bezzi, 1914 (by original designation).

As specimens of *D. unicolor* (Hendel) were not available for study, it is only provisionally placed in this subgenus. The placing of such species in Callantrinae by Munro (1984) on the basis of abdominal shape is unacceptable for the South Pacific fauna. The gradual change in abdominal shape from oval to strongly petiolate prevents the establishment of a line of demarcation that would

allow a group of species to be placed in taxa as high as genera and subfamily.

DEFINITION: *Dacus* with abdominal sternum V of male slightly concave on posterior margin; prsc. bristles absent; antennae longer than vertical length of head; abdomen strongly petiolate (tergum I at least as long as wide).

Subgenus **Dacus** Fabricius

Dacus Fabricius, 1805: 272; Hardy, 1955b: 428 (as subgenus); Drew, 1972a: 11–12 and 1979: 72 (as subgenus). Type species *Dacus armatus* Fabricius, 1805 (by subsequent designation of Speiser, 1924: 140).
Tridacus Bezzi, 1915: 86; Hendel, 1927a: 24 (syn.). Type species *Dacus armatus* Fabricius, 1805 (by subsequent designation of Collart, 1935: 9).
Neodacus Perkins, 1937: 58; May, 1963: 41–2 (syn.). Type species *Neodacus newmani* Perkins, 1937 (by monotypy).

The holotype of the type species, *D. armatus*, was described and illustrated by Drew (1979). The following definition is based on that study and other specimens of *D. armatus*.

DEFINITION: *Dacus* with abdominal sternum V of male slightly concave on posterior margin; prsc. bristles absent; antennae equal to or less than vertical length of head; abdomen elongate-oval (tergum I wider than long); sa. bristles present.

Subgenus **Didacus** Collart

Dacus (*Didacus*) Collart, 1935: 33; Drew, 1979: 74. Type species *Dacus* (*Didacus*) *ciliatus* Loew, 1862 (by original designation).

Characters from the type species, *D. ciliatus* Loew, were recorded by Drew (1979).

DEFINITION: *Dacus* with abdominal sternum V of male slightly concave on posterior margin; prsc. bristles absent; antennae equal to or less than vertical length of head; abdomen elongate-oval (tergum I wider than long); sa. bristles absent.

Semicallantra, n. subgen.

TYPE SPECIES: *Dacus aquilus*, n. sp.

This subgenus takes in 3 new South Pacific species.

DEFINITION: *Dacus* with abdominal sternum V of male deeply concave on posterior margin; prsc. bristles present.

Genus **Paracallantra** Hendel

Paracallantra Hendel, 1927b: 59; Drew, 1972a: 20. Type species *Paracallantra vespiformis* Hendel, 1927 (by original designation).
Dacus (*Paracallantra*) Hendel. Hardy, 1955b: 434.

The holotype of the type species of this monotypic genus has been lost (Drew, 1972a) and despite intensive collecting in New Britain (the type locality) no further specimens have been collected. Although the original description is vague, *P. vespiformis* may be synonymous with *D. (Callantra) axanus* (Hering), a common species in New Britain.

KEY TO GENERA AND SUBGENERA OF SOUTH PACIFIC DACINAE

1. Abdominal terga fused (Genus *Dacus* Fabricius) 2
   Abdominal terga not fused (Genus *Bactrocera* Macquart) 5
2(1). Abdominal sternum V of male with a deep concavity on posterior margin; prescutellar bristles present ..... *Semicallantra*; n. subgen.
   Abdominal sternum V of male with a slight concavity on posterior margin; prescutellar bristles absent 3
3(2). Combined lengths of all antennal segments greater than vertical length of head; abdomen strongly petiolate (tergum I length greater than or equal to width) .....Subgenus *Callantra* Walker
   Combined lengths of all antennal segments equal to or less than vertical length of head; abdomen elongate-oval (tergum I length less than width) 4
4(3). Supra-alar bristles present .....Subgenus *Dacus* Fabricius
   Supra-alar bristles absent ..... Subgenus *Didacus* Collart
5(1). Posterior surstylus lobe short (at most twice as long as anterior lobe) 6
   Posterior surstylus lobe long (at least 6 times as long as anterior lobe) 14

6(5). Abdominal sternum V of male with a deep concavity on posterior margin (*Bactrocera* Group of Subgenera) 7
Abdominal sternum V of male with a slight concavity on posterior margin (*Melanodacus* Group of Subgenera) 12
7(6). Pecten on abdominal tergum III of male absent 8
Pecten on abdominal tergum III of male present 9
8(7). Prescutellar and supra-alar bristles absent ..... *Trypetidacus*, n. subgen.
Prescutellar and supra-alar bristles present ..... Subgenus *Gymnodacus* Munro
9(7). Humeral bristles present ..... Subgenus *Notodacus* Perkins
Humeral bristles absent 10
10(9). Supra-alar bristles present ..... Subgenus *Bactrocera* Macquart
Supra-alar bristles absent 11
11(10). Prescutellar bristles present ..... Subgenus *Afrodacus* Bezzi
Prescutellar bristles absent ..... Subgenus *Polistomimetes* Enderlein
12(6). Prescutellar bristles absent ..... *Hemisurstylus*, n. subgen.
Prescutellar bristles present 13
13(12). Pecten on abdominal tergum III of male present ..... Subgenus *Hemizeugodacus* Hardy
Pecten on abdominal tergum III of male absent ..... Subgenus *Melanodacus* Perkins
14(5). Abdominal sternum V of male with a deep concavity on posterior margin ..... *Queenslandacus*, n. subgen.
Abdominal sternum V of male with a slight concavity on posterior margin (*Zeugodacus* Group of Subgenera) 15
15(14). 1 pair of scutellar bristles present 16
2 pairs of scutellar bristles present 19
16(15). Supra-alar bristles absent ..... Subgenus *Javadacus* Hardy
Supra-alar bristles present 17
17(16). Pecten on abdominal tergum III of male present 18
Pecten on abdominal tergum III of male absent ..... *Niuginidacus*, n. subgen.
18(17). Prescutellar bristles absent ..... Subgenus *Sinodacus* Zia
Prescutellar bristles present (some specimens of *B. cucurbitae* only) ..... Subgenus *Zeugodacus* Hendel
19(15). Pecten on abdominal tergum III of male absent 20
Pecten on abdominal tergum III of male present 22
20(19). Supra-alar bristles absent ..... Subgenus *Austrodacus* Perkins
Supra-alar bristles present 21
21(20). Prescutellar bristles present ..... Subgenus *Paratridacus* Shiraki
Prescutellar bristles absent ..... *Hemiparatridacus*, n. subgen.
22(19). Supra-alar bristles absent 23
Supra-alar bristles present 25
23(22). Prescutellar bristles absent ..... Subgenus *Diplodacus* May
Prescutellar bristles present 24
24(23). Humeral bristles present ..... *Heminotodacus*, n. subgen.
Humeral bristles absent ..... Subgenus *Papuodacus* Drew
25(22). Prescutellar bristles absent ..... Subgenus *Paradacus* Perkins
Prescutellar bristles present ..... Subgenus *Zeugodacus* Hendel

Descriptions and Keys

Some characters used in the subgeneric classification of genus *Bactrocera* only apply to males. Consequently females cannot be identified to subgenera and keys to species within each subgenus could only be used when males are available. In order to identify females, and specimens belonging to monotypic subgenera, a key to species within the genus *Bactrocera* is provided while keys to species within each subgenus are not included. In this key, no species is identified solely on characters applicable to one sex, except in the case of *B. calophylli* which in couplet 126, can only be separated on the absence of a pecten of cilia on abdominal tergum III of the male.

For some species, holotypes have not been

recorded as studied under material examined. In such cases, the holotypes were studied for earlier publications by the author (Drew 1973, 1974a). The location of types for species listed as synonyms is recorded where this information is known. Lectotypes have been designated for species where the designation of a holotype is uncertain (see Articles 72b (vii) and 74a of the International Code of Zoological Nomenclature).

Genus **Bactrocera** Macquart

Bactrocera Group of Subgenera

Subgenus **Afrodacus** Bezzi

Bactrocera (Afrodacus) aenigmatica (Malloch), n. comb. (Fig. 2)

Dacus aenigmaticus Malloch, 1931: 261–2.
Dacus (Afrodacus) aenigmaticus: Hardy, 1955a: 6; Drew, 1974a: 2–3.

MATERIAL EXAMINED
Holotype ♀.
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION
Malololelei, Western Samoa (type locality).

DIAGNOSIS
Small species; humeral calli yellow; notopleural calli orange-brown; mesonotum shiny orange-brown with a narrow medial longitudinal black vitta, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural yellow vitta absent, scutellum orange-brown; wing with a narrow fuscous costal band and pale fulvous anal cell, costal cells colourless, microtrichia covering most of second costal cell only; abdominal terga III–V shining orange-brown with a medial and 2 broad lateral longitudinal shining black bands.
ATTRACTANT: No known record.

COMMENTS
This species was described adequately by Drew (1974a). It is similar to *B. jarvisi* (Tryon) and *B. ochracea* in possessing a pale coloured mesonotum, a uniformly coloured scutellum and lacking infuscation around r–m crossvein. It is distinct from these species in possessing a medial longitudinal black vitta on the mesonotum, notopleural calli orange-brown and abdominal terga III–V shining orange-brown with a medial and 2 broad lateral shining black bands.

Bactrocera (Afrodacus) brunnea (Perkins and May), n. comb. (Figs 3–5)

Afrodacus brunneus Perkins and May, 1949: 18–21.
Dacus (Afrodacus) brunneus: Hardy, 1951: 118.
Afrodacus brunneus: May, 1963: 49.

MATERIAL EXAMINED
AUSTRALIA, south-east Queensland: lectotype ♀, Gayndah, November 1945, A.W.S. May and 1 ♂ (T.5260), Toowoomba, December 1937, H. Jarvis (in QM); paralectotype ♀ labelled "Stanthorpe, Q., 24.i.1925, traps"; a series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: Lectotype (T.5261) and paralectotype (T.10601) in QM.

DISTRIBUTION
Known throughout south-east Queensland as far west as Stanthorpe and Toowoomba; type locality, Gayndah. It has been collected in north Queensland at higher altitudes on the Atherton Tableland.

DIAGNOSIS
Medium sized species; medium sized pale facial spots present; humeral calli yellow; notopleural calli red-brown, mesonotum red-brown, broad mesopleural stripe reaching humeral callus, narrow lateral postsutural vittae ending before upper pa. bristle, medial postsutural vitta absent, scutellum yellow except fuscous on apical ½; wing with a narrow fuscous costal band expanding at apex, a narrow fuscous band along r–m crossvein, a broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad fuscous margin on tergum III and narrow pale fuscous margins on terga IV and V.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.3 mm. Frons narrowing slightly posteriorly, length 1.78 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with small oval fuscous spots; length of face 0.45 mm. Genae fulvous, dark subocular spot absent; fulvous bristle present. Occiput red-brown, yellow along eye margins; occipital row with 2–4 strong black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong dark fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.25 mm; 0.58 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown with fuscous on sternopleuron. Yellow markings as follows: humeral calli; broad mesopleural stripe, reaching humeral callus dorsally, not continuing to sternopleuron, anterior margin deeply concave; upper hypopleural calli (posterior apices dark fuscous); anterior 3/5 lower hypopleural calli (remainder dark fuscous); 2 narrow parallel sided lateral postsutural vittae ending before upper pa. bristles. Notopleural calli red-brown. Medial postsutural vittae absent. Scutellum yellow except fuscous on apical ½. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except darker fulvous on apex of fore femora, pale fuscous on apex of mid femora, fuscous on apex of hind femora and dark fuscous hind tibiae; mid tibiae each with an apical black spur.

Wings length 5.5 mm; costal cells fulvous (second cell paler apically); microtrichia in outer corner of second costal cell only; remainder of wing colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and expanding in apex of wing to end between extremities of R_{4+5} and M, a fuscous band around r–m cross-vein, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; tergum II orange-brown with a broad transverse fuscous band across anterior ⅓ and widening to cover lateral margins; terga III–V orange-brown with broad fuscous margins on tergum III which continue along anterior margin of tergum, narrower pale fuscous lateral margins on terga IV and V. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, elongate and almost circular in transverse cross section. Ratio of length of oviscape to length of tergum V 1.52:1. Apex of piercer with 3 pairs of subapical keels and 2 pairs of small subapical bristles (Fig. 4). Spicules at distal end of middle segment sparse, triangular and elongate in shape, without dentations (Fig. 5).

ATTRACTANT: No known record.

COMMENTS

B. brunnea is similar to *B. aenigmatica* (Malloch), *B. jarvisi* (Tryon) and *B. ochracea* in possessing a pale coloured mesonotum but differs in having the apical ½ of the scutellum fuscous and infuscation surrounding r–m crossvein. Originally, Perkins and May (1949) described the costal band as not reaching extremity of R_{4+5}; it actually overlaps R_{4+5}, reaching just beyond the end of M. The authors described the species "from 2 females and 1 male trapped at Gayndah and Stanthorpe in a citrus and deciduous fruit orchard respectively", but designated no types. Two specimens each labelled holotype are in QM, a female (T.5261) labelled Gayndah, November 1945, A.W.S. May and a male labelled Toowoomba, December 1937, H. Jarvis. Another female found in DPI is labelled "Stanthorpe, Q., 24.i.1925, traps". The specimens from Gayndah and Stanthorpe are part of the type series, but the male labelled holotype cannot be confirmed as a type as no specimen from Toowoomba was mentioned in the original description. The third type could not be located although the male from Toowoomba may be the specimen. I designate the female from Gayndah as lectotype and the female from Stanthorpe as paralectotype.

Bactrocera (Afrodacus) hypomelaina, n. sp. (Fig. 6)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Moroboe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 28.iii.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, 1 ♂ (20.iii.1980) and 1 ♂ (1.iv.1980), attracted to cue lure, P. Daur; Mt Missim (1200–1700 m) — 2 ♂♂ (6.xi.1980), 1 ♂ (11.xi.1980), 1 ♂ (13.xi.1980), 1 ♂ (18.xii.1980), 1 ♂ (25.xii.1980), 1 ♂ (8.i.1981), 1 ♂ (19.i.1981), 3 ♂♂ (5.ii.1981), 2 ♂♂ (21.v.1981), 2 ♂♂ (4.vi.1981), all attracted to cue lure, A. Allison; Mt Kaindi — 1 ♂ (1600 m), 15.xii.1980 and 1 ♂ (2150 m), 18.xi.1980, attracted to cue lure, A. Allison. Western Highlands Province: 1 ♂, Mt Hagen, attracted to cue lure, 23.xii.1980, B. Thistleton.

LOCATION OF TYPES: Holotype (T.10470) and 1 paratype (T.10471) in QM; 4 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI (PNG); 13 paratypes in DPI.

DISTRIBUTION

Known from the Morobe and Western Highlands Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous without facial spots; humeral calli black; notopleural calli yellow; mesonotum black, lateral and medial postsutural vittae absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow with a broad medial longitudinal black band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdomen black except paler on posterior ½ of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with no dark spots; length of face 0.5 mm. Genae fulvous, pale subocular spot present; red-brown bristle present. Occiput black, fulvous along eye margins; occipital row with 2–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except dark fuscous on apex and outer surface; a small fuscous dorsal bristle on segment 2; arista black (fuscous basally); length of segments: 0.20 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum and pleural areas black. Yellow markings as follows: notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin irregular; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including broad ventral margin black). Humeral calli black. Lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow except for a broad medial longitudinal black band and a large fuscous spot on apex. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4–6; all bristles well developed and black.

Legs fore and mid coxae fuscous, hind coxae dark fuscous; all other segments fulvous except dark fuscous on apices of hind femora and hind tibiae (remainder of hind tibiae black), fuscous on basal areas of fore and mid tibiae and on apical 4 segments of fore tarsi; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; remainder of wings colourless except for a dark fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and beyond extremity of R_{2+3} it narrows to a fine fuscous line around costal margin to end between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V black except for a pair of oval shining spots on tergum V which are dark fuscous anteriorly and red-brown posteriorly and a narrow dark fuscous band along posterior margin of tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. hypomelaina is similar to *B. minuta* (Drew) and *B. tigrina* (May) in possessing a black mesonotum but is distinct from these species in having a broad medial longitudinal black band on dorsal surface of scutellum, abdominal terga uniformly black and costal cells with a pale fuscous tint.

Bactrocera (Afrodacus) jarvisi
(Tryon), n. comb. (Figs 7–9)

Chaetodacus jarvisi Tryon, 1927: 201–3.
Chaetodacus jarvisi var. *careya* Tryon, 1927: 202 (nomen nudum).
Dacus (*Chaetodacus*) *australis* Hendel, 1928: 341–2.
Dacus (*Chaetodacus*) *australis* var. *halterata* Hendel, 1928: 342–3.
Dacus (*Afrodacus*) *jarvisi*: Hardy, 1951: 120–1.
Afrodacus jarvisi: May, 1963: 38, 49.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: *C. jarvisi*, holotype ♀ (D.3131) and syntypes of var. *careya* (1 ♀ and 1 ♂, D.3132) in QM; *D. australis*, 7 syntypes (both sexes) in DEI; *D. australis* var. *halterata*, holotype ♀ in DEI.

DISTRIBUTION

PREVIOUSLY RECORDED: Occurs in large populations throughout most of its range. It has been recorded across northern Australia from Broome in Western Australia to eastern Arnhem Land and along the eastern coast (type locality, Stanthorpe) from Cape York in Queensland to the

Sydney area of New South Wales. Also recorded from the following Torres Strait islands: Badu, Darnley, Horn, Thursday and Yorke.
NEW RECORDS: Torres Strait islands: Prince of Wales, Saibai, Yam (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized irregularly oval black facial spots present; humeral and notopleural calli yellow and connected by a broad yellow band; mesonotum red-brown, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vittae absent, wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a fuscous to black transverse band across anterior margin of tergum III and a fuscous to black medial longitudinal band generally over all 3 terga but often variable.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.52 times breadth; fulvous with pale fuscous on anteromedial hump and occasionally around s.or. bristles; anteromedial hump covered with a small number of short pale setae; oribtal bristles weak and black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized irregularly oval black spots; length of face 0.48 mm. Genae fulvous without subocular dark spot; pale fulvous bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with pale fuscous on apex and outer surface; a weak fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.28 mm; 0.70 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; broad band connecting humeral and notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices dark red-brown); anterior ⅓ lower hypopleural calli (remainder dark red-brown); 2 broad parallel sided lateral postsutural vittae ending posterior to upper pa. bristles. Medial postsutural vittae absent. Postnotum dark red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments including coxae fulvous; mid tibiae each with an apical black spur.

Wings length 5.9 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with or just overlapping R_{2+3} and expanding into a broad band apically to end between extremities of R_{4+5} and M, a broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fulvous; tergum II fulvous except for a narrow transverse pale fuscous band across anterior margin but not reaching lateral margins; terga III–V orange-brown except for a narrow transverse fuscous to black band along anterior margin of tergum III (not reaching lateral margins in some specimens) and a narrow medial longitudinal fuscous to black band over terga III–V (this band varies in colour and continuity and often exists only as a spot on terga IV and V). A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, elliptical in transverse cross section. Ratio of length of oviscape to length of tergum V 1.2:1. Apex of piercer broadly rounded with 4 pairs of subapical bristles (Fig. 8). Spicules at distal end of middle segment very wide with approximately 8 long narrow dentations (Fig. 9).

HOST PLANTS

NEW RECORDS: *Planchonella* sp. (Sapotaceae), Cairns, north Queensland, 6.i.1977, B. McCulloch; *Notalaea* sp. (Oleaceae), Somerset road (23 km north of Bamaga) Cape York, Queensland, 19.xii.1974, D.J. Rogers, in association with *B. kraussi* (Hardy) and *B. neohumeralis* (Hardy); *Aglaia sapindina* (Meliaceae), Cairns, north Queensland, Jan. 1977, B. McCulloch; ripe cavendish bananas (*Musa* sp.), Kamerunga Horticulture Research Station, near Cairns, March 1985, R. Drew (5 specimens in association with approximately 2000 *B. musae* (Tryon), banana fruit

fly); *Terminalia melanocarpa* (Combretaceae), Trinity Beach, G. Fitt, in association with *B. neohumeralis* (Hardy); *Syzygium rubrimolle* (Myrtaceae) (red lady apple), various localities between Bamaga and Somerset, Cape York, December 1974, D.J. Rogers.
ATTRACTANT: Weak attractancy to cue lure in north-west Western Australia.

COMMENTS

B. jarvisi is similar to *B. ochracea* in having a pale coloured mesonotum, yellow notopleural calli and abdominal terga III–V without dark lateral margins. It is distinct from this species in having a broad yellow band connecting humeral and notopleural calli, colourless costal cells with microtrichia in outer corner of second costal cell only, costal band expanded slightly at apex of wing and abdominal terga III–V with a fuscous to black narrow band across base of tergum III and a medial longitudinal fuscous to black band over all 3 terga.

In the original description, Tryon (1927) indicated a variety *careya* but did not distinguish it from *jarvisi* except by host data. Therefore the name is unavailable (Article 12c of the International Code of Zoological Nomenclature).

Bactrocera (Afrodacus) minuta (Drew), n. comb. (Fig. 10)

Dacus (*Afrodacus*) *minutus* Drew, 1971: 29–31.

MATERIAL EXAMINED

A large series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6927) in QM.

DISTRIBUTION

Known only from Vanuatu (formerly New Hebrides), type locality, Vila, Efate I.

DIAGNOSIS

Small species; facial spots absent; humeral calli fuscous to black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; all abdominal terga orange-brown except for a narrow fuscous medial longitudinal band over terga IV and V.
ATTRACTANT: Cue lure.

COMMENTS

This species was described adequately by Drew (1971). It is similar to *B. hypomelaina* in having lateral and medial postsutural vittae absent and humeral calli fuscous to black but differs in having the scutellum entirely yellow, costal cells colourless and the abdominal terga uniformly orange-brown with a narrow medial longitudinal fuscous band on terga IV and V.

Bactrocera (Afrodacus) ochracea, n. sp. (Fig. 11)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central District: Mt Lawes (800 feet), attracted to cue lure, 9–13.iii.1970, T.L. Fenner.

Paratypes, PAPUA NEW GUINEA, Central District: 13 ♂♂, Mt Lawes (800 feet), attracted to cue lure, 9–13.iii.1970, T.L. Fenner.
LOCATION OF TYPES: Holotype (T.10472) and 1 paratype (T.10473) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 8 paratypes in DPI.

DISTRIBUTION

Known only from Mt Lawes, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with black spots present; humeral and notopleural calli yellow, mesonotum orange-brown with irregular fuscous markings, lateral postsutural vittae present, mesopleural stripe broad reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells pale fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown with a diffuse darker orange-brown medial longitudinal band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons narrowing slightly posteriorly, length 1.68 times breadth; fulvous without dark markings; anteromedial hump with a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots present; length of face 0.45 mm. Genae fulvous, dark subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with all segments fulvous except pale fuscous on apex and outer surface; a small pale dorsal bristle on segment 2; arista red-brown (fulvous basally);

length of segments: 0.16 mm; 0.25 mm; 0.78 mm.

Thorax mesonotum orange-brown with irregular fuscous markings at sites of attachment of dorsoventral flight muscles. Pleural areas red-brown to pale fuscous. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; 2 moderately broad lateral postsutural vittae narrowing slightly posteriorly to end at the upper pa. bristles; upper hypopleural calli (posterior apices pale fuscous); anterior 3/5 lower hypoplerual calli (remainder pale fuscous). Postnotum red-brown. Scutellum yellow except for narrow orange-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 3–5; all bristles red-brown and not generally well developed.

Legs all segments fulvous; mid tibiae each with an apical fuscous spur; fore femora with rows of long pale setae on dorsal surface.

Wings length 5.4 mm; costal cells pale fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; remainder of wings colourless except for a fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II slightly wider than long; sternum II with a deep concavity on anterior margin. Tergum I orange-brown, tending fuscous laterally. Tergum II orange-brown, tending whitish posteriorly. Terga III–V orange-brown with an indication of a darker orange-brown medial longitudinal band over all 3 terga. A pair of oval shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. ochracea is similar to *B. jarvisi* (Tryon) in possessing a pale mesonotum, yellow notopleural calli and abdominal terga III–V without dark lateral margins but differs in having the humeral and notopleural calli not joined by a yellow band, costal band of uniform width throughout, costal cells pale fuscous with microtrichia covering all of second costal cell and outer ½ of first costal cell, abdominal terga without dark colour patterns.

Bactrocera (Afrodacus) tigrina (May), n. comb. (Figs 12–15)

Afrodacus tigrinus May, 1952: 339–41, 1957b: 296–7, 1963: 37–8, 49.

Afrodacus flavinotus May, 1957b: 293–4. New synonymy based on study of holotypes of *A. flavinotus* and *A. tigrinus*.

Afrodacus furvus May, 1957b: 294–6, 1963: 38, 49. New synonymy based on study of holotypes of *A. furvus* and *A. tigrinus* and a series of specimens of *A. tigrinus*.

MATERIAL EXAMINED

AUSTRALIA, Queensland: 2 ♀ ♀ (23.xii.1976) and 1 ♀ (2.ii.1977), Lake Placid, collected at protein hydrolysate lure, B.C. McCulloch; 1 ♀ (13.i.1956), Cairns, A.W.S. May; 4 ♂ ♂ and 4 ♀ ♀, 11 km ENE of Mt Tozer, Cape York, attracted to light trap, 11-16 July 1986, D.H. Colless; specimens in DPI; type specimens of *A. tigrinus, A. flavinotus* and *A. furvus*.

LOCATION OF TYPES: *A. tigrinus*, holotype ♀ (T.5274), paratype ♀ and allotype ♂ (T.5604) in QM; *A. flavinotus*, holotype ♀ (T.5603) in QM; *A. furvus*, holotype ♂ (T.5605) and allotype ♀ (T.5606) in QM.

DISTRIBUTION

Known from the Cairns district (type locality, Kamerunga), Atherton Tableland and Mt Tozer, north Queensland.

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli yellow (except posterodorsal corners black in male); notopleural calli with anterior ½ brown and posterior ½ yellow; mesonotum black, lateral and medial postsutural vittae present, mesopleural stripe broad extending to humeral callus, scutellum yellow; wing of female with a narrow fuscous costal band expanding slightly in apex of wing and a broad fuscous anal streak, wing of male with the costal band ending at extremity of R_1 and a large fuscous spot in wing apex and anal streak absent, costal cells fuscous with microtrichia covering second costal cell and outer ½ of first costal cell of female and both costal cells in male; abdominal terga III–V of female orange-brown with a narrow transverse black band across base of tergum III, 2 narrow lateral longitudinal black bands over all 3 terga and a narrow medial longitudinal black band on terga IV and V, abdominal terga III–V of male orange-brown except for 2 lateral longitudinal black bands over all 3 terga and a medial longitudinal black band over terga IV and V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.03 mm. Frons of even width, length 1.31 times breadth; fulvous without dark markings;

anteromedial hump covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark spots; length of face 0.33 mm. Genae fulvous, dark subocular spot absent; red-brown bristle present. Occiput fulvous with dark fuscous markings laterally and yellow along eye margins; occipital row with a large number of very small pale bristles. Antennae with all segments fulvous; a very weak pale dorsal bristle on segment 2; arista red-brown; length of segments: 0.10 mm; 0.18 mm; 0.40 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, along mesonotal suture and between humeral and notopleural calli. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; posterior ½ of notopleural calli (remainder brown); broad mesopleural stripe reaching humeral callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles; a short but broad medial postsutural vitta which begins at the posterior margin of the mesonotum and narrows to a point in the centre of the mesonotum. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments including coxae fulvous except hind tibiae very pale fuscous; mid tibiae each with an apical black spur.

Wings length 4.2 mm; costal cells fuscous; microtrichia covering second costal cell and outer ½ of first costal cell; remainder of wing with a pale fuscous tint, except fuscous subcostal cell, narrow fuscous costal band confluent with R_{4+5} except in centre of wing where it is confluent with R_{2+3} and broadening in apex of wing to end at extremity of M, broad pale fuscous anal streak merging into a pale tint in the wing membrane; dense aggregation of microtrichia around A_1 + CuA_2 absent; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I orange-brown; tergum II orange-brown with a narrow transverse black band across anterior margin but not reaching lateral margins; terga III–V orange-brown with a narrow tranvserse black band across anterior margin of tergum III, narrow lateral longitudinal black bands over all 3 terga (but not confluent with lateral margins of terga III and IV) and a narrow medial longitudinal black band on terga IV and/or V. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor red-brown, dorsoventrally compressed and narrowing posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.69:1; apex of piercer with 2 lateral keels midway between bristles and gonopore and with 3 pairs of small subapical bristles (Fig. 14). Spicules at distal end of middle segment of medium width with a row of 7–10 dentations of approximately equal size. (Fig. 15).

MALE: Head generally fulvous. Vertical length 1.1 mm. Frons narrowing slightly posteriorly, length 1.4 times breadth; fulvous with fuscous around s.or. bristles; anteromedial hump with a few short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark facial spots; length of face 0.3 mm. Genae fulvous, subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of very small pale bristles. Antennae with all segments fulvous; arista black (fulvous basally); length of segments: 0.10 mm; 0.15 mm; 0.32 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, along mesonotal suture and between humeral and notopleural calli. Pleural areas dark fuscous to black except fulvous above mid coxae and below humeral calli. Yellow markings as follows: humeral calli (posterodorsal corners black); posterior ½ notopleural calli (remainder brown); broad mesopleural stripe reaching humeral callus dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles; a broad, short, medial postsutural vitta broadly rounded posteriorly and narrowing sharply anteriorly to end in a point at centre of mesonotum. Postnotum black. Scutellum yellow except for narrow black basal band which widens slightly laterally. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; rows of long pale setae on ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 3.8 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with M and ending at extremity of R_1, a large fuscous spot at apex of wing; anal streak absent; dense aggregation

of microtrichia around A_1 + CuA_2; supernumerary lobe large; a large well developed bulla over anal cell extension.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I orange-brown except for 2 anterolateral fuscous spots; tergum II orange-brown except for 2 large lateral black spots; terga III–V orange-brown except for large black spots on lateral margins and a medial longitudinal black band over terga IV and V (this band consists of 2 elongate spots which are broad on the posterior margin of each tergum and narrowed to a point on the anterior margin). Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

The specimens of *B. tigrina* listed above as collected at light trap, reveal a marked sexual dimorphism in important taxonomic characters. This is unique in the Dacinae. Consequently, having described *A. tigrinus* from a female (May, 1952), he described *A. furvus* from a male (May, 1957b) now known to be *B. tigrina*. Originally the notopleural calli were described as yellow — the correct description is anterior ½ fuscous, posterior ½ yellow.

May (1952) designated a female holotype and 1 female paratype for *A. tigrinus*. A male labelled allotype in QM designated by May (1957b) cannot be a type as it was not part of the original type series.

Subgenus **Bactrocera** Macquart

SPECIES PLACED IN COMPLEXES

aemula complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells colourless or with a pale tint and without microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with narrow dark basal band, mesonotum black (or with a distinct black lanceolate pattern), abdominal terga III–V with a medial longitudinal dark band and variable dark patterns on lateral margins, males attracted to cue lure.

Bactrocera (Bactrocera) aemula , n. sp. (Fig. 16)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Western Highlands Province: Mt Hagen, attracted to cue lure, 24.iii.1981, B. Thistleton.

LOCATION OF TYPE: Holotype (T.10474) in QM.

DISTRIBUTION

Known only from Mt Hagen, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized rectangular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells very pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V dark (III—black, IV—dark fuscous to black, V—fuscous) except fuscous posterocentrally on IV and red-brown posterocentrally on V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.9 mm. Frons narrowing slightly posteriorly, length 1.56 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized rectangular spots; length of face 0.60 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.35 mm; 0.98 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, along mesonotal suture, above notopleural suture and inside humeral calli. Pleural areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron

as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder including ventral margin black); 2 very broad lateral postsutural vittae narrowing sharply posteriorly to end well before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except apical ⅓ of all femora pale fuscous, fore tibiae pale fuscous and hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except fuscous lateral margins and a narrow transverse black band across centre of tergum and ending before lateral margins; tergum III black; tergum IV dark fuscous to black except small fuscous areas each side of a broad medial longitudinal black band; tergum V red-brown except anterolateral corners fuscous and a broad medial longitudinal black band,a pair of red-brown shining spots present. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. aemula is similar to *B. mimulus* (*dorsalis* complex) in having the costal band overlapping R_{2+3}, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle and costal cells with a pale fulvous tint. It differs from this species in possessing a narrower costal band which does not extend close to R_{4+5}.

Bactrocera (Bactrocera) consectorata , n. sp
(Fig. 17)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Stony logging area, Bulolo, attracted to cue lure, 4.iii.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 2 ♂♂ (18.ii.1980) and 2 ♂♂ (4.iii.1980), Upper Stony logging area, Bulolo, P. Daur; 4 ♂♂ (22.vi.1980), Oomsis Forestry Reserve, R.A.I. Drew and D.W. Currey; 3 ♂♂ (18–22.vi.1980), Gabensis, on Lae–Bulolo road, R.A.I. Drew and D.W. Currey; 3 ♂♂ (24.vi.1980), Mt Susu, P. Daur; 1 ♂ (31.xii.1980), Mt Missim (1500 m), A. Allison; all attracted to cue lure. NEW BRITAIN: 1 ♂ (31.vii.1969), Keravat, attracted to Willison"s lure, D. O"Sullivan.

LOCATION OF TYPES: Holotype (T.10475) and 1 paratype (T.10476) in QM; 4 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI(PNG); 8 paratypes in DPI.

DISTRIBUTION

Known only from the Morobe Province, Papua New Guinea and New Britain.

DIAGNOSIS

Medium sized species; medium sized triangular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripes broad reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a moderately broad medial and 2 broad lateral longitudinal dark bands connected along anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.75 mm. Frons narrowing slightly posteriorly, length 1.58 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump with a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized triangular black spots; length of face 0.5 mm. Genae fulvous, small brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–6 well developed black bristles. Antennae with segments 1 and 2 red-brown, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.38 mm; 0.93 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae. Pleural areas black except brown below humeral calli and dark fuscous above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching anterior npl. bristle

dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae dark fuscous; all other segments fulvous except pale fuscous tint on apical areas of fore femora and basal ⅓ of fore tibiae, fuscous hind tibiae; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for narrow dark fuscous lateral margins and a very narrow discontinuous transverse dark fuscous band across centre which reaches lateral margins; terga III–V orange-brown except as follows: a broad transverse black band across anterior margin of tergum III; 2 lateral longitudinal bands which are black anteriorly on tergum III, dark fuscous posteriorly on tergum III and anteriorly on tergum IV, fuscous posteriorly on tergum IV and laterally on tergum V; a moderately broad medial longitudinal black band over all 3 terga; tergum V fuscous between the dark fuscous oval shining spots. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. consectorata is similar to *B. fuliginus* (Drew and Hancock) in having a wide mesopleural stripe reaching to or anterior to the anterior npl. bristle but differs in the mesopleural stripe reaching the anterior npl. bristle whereas in *B. fuliginus* it extends almost to the humeral callus.

Bactrocera (Bactrocera) fuliginus (Drew and Hancock), n. comb (Fig. 18)

Dacus (Bactrocera) fuliginus Drew and Hancock, 1981: 66–7.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8261) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Cape York Peninsula, Queensland (type locality, Lockerbie).

NEW RECORDS: Papua New Guinea, Northern District: 1 ♂ (24.viii.1966), 1 ♂ (31.x.1966), Popondetta, B. Keoro; Morobe Province: 1 ♂, Gabensis, on Lae–Bulolo Road, attracted to cue lure, 18–22.vi.1980, R.A.I.Drew and D.W. Currey. Torres Strait islands: Badu I. (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; large oval facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching almost to humeral callus, lateral postsutural vittae present, medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal dark bands.

ATTRACTANT: Cue lure.

COMMENTS

B. fuliginus is similar to *B. consectorata* in having a wide mesopleural stripe extending to or anterior to anterior npl. bristle but differs in having a wider mesopleural stripe reaching almost to humeral callus.

Bactrocera (Bactrocera) inconstans , n. sp (Fig. 19)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute (1400 m), attracted to cue lure, 16.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: Upper Manki Logging area, Bulolo, 1 ♂ (21.iii.1980), 1 ♂ (25.iii.1980), 1 ♂ (28.iii.1980), 1 ♂ (1.iv.1980), attracted to cue lure, P. Daur; Upper Stony logging area, Bulolo, 3 ♂♂ (15.ii.1980), 3 ♂♂ (18.ii.1980), attracted to cue lure, P. Daur; 1 ♂, Wau, attracted to Willison"s lure, 3–10.iv.1965, E.N. Marks; 8 ♂♂, Mt Missim (1350–1650 m), attracted to cue lure, 30.x.1980, A. Allison. Central Province: 1 ♂, Bisianumu, Sogeri, attracted to cue lure, 25.vi.1980, R.A.I. Drew and D.W. Currey.

LOCATION OF TYPES: Holotype (T.10477) and 1 paratype (T.10478) in QM; 4 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI(PNG); 12 paratypes in DPI.

DISTRIBUTION

Known from Morobe and Central Provinces, Papua New Guinea.

DIAGNOSIS

Small species; small circular fuscous facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells very pale fulvous, microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V pale orange-brown except for a narrow medial and 2 moderately broad lateral longitudinal dark bands over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.25 mm. Frons of even width, length 1.45 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small circular to oval fuscous spots; length of face 0.40 mm. Genae fulvous, with large fuscous subocular spot present; fuscous bristle present. Occiput fuscous, yellow along eye margins; occipital row with 3–5 well developed bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.25 mm; 0.68 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae, along mesonotal suture, above notopleural suture. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing sharply posteriorly to end well before upper pa. bristles (occasionally these vittae are broader and end at the upper pa. bristles). Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells colourless to very pale fulvous; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless or with a pale fulvous tint, fuscous subcostal cell, narrow fuscous costal band confluent with or just overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band posterocentrally; tergum II pale orange-brown except for a broad transverse dark fuscous band across anterior ½ and becoming fuscous as it expands to cover lateral margins; terga III–V pale orange-brown except for 2 moderately broad lateral longitudinal bands which are dark fuscous to fuscous on tergum III and fuscous to pale fuscous on terga IV and V, a narrow medial longitudinal dark fuscous to black band over all 3 terga. A pair of oval orange-brown to fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. inconstans is similar to *B. mimulus* (*dorsalis* complex) and *B. aemula* (*aemula* complex) in possessing a mesopleural stripe which ends midway between anterior margin of notopleural callus and anterior npl. bristle above but differs in having the costal band confluent with R_{2+3} and a pale fuscous tint across wing membrane.

Bactrocera (Bactrocera) indecora (Drew), n. comb (Fig. 20)

Dacus (Asiadacus) indecorus Drew, 1971: 37–9.
Dacus (Strumeta) indecorus: Drew, 1972a: 19, 21.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6932) in QM.

DISTRIBUTION
New Britain and Lihir I. (type locality).

DIAGNOSIS
Medium sized species; circular facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vittae absent, scutellum yellow, prescutellar bristles absent; wing with a narrow fuscous costal band and broad fuscous anal streak, first costal cell pale fulvous and second costal cell colourless, microtrichia in outer corner of second costal cell only; abdominal terga II–V orange-brown with a broad medial longitudinal black band over all 4 terga and 2 broad lateral longitudinal dark bands over terga III–V.
ATTRACTANT: Cue lure.

COMMENTS
B. indecora was described adequately by Drew (1971). It is similar to *B. vulgaris* (Drew) in having the mesopleural stripe reaching to the anterior npl. bristle above but differs from this species in the costal band being confluent with R_{2+3} (not overlapping), lateral postsutural vittae parallel sided and ending before upper pa. bristle, prescutellar bristles absent. It is significant that the distribution of *B. indecora* is New Britain and New Ireland whereas *B. vulgaris* occurs in mainland Papua New Guinea.

Bactrocera (Bactrocera) laticosta , n. sp
(Fig. 21)

TYPE SPECIMENS
Holotype ♂, PAPUA NEW GUINEA, Central District: Hombrom Bluff, attracted to cue lure, 30.iii.1974, J. Stibick.
Paratypes, PAPUA NEW GUINEA, Central District: 1 ♂ (16.xi. 1973), 7 ♂♂ (30.xi.1973), 7 ♂♂ (5.i.1974), 4 ♂♂ (16.i.1974), Hombrom Bluff, J. Stibick; 3 ♂♂ (3.iii.1970), Brown River, T.L. Fenner; 1 ♂ (9.xi.1973), Sogeri, J. Stibick; 1 ♂ (30.xi.1973) and 1 ♂ (16.i.1974), Ninoa Estate, J. Stibick; 1 ♂ (8.xii.1973) and 5 ♂♂ (19.i.1974), Crystal Rapids, J. Stibick; all above paratypes attracted to cue lure. Morobe Province: 1 ♂, Wau Ecology Institute, Mt Kaindi (1230 m), attracted to cue lure, 15.xii.1980, A. Allison. WEST NEW BRITAIN: 1 ♂, Dami Oil Palm Station, attracted to Willison"s lure, 5–9.vi.1972, J. Stibick.
LOCATION OF TYPES: Holotype (T.10479) and 2 paratypes (T.10480–T.10481) in QM; 4 paratypes in ANIC; 4 paratypes in BMNH; 1 paratype in DPI(PNG); 22 paratypes in DPI.

DISTRIBUTION
Known from the Central District and Morobe Province, Papua New Guinea and West New Britain.

DIAGNOSIS
Medium sized species; very large subquadrate facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and narrow fuscous anal streak, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V dark orange-brown except for broad lateral and medial longitudinal dark bands which connect along anterior margin of tergum III.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.8 mm. Frons of even width, length 1.31 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fuscous with very large subquadrate black spots; length of face 0.55 mm. Genae fulvous, brown subocular spot present; fulvous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 5–10 well developed black bristles. Antennae with segments 1 and 2 red-brown, segment 3 fuscous; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.35 mm; 0.93 mm.

Thorax mesonotum black except dark brown markings as follows: below and behind lateral postsutural vittae; along mesonotal suture; between humeral and notopleural calli; inside humeral calli. Pleural areas dark fuscous except a black area on sternopleuron and red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; fore and mid femora dark fuscous (paler on ends), hind femora with apical ⅓ dark

fuscous (remainder fulvous); fore and hind tibiae dark fuscous, mid tibiae fulvous; all tarsi fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.4 mm; costal cells with pale fulvous tint, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} (except for a very narrow pale line above R_{4+5} centrally) and ending just beyond extremity of R_{4+5}, narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous to dark fuscous; tergum II orange-brown except anterolateral corners fuscous to dark fuscous and a transverse fuscous to dark fuscous band centrally but not reaching lateral margins; terga III–V dark orange-brown except for a broad transverse dark fuscous to black band cross anterior ½ of tergum III, 2 broad lateral longitudinal bands which are dark fuscous on terga III and IV and fuscous on tergum V, a broad medial longitudinal band which is dark fuscous on tergum III and black on terga IV and V. A pair of oval dark orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. laticosta is similar to *B. abdolonginqua* (Drew) and *B. dapsiles* (*dorsalis* complex) and *B. indecora* (Drew) and *B. vulgaris* (Drew) (*aemula* complex) in possessing costal cells coloured with a pale fulvous tint. It differs from *B. abdolonginqua* and *B. dapsiles* in having a broader costal band which is almost confluent with R_{4+5} and from *B. indecora* and *B. vulgaris* in having a narrower mesopleural stripe which ends midway between anterior margin of notopleural callus and anterior npl. bristle.

Bactrocera) trivialis
(Drew), n. comb. (Figs 22–24)

Dacus (*Strumeta*) *trivialis* Drew, 1971: 93–5.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6968) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Throughout Papua New Guinea (type locality, Kiwai I.) and Irian Jaya.

NEW RECORDS: Torres Strait islands: Badu, Boigu, Saibai (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized pear shaped facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; males with all leg segments fulvous except hind tibiae fuscous, females with dark colour patterns on femora and tibiae; abdominal terga III–V generally black with a medial longitudinal fulvous area from posterior margin of tergum III to tergum V.

DESCRIPTION

FEMALE: Ovipositor basal segment fuscous, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.74:1. Apex of piercer needle shaped with subapical bristles (Fig. 23). Spicules at distal end of middle segment wide with 11–15 small dentations of uneven length (Fig. 24).

HOST PLANTS

NEW RECORDS: *Capsicum* (Sogeri, Central District, August 1984, F. Dori) and grapefruit (Mt Hagen, Western Highlands District, 1980 and 1981, B. Thistleton). There are no known wild host records.

ATTRACTANT: Cue lure.

COMMENTS

B. trivialis was described adequately by Drew (1971). However, a large collection of specimens recently reared from grapefruit at Mt. Hagen, 1980, 1981, show sexual dimorphism in leg colour patterns: females possess fore, mid and apical ⅓ of hind femora dark fuscous, fore tibiae and apical 4 segments of fore tarsi fuscous, hind tibiae dark fuscous; males have all segments fulvous except hind tibiae fuscous. It is similar to *B. cacuminata* (Hering), *B. nigrescens* (Drew) and *B. opiliae* (Drew and Hardy) (*dorsalis* complex) in having colourless costal cells and the mesopleural stripe reaching midway between the anterior margin of notopleural callus and anterior npl. bristle. It differs from *B. cacuminata* and *B. opiliae* in having an entirely

black mesonotum and from *B. nigrescens* in having abdominal terga III–V mostly dark fuscous to black except orange-brown posterocentrally on tergum III and centrally on terga IV and V.

Bactrocera (Bactrocera) vulgaris (Drew), n. comb. (Figs 25–27)

Dacus (Strumeta) vulgaris Drew, 1971: 99–100.

MATERIAL EXAMINED
A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6973) in QM.

DISTRIBUTION
Known throughout Papua New Guinea (type locality, Kainantu).

DIAGNOSIS
Medium sized species; medium sized oval facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wings with a narrow fuscous costal band and anal streak, first costal cell pale fulvous, second costal cell colourless, microtrichia in outer corner of second costal cell only; abdominal terga II–V orange-brown with a broad medial longitudinal dark band over all 4 terga and narrow lateral longitudinal dark bands on terga III–V.

DESCRIPTION
FEMALE: Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 2.03:1. Apex of piercer rounded with 4 pairs of subapical bristles (Fig. 26). Spicules at distal end of middle segment of medium width with 8–10 dentations of uneven length (Fig. 27).
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. vulgaris was described adequately by Drew (1971). It is similar to *B. abdolonginqua* (Drew), *B. dapsiles* (*dorsalis* complex) and *B. indecora* (Drew), *B. laticosta* (*aemula* complex) in having costal cells coloured with a pale fulvous tint. It differs from *B. abdolonginqua*, *B. dapsiles* and *B. laticosta* in having a broader mesopleural stripe reaching to anterior npl. bristle, and from *B. indecora* in prescutellar bristles being present, costal band overlapping R_{2+3} and lateral postsutural vittae narrowing posteriorly to end at upper pa. bristles.

alyxiae complex

DEFINITION OF COMPLEX: *Bactrocera* species with infuscation on wing as a broad incomplete shaped band across centre and a narrow transverse band across apex in addition to costal band and anal streak, mesopleural stripe broad (reaching humeral callus dorsally), lateral postsutural vittae present, medial postsutural vitta absent, scutellum entirely yellow, males of some species attracted to cue lure.

Bactrocera (Bactrocera) alyxiae (May), n. comb. (Figs 28–30)

Strumeta alyxiae May, 1952: 335–7.
Dacus (Strumeta) alyxiae: Drew, 1974a: 14–16.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.5275) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: North Queensland (type locality, Mossman) and Papua New Guinea.
NEW RECORDS: Torres Strait islands: Badu, Boigu, Hammond, Horn, Moa (Banks), Prince of Wales, Saibai, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; medium sized pear shaped facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with broad lateral longitudinal dark markings, mesopleural stripe reaching to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wings with a broad fuscous costal band and anal streak, a broad recurved fuscous band across centre of wing and a narrow pale fuscous band across apex of wing, costal cells colourless, microtrichia in outer corner of second costal celly only; abdominal terga III–V orange-brown with 2 broad lateral longitudinal fuscous bands.

DESCRIPTION
FEMALE: Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.69:1. Apex of piercer tapering sharply from line of subapical bristles and rounded bluntly, with 3 pairs of subapical bristles (Fig. 29). Spicules at distal end of middle segment of medium width with 8–10 uneven elongate dentations (Fig. 30).
ATTRACTANT: Cue lure.

COMMENTS

B.alyxiae was described adequately by Drew (1974a) except that the mesonotum was defined as dull black rather than red-brown with irregular broad lateral longitudinal fuscous to dark fuscous bands. It is similar to *B. repanda* in having an identical wing colour pattern and similar yellow markings on thorax but differs from this species in having 2 broad lateral longitudinal fuscous bands on abdominal terga III–V.

Bactrocera (Bactrocera) repanda , n. sp.
(Fig. 31)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western District: 4 miles E of Morehead, 30.ix.1972, J. Stibick.

Paratypes, PAPUA NEW GUINEA, Western District: 3 ♂♂, 4 miles E of Morehead, 30.ix.1972, J. Stibick. East Sepik Province: 2 ♂♂, Maprik, Oct.–Dec. 1957, Malaria Control Sect.

LOCATION OF TYPES: Holotype (T.10482) in QM; 1 paratype in ANIC; 4 paratypes in DPI.

DISTRIBUTION

Known from Western District and East Sepik Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum black with fuscous markings, mesopleural stripe broad reaching to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a narrow transverse fuscous band across apex of wing and a broad recurved fuscous band across centre, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for narrow transverse fuscous bands anterolaterally on tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.75 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles fuscous: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–7 well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong red-brown dorsal bristle on segment 2; length of segments: 0.20 mm; 0.35 mm.

Thorax mesonotum black except fuscous markings as follows: a medial longitudinal band which broadens to cover posterior area, below and behind lateral postsutural vittae, around mesonotal suture, between humeral and notopleural calli, inside humeral calli. Pleural areas fuscous to dark fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching to humeral callus dorsally, continuing to sternopleuron as a small tranverse spot, anterior margin concave; upper hypopleural calli (posterior apices dark fuscous); anterior 3/5 lower hypopleural calli (remainder dark fuscous); 2 lateral postsutural vittae of medium width narrowing posteriorly to end before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; npl. 1; mpl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M, a narrow transverse fuscous band across apex of wing, a broad transverse fuscous band across centre of wing which encloses both crossveins and recurves back along posterior margin of CuA_1, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous tending darker laterally; tergum II orange-brown except for a broad pale fuscous transverse band across anterior ½ and widening to cover lateral margins; terga III–V orange-brown except for a narrow transverse fuscous band anterolaterally on tergum III. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. repanda is similar to *B. alyxiae* (May) in

having an identical wing colour pattern and similar yellow markings on thorax but differs in having abdominal terga III–V orange-brown except for narrow transverse anterolateral fuscous spots on tergum III.

anthracina complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, humeral and notopleural calli yellow, scutellum yellow with narrow dark basal band, mesonotum and abdominal terga entirely black, males of some species attracted to cue lure.

Bactrocera (Bactrocera) anthracina (Drew), n. comb. (Fig. 32)

Dacus (*Strumeta*) *anthracinus* Drew, 1971: 59–61.

MATERIAL EXAMINED
Holotype ♂, Upper Warangoi Valley, New Britain, attracted to cue lure, October 1969, D.F. O'Sullivan.
LOCATION OF TYPE: Holotype (T.6945) in QM.

DISTRIBUTION
Upper Warangoi Valley, New Britain (type locality).

DIAGNOSIS
Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe equal in width to notopleural callus, scutellum yellow; wings with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia in outer corner of second costal cell only; all abdominal terga black.
ATTRACTANT: Cue lure.

COMMENTS
B. anthracina was described adequately by Drew (1971). It is similar to *B. batemani* (*nigella* complex) in possessing coloured costal cells with microtrichia in outer corner of second costal cell only but differs in having broad lateral postsutural vittae ending behind the upper pa. bristles and legs with all tibiae and apices of all femora fuscous.

Bactrocera (Bactrocera) aterrima (Drew), n. comb. (Fig. 33)

Dacus (*Strumeta*) *aterrimus* Drew, 1972b: 204–5.

MATERIAL EXAMINED
A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6991) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: Bougainville I. (type locality, Daru Village).
NEW RECORD: Shortland Is (Solomon Islands).

DIAGNOSIS
Medium sized species; very large black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching almost to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad black basal band; wing with a narrow pale fuscous costal band and a broad fuscous anal streak, costal cells colourless to extremely pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga mostly dull black.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. aterrima was described adequately by Drew (1972b). It is similar to *B. nigella* (Drew) (*nigella* complex) and *B. terminaliae* (*anthracina* complex) in possessing costal cells colourless or almost colourless but differs in having the mesopleural stripe reaching almost to the humeral callus and the lateral postsutural vittae ending well before the upper pa. bristle.

Bactrocera (Bactrocera) caliginosa (Hardy), n. comb.

Dacus (*Strumeta*) *caliginosus* Hardy, 1970: 116–8; Drew, 1974a: 24–5.

MATERIAL EXAMINED
1 ♂ paratype, Yalom, New Britain, May 1962, collected on Noona Dan Expedition.
LOCATION OF TYPE: Holotype ♂ in ZMC.

DISTRIBUTION
Yalom, New Britain (type locality).

DIAGNOSIS
Medium sized species; large elongate black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vittae absent, scutellum yellow with a broad black basal band; wing with a narrow fuscous costal band and broad

fuscous anal streak, costal cells pale fuscous with microtrichia in all of second costal cell and most of first cell; abdominal terga mostly black.
ATTRACTANT: No known record.

COMMENTS

B. caliginosa was described adequately by Hardy (1970) with additional notes by Drew (1974a). It is similar to *B. kelaena* (*nigella* complex) in possessing coloured costal cells with microtrichia covering all of second and most of first costal cells but differs in having narrow lateral postsutural vittae ending well before the upper pa. bristle, scutellum with a broad black basal band and the mesopleural stripe not reaching the humeral callus above.

Bactrocera (Bactrocera) terminaliae , n. sp.
(Figs 34–36)

TYPE SPECIMENS

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Oomsis logging area, bred ex fruit of *Endiandra* sp., 17.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province, Oomsis: 1 ♀, bred ex fruit of *Endiandra* sp., 17.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♀ (29.iii.1978) and 1 ♀ (20.iii.1979), bred ex fruit of *Terminalia complanata*, J. Simpson.

LOCATION OF TYPES: Holotype (T.10483) in QM; 1 paratype in ANIC; 2 paratypes in DPI.

DISTRIBUTION

Known only from Oomsis, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots large and oval; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia covering outer ⅓ of second costal cell only; abdominal terga III–V black except for small orange-brown areas each side of a narrow medial longitudinal fuscous to dark fuscous band on tergum V and posterior area of tergum IV.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.7 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large oval black spots; length of face 0.45 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fuscous, yellow along eye margins; occipital row with 5–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.28 mm; 0.80 mm.

Thorax mesonotum black except brown behind lateral postsutural vittae. Pleural areas dark fuscous to black except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior 5/9 lower hypopleural calli (remainder including broad ventral margins dark fuscous); 2 lateral postsutural vittae of medium width narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae dark fuscous; fore femora dark fuscous (tending fulvous basally), mid femora black, hind femora with apical ⅓ black (remainder fulvous); fore and mid tibiae fuscous (fore tibiae slightly darker), hind tibiae dark fuscous; all tarsi fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.6 mm; costal cells colourless; microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad transverse black band across anterior ½ and widening to cover lateral margins; terga III–V mostly black except for small orange-brown areas either side of a narrow medial

longitudinal fuscous to dark fuscous band on tergum V and posterior margin of tergum IV. A pair of oval dark fuscous shining spots on tergum V. Basal segment of ovipositor dark fuscous, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.81:1. Apex of piercer needle shaped with 2 pairs of large subapical bristles (Fig. 35). Spicules at distal end of middle segment of medium width with 4–5 broad and occasional smaller dentations (Fig. 36).

ATTRACTANT: No known record.

COMMENTS

B. terminaliae is similar to *B. aterrima* (Drew) (*anthracina* complex) and *B. nigella* (Drew) (*nigella* complex) in possessing costal cells colourless or almost so but differs from *B. aterrima* in having the mesopleural stripe ending well before the humeral callus above and lateral postsutural vittae ending at the upper pa. bristles. It differs from *B. nigella* in having large oval facial spots, femora dark fuscous to black (except hind femora with basal ⅔ fulvous), fore and mid tibiae fuscous and hind tibiae dark fuscous.

assita complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for a narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells generally coloured, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a dark basal band, mesonotum black, abdominal terga III–V mostly orange-brown, males of some species attracted to cue lure.

Bactrocera (Bactrocera) assita , n. sp. (Fig.37)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Milne Bay Province: Gurney, 16–23.vii.1977, A. Eteboyo.

Paratypes, PAPUA NEW GUINEA, Milne Bay Province: 1 ♂ (Dak Pot trap), Waigani, 16–23.vii.1977, A. Eteboyo; 1 ♂, Gurney, 16–23.vii.1977, A. Eteboyo. Morobe Province: 1 ♂, Bubia, attracted to cue lure, June–July 1971 and 1 ♂, Bubia, attracted to Willison's lure, April–May 1971, J. Maiyel; 1 ♂, Mt Missim (1100 m), attracted to cue lure, 30.vii.1981, A. Allison.

LOCATION OF TYPES: Holotype (T.10484) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 3 paratypes in DPI.

DISTRIBUTION

Known from Milne Bay and Morobe Provinces, Papua New Guinea.

DIAGNOSIS

Small species; facial spots medium sized and oval; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe slightly wider than notopleural callus dorsally, scutellum yellow; wing with a narrow fuscous costal band (but almost confluent with R_{4+5}) and broad fuscous anal streak, first costal cell very pale fuscous, second costal cell pale fuscous, microtrichia covering second costal cell and most of first costal cell; abdominal terga III–V orange-brown except for lateral longitudinal fuscous bands which are broad on tergum III and either narrow or absent on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.55 times breadth; fulvous with at most pale fuscous around s.or. bristles, anteromedial hump prominent and covered by a small number of short pale setae; orbital bristle dark fuscous: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; dark fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 3–4 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.73 mm.

Thorax mesonotum black except brown behind lateral postsutural vittae. Pleural areas dark fuscous to black except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, slightly wider than notopleural callus, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs all coxae fuscous; all other segments fulvous; rows of short pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.3 mm; first costal cell pale fuscous, second costal cell fuscous, microtrichia

covering second costal cell and most of first costal cell; remainder of wings colourless except dark fuscous subcostal cell, narrow dark fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown with a broad transverse dark fuscous band across anterior ⅓ and widening to cover lateral margins; terga III–V orange-brown except for lateral longitudinal fuscous bands which are broad on tergum III and either narrow or absent on terga IV and V. A pair of oval orange-brown to pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. assita is similar to *B. bancroftii* (Tryon) (*musae* complex), *B. circamusae*, *B. contermina* and *B. contigua* (*assita* complex) in possessing coloured costal cells but differs from these species in having fuscous costal cells covered by dense microtrichia.

Bactrocera (Bactrocera) brevistriata (Drew), n. comb. (Figs 38–40)

Strumeta brevistriata Drew, 1968b: 77–8.
Dacus (*Strumeta*) *brevistriatus*: Drew, 1972a: 21.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6611) in QM.

DISTRIBUTION

Known from Bulolo to Wau (type locality), Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots either absent or very pale and small; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown with a narrow elongate medial fuscous spot on tergum V.

DESCRIPTION

FEMALE: Ovipositor ratio of length of oviscape to length of tergum V 1.7:1; apex of piercer tapering sharply to a point from line of subapical bristles, with 4 pairs of subapical bristles (Fig. 39). Spicules at distal end of middle segment of medium width with 4–7 short broad triangular dentations (Fig. 40).

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. brevistriata was described adequately by Drew (1968b). It is similar to *B. prolixa* (*musae* complex) and *B. commina* (*assita* complex) in having lateral postsutural vittae ending before upper pa. bristles. It differs from *B. commina* in possessing colourless costal cells, abdominal terga II–V mostly uniformly orange-brown and in the shape of the apex of the piercer and spicules on the middle segment of the ovipositor. *B. brevistriata* differs from *B. prolixa* in having the costal band confluent with R_{2+3} and abdomen oval with a medial longitudinal fuscous band on tergum III.

Bactrocera (Bactrocera) circamusae , n. sp. (Fig. 41)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, attracted to cue lure, 22.vi.1980, R.A.I.Drew and D.W. Currey.
LOCATION OF TYPE: Holotype (T.10485) in QM.

DISTRIBUTION

Known only from Oomsis, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; small pale fuscous facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe broad reaching almost to anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia in outer ⅓ of second costal cell only; abdominal terga I–V orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.75 mm. Frons of even width, length 1.6 times breadth; fulvous with pale fuscous around s.or. bristles and upper pair of i.or. bristles; anteromedial hump with a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or. (3

on 1 side); lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with small pale fuscous spots present; length of face 0.50 mm. Genae fulvous, subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.33 mm; 0.85 mm.

Thorax mesonotum black except brown markings as follows: below and behind lateral postsutural vittae, around mesonotal suture, above notopleural suture, inside humeral calli. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous; mid tibiae each with an apical black spur; rows of long pale setae on dorsal surfaces of fore femora.

Wings length 6.6 mm; costal cells fulvous; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band just overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V orange-brown with no dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. circamusae is similar to *B. bancroftii* (Tryon) (*musae* complex), *B. contermina* and *B. contigua* (*assita* complex) in possessing pale coloured costal cells with microtrichia in outer corner of second costal cell only but differs in having the mesopleural stripe reaching anterior npl. bristle dorsally, facial spots very small and pale and costal cells fulvous.

Bactrocera (Bactrocera) commina, n. sp.
(Figs 42–44)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Upper Stony logging area, Bulolo, collected under leaf of *Musa* sp., 20.VII.1979, H. Ivagai.

LOCATION OF TYPE: Holotype (T.10486) in QM.

DISTRIBUTION

Known only from Upper Stony logging area, Bulolo, Morobe Province, Papua New Guinea.

DIAGNOSIS

Small species; medium sized triangular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band (but not confluent with R_{4+5}) and anal streak, costal cells pale fulvous, microtrichia covering most of second costal cell; abdominal terga III–V orange-brown except for a narrow medial and 2 moderately broad lateral longitudinal dark bands over all 3 terga and joined along anterior margin of tergum III.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.15 mm. Frons of even width, length 1.47 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized triangular black spots; length of face 0.35 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput fuscous, yellow along eye margins; occipital row with 2–4 weak bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a weak pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.65 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally,

continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing slightly posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2 scp. 4; all bristles weak and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except fore and mid tibiae fuscous, hind tibiae dark fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.7 mm; costal cells pale fulvous; microtrichia along anterior margin of first costal cell and covering most of second costal cell except posterior margin; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad black transverse band across anterior ½ which changes to dark fuscous as it widens to cover lateral margins; terga III–V orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum III, a narrow medial longitudinal dark fuscous band and 2 moderately broad lateral longitudinal fuscous bands over all 3 terga. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 2.46:1; apex of piercer rounded at tip with 3 pairs of subapical bristles (Fig. 43). Spicules at distal end of middle segment of medium width with 2–4 dentations, 1 or 2 of which are elongate and broad (Fig. 44).

ATTRACTANT: No known record.

COMMENTS

B. commina is similar to *B. prolixa* (*musae* complex) and *B. brevistriata* (Drew) (*assita* complex) in having lateral postsutural vittae ending before upper pa. bristle but differs from these species in having costal cells pale fulvous, abdominal terga III–V orange-brown with narrow medial and lateral longitudinal pale fuscous to fuscous bands joined along anterior margin of tergum III. It also differs from *B. brevistriata* in the shape of the apex of the piercer and spicules on the middle segment of the ovipositor.

Bactrocera (Bactrocera) contermina, n. sp. (Figs 45–47)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Stony logging area, Bulolo, attracted to a yellow tray, 26.i.1979, H. Roberts.

LOCATION OF TYPE: Holotype (T.10487) in QM.

DISTRIBUTION

Known only from Stony logging area, Bulolo, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; small circular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band (but not confluent with R_{4+5}) and anal streak, costal cells very pale fulvous, microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V orange-brown except for 2 narrow lateral longitudinal fuscous bands joined along anterior margin of tergum III and a narrow medial longitudinal fuscous band from centre of tergum III to posterior margin of tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.45 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small circular black spots; length of face 0.43 mm. Genae fulvous, large brown subocular spot present; fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 6–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fuscous except fulvous along ventral margin; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.78 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas

dark fuscous except red-brown below humeral calli, above mid coxae and black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior 3/5 lower hypopleural calli (remainder dark fuscous); 2 lateral postsutural vittae of medium width narrowing slightly posteriorly to end at pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except fore tibiae pale fuscous and hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.5 mm; costal cells very pale fulvous; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. All terga orange-brown, without dark markings. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 2.0:1; apex of piercer narrow and needle shaped with 5 pairs of subapical bristles (Fig. 46). Spicules at distal end of middle segment wide with 9–14 thin dentations of approximately equal size (Fig. 47).

ATTRACTANT: No known record.

COMMENTS

B. contermina is similar to *B. bancroftii* (Tryon) (*musae* complex) and *B. contigua* (*assita* complex) in possessing pale fulvous costal cells, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle and clearly defined facial spots. It differs from *B. bancroftii* in having scutellum entirely yellow without a dark spot on apex and from *B. contigua* in having all abdominal terga uniformly orange-brown and in the shape of the apex of the piercer and spicules on middle segment of the ovipositor.

Bactrocera (Bactrocera) contigua, n. sp.
(Figs 48–50)

TYPE SPECIMENS

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Robbies Creek, Stony logging area, Bulolo, hand collected under leaf of *Musa* sp., 13.vii.1979, H. Roberts.

Paratype, PAPUA NEW GUINEA, Morobe Province: 1 ♀, Robbies Creek, Stony logging area, Bulolo, hand collected under leaf of *Musa* sp., 13.vii.1979, H. Roberts.

LOCATION OF TYPES: Holotype (T.10488) in QM; paratype in DPI.

DISTRIBUTION

Known only from the Bulolo area, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; small to medium circular black facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and narrow fuscous anal streak, costal cells very pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for anterolateral corners of tergum III fuscous and a narrow medial longitudinal fuscous band over all 3 terga and broken at sutures.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.9 mm. Frons of even width, length 1.46 times breadth; fulvous with fuscous around orbital bristles and pale fuscous on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with small to medium sized circular black spots; length of face 0.58 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.40 mm; 0.93 mm.

Thorax mesonotum black except brown

markings as follows: below and behind lateral postsutural vittae; along mesonotal suture; between humeral and notopleural calli; inside humeral calli. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 4 (1 basal bristle weak); prsc. 2; pa 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs all coxae fuscous; all other segments fulvous except fore and mid tibiae pale fuscous and hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 7.0 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad dark fuscous transverse band across anterior margin which changes to fuscous as it widens to cover lateral margins; terga III–V orange-brown except for fuscous anterolateral corners on tergum III and a narrow medial longitudinal fuscous band which is broken at intersegmental lines (in the paratype there is a narrow fuscous band along anterior margin of tergum III). A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 1.68:1; apex of piercer rounded with 4 pairs of subapical bristles (Fig. 49). Spicules at distal end of middle segment of medium width with 1–4 dentations, 1–3 of which are very long (Fig. 50).

ATTRACTANT: No known record.

COMMENTS

B. contigua is similar to *B. bancroftii* (Tryon) (*musae* complex) and *B. contermina* (*assita* complex) in possessing pale fulvous costal cells, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle) and clearly defined facial spots. It differs from *B. bancroftii* in lacking a brown spot on apex of scutellum and in possessing dark markings on abdominal terga III–V and a wider costal band (at least as wide as subcostal cell). It differs from *B. contermina* in having abdominal tergum III with pale fuscous anterolateral corners, apex of ovipositor short and stout (length from gonopore to tip:width at preapical sensory bristles is 4.4:1), spicules at distal end of middle segment of ovipositor 2.5 times as wide as long with 1–3 very large dentations (Figs 49, 50).

Bactrocera (Bactrocera) finitima, n. sp.
(Figs 51–53)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Robbies Creek, Stony logging area, Bulolo, hand collected on leaf of *Musa* sp., 3.vii.1979, H. Roberts.

LOCATION OF TYPE: Holotype (T.10489) in QM.

DISTRIBUTION

Known only from the Bulolo area, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized pear shaped facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band (but not confluent with R_{4+5}) and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V pale orange-brown except for a narrow medial longitudinal band on posterior ½ of tergum IV and on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.50 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small

number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.55 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.35 mm; 0.90 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II pale orange-brown except for an irregular fuscous spot anterocentrally; terga III–V pale orange-brown except for a narrow medial longitudinal band which is fuscous on posterior ½ of tergum IV and black on tergum V. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 2.63:1; apex of piercer narrow, needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 52). Spicules at distal end of middle segment of medium width with 8–12 thin dentations of approximately equal size (Fig. 53).

ATTRACTANT: No known record.

COMMENTS

B. finitima is similar to *B. musae* (Tryon) (*musae* complex) and *B. tinomiscii* (*assita* complex) in possessing a black mesonotum and colourless costal cells but differs in possessing a broader costal band (almost confluent with R_{4+5}), apex of ovipositor narrowing gradually from level of gonopore to tip and spicules at distal end of middle segment with 8–12 dentations of approximately equal size.

Bactrocera (Bactrocera) robertsi, n. sp. (Fig. 54)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute (1400 m), attracted to cue lure, 16.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Wau Ecology Institute (1400 m), 16.vi.1980, R.A.I. Drew and D.W. Currey; 3 ♂♂ (28.iii.1980), 5 ♂♂ (1.iv.1980), Upper Manki logging area, Bulolo, P. Daur; 1 ♂ (26.v.1980), 1 ♂ (30.v.1980), Gumi Watut, Bulolo, P. Daur; 1 ♂, Mt Missim (1650 m), 30.x.1980 and 1 ♂, Mt Missim (1400 m), 4.vi.1981, A. Allison; 1 ♂, Mt Kaindi (1450 m), 18.vi.1980 and 1 ♂, Namie Creek, Mt Kaindi (1600 m), 15.xii.1980, A. Allison. Western Highlands Province: 1 ♂ (30.x.1978), 1 ♂ (6.xii.1978), Kuk Tea Research Station, Mt Hagen and 1 ♂, HATI, Mt Hagen, 3.ii.1981, B. Thistleton. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10490) and 1 paratype (T.10491) in QM; 4 paratypes in ANIC; 2 paratypes in BMNH, 1 paratype in DPI(PNG); 10 paratypes in DPI.

DISTRIBUTION

Known from the Morobe and Western Highlands Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with facial spots absent or very small and pale; humeral calli yellow; notopleural calli yellow except anterior ⅓ to ½ black; mesonotum black, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, first costal cell fulvous, second costal cell pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown with a narrow transverse dark band across anterior margin of tergum III, narrow irregular lateral

fuscous margins and a narrow medial longitudinal fuscous to black band on all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.73 mm. Frons of even width, length 1.42 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered with a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with spots absent or very small and pale; length of face 0.5 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 3–4 well developed dark bristles. Antennae with all segments fulvous except fuscous on apex and outer surface of segment 3; arista black (fulvous basally); length of segments: 0.18 mm; 0.33 mm; 0.85 mm.

Thorax mesonotum black except dark brown below lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli (black on anterior ⅓ to ½); mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin slightly convex; 2 moderately broad lateral postsutural vittae narrowing posteriorly to end before the upper pa. bristle; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black). Postnotum black. Scutellum yellow except for broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs coxae dark fuscous; all other segments fulvous except hind tibiae fuscous; mid tibiae each with an apical black spur; fore femora with rows of long dark setae on dorsal surfaces.

Wings length 7.0 mm; first costal cell fulvous, second costal cell pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless (or with a very pale fulvous tint) except for a fuscous subcostal cell, a narrow fuscous costal band confluent with R_{2+3} and ending between extremitiies of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III; tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse red-brown band across posterior margin. Tergum II red-brown except for a broad transverse black band across anterior margin and ending before lateral margin. Terga III–V red-brown except for a narrow transverse band across anterior margin of tergum III which is fuscous in centre and dark fuscous on lateral margins, irregular narrow fuscous lateral margins on terga IV and V, a narrow medial longitudinal band which is fuscous on tergum III and black on terga IV and V. (Two specimens have terga III–V pale with only the medial longitudinal black band on terga IV and V.) A pair of red-brown oval shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. robertsi is similar to other species of the *assita* and *musae* complexes in possessing clear wings except for costal band and anal streak, a black mesonotum and abdominal terga mostly orange-brown but differs in having notopleural calli with anterior ½ black and posterior ½ yellow and a broad black basal band on the scutellum.

This species is named after Dr H. Roberts, Bulolo, who has provided valuable specimens through field collecting in Papua New Guinea.

Bactrocera (Bactrocera) tinomiscii, n. sp. (Figs 55–58)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central District: in rainforest at Rouna Power Station No. 2, near Sogeri, bred ex *Tinomiscium phytocrenoides*, 25.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Central District: 1 ♀, Rouna Power Station No. 2, near Sogeri, caught on fruit of *Tinomiscium phytocrenoides*, 7.vi.1980, R.A.I. Drew and D.W. Currey; 20 ♂♂ and 29 ♀♀ (25.vi.1980), in rainforest at Rouna Power Station No. 2, near Sogeri, bred ex *Tinomiscium phytocrenoides*, R.A.I.Drew and D.W. Currey; 9 ♂♂ (25.vi.1980) in rainforest at Rouna Power Station No. 2, near Sogeri, attracted to cue lure, R.A.I. Drew and D.W. Currey. Morobe Province: 4 ♂♂ and 4 ♀♀ (21.vi.1980), Waramuri Creek, Bulolo, bred ex *Chlaenandra ovata*, H. Roberts; 3 ♀♀ (21.iv.1980), Waramuri Creek, Bulolo, bred ex fruit, P. Daur; 1 ♂ (December, 1978) and 1 ♀ (29.i.1979), Stony logging area, Bulolo, bred ex *Xanthophyllum* sp., H. Ivagai; 1 ♂ (14.vi.1978), Stony logging area, Bulolo, bred ex *Xanthophyllum* sp., H. Roberts; 1 ♂ (22.vi.1980), Bulolo, attracted to cue lure, R.A.I. Drew and D.W. Currey.

LOCATION OF TYPES: Holotype (T.10492) and 2 paratypes (T.10493–T.10494) in QM; 10 paratypes in ANIC; 10 paratypes in BMNH; 7 paratypes in DPI(PNG); 45 paratypes in DPI.

DISTRIBUTION

Known from Sogeri (Central District), Bulolo

(Morobe Province), Kassam Pass (Eastern Highlands District) and the Sepik District in Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with small irregularly oval facial spots; humeral and notopleural calli yellow; mesontoum black, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with small fuscous markings on anterolateral and posterolateral corners of tergum III and with a narrow medial longitudinal dark band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.65 mm. Frons narrowing slightly posteriorly, length 1.65 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small irregularly oval spots present; length of face 0.53 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.33 mm; 0.80 mm.

Thorax mesonotum black except brown markings as follows: below and behind lateral postsutural vittae, around mesonotal suture, above notopleural suture, inside humeral calli and along anterior margin. Pleural areas fuscous except red-brown below humeral calli and black along anterior margin of mesopleural stripe and on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae narrowing slightly over posterior ½ to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae fuscous; remaining segments fulvous except basal ½ of hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band just overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak narrowing sharply to end before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous to dark fuscous except for orange-brown along posterior and lateral margins; tergum II orange-brown except for a narrow fuscous transverse band along anterior margin but not reaching lateral margins. Terga III–V orange-brown with small fuscous markings on anterolateral and posterolateral corners of tergum III and a narrow medial longitudinal band which is dark fuscous on tergum III and black on terga IV and V (in some specimens this band is absent on tergum III). A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 2.67:1. Apex of piercer needle shaped, curved upwards with 3 or 4 pairs of short subapical bristles; the upward curve of the apex is a most unusual character within the Dacinae (Figs 56, 57). Spicules at distal end of middle segment varying from wide to medium width with 4–6 dentations, some broad and elongate and some small (Fig. 58). ATTRACTANT: Cue lure.

COMMENTS

B. tinomiscii is similar to *B. musae* (Tryon) (*musae* complex) and *B. finitima* (*assita* complex) in possessing a black mesonotum and colourless costal cells but differs in possessing a paler costal band barely overlapping R_{2+3} and narrowing

towards apex of wing, apex of ovipositor curved upwards in lateral view, elongated and pointed sharply at tip, subapical sensory setae small and approximately of equal size (Figs 56, 57).

bidentata complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for a narrow costal band (not confluent with R_{4+5}) and anal streak, costal cell fulvous and without dense microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V without dark colour patterns on lateral margins, males of some species attracted to cue lure.

Bactrocera (Bactrocera) aeroginosa (Drew and Hancock), n. comb. (Fig. 59)

Dacus (*Bactrocera*) *aeroginosus* Drew and Hancock, 1981: 57–9.

MATERIAL EXAMINED
A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8242) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: Coastal areas of Queensland, north of Innisfail (type locality, Lockerbie in Cape York Peninsula).
NEW RECORD: Torres Strait islands: Saibai (record from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; medium sized black facial spots; humeral and notopleural calli yellow; mesonotum pale red-brown, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia in outer corner of second costal cell only; abdominal terga mostly orange-brown with a narrow medial longitudinal dark band on terga IV and V and occasionally on tergum III.
ATTRACTANT: Cue lure.

COMMENTS
B. aeroginosa was described adequately by Drew and Hancock (1981). It is similar to *B. bidentata* (May) in possessing a uniformly red-brown mesonotum, abdominal terga III–V orange-brown without dark lateral margins and costal cells fulvous without dense microtrichia but differs from this species in having broad parallel sided lateral postsutural vittae ending at upper pa. bristles, fulvous hind tibiae and costal band confluent with R_{2+3}.

Bactrocera (Bactrocera) bidentata (May), n. comb. (Figs 60–62)

Strumeta bidentata (May), 1962b: 527–30; May, 1963: 50.

MATERIAL EXAMINED
Holotype ♂, 3 ♂ and 4 ♀ paratypes.
LOCATION OF TYPE: Holotype (T.5890) in QM.

DISTRIBUTION
Byfield (type locality) and Cairns, Queensland.

DIAGNOSIS
Medium sized species; medium sized circular black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs entirely fulvous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a narrow transverse fuscous band across anterior margin of tergum III, a medial longitudinal elongate fuscous spot on tergum IV and a black spot on tergum V.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.5 times breadth; fulvous without dark markings; anteromedial hump covered by a large number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots; length of face 0.48 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.73 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between

anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 lateral postsutural vittae narrowing posteriorly to end just before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.0 mm; costal cells pale fuscous (second cell slightly paler); microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I and II orange-brown except fulvous along posterior margin of tergum II; terga III–V orange-brown except for a narrow transverse fuscous band across anterior margin of tergum III, a medial longitudinal elongate fuscous spot on tergum IV and a medial longitudinal elongate black spot on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, conical in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1:1. Apex of piercer with 3 pairs of well developed subapical lobes; 3 pairs of subapical bristles (1 large and 2 small) (Fig. 61). Spicules at distal end of middle segment of medium width with 9–13 dentations of slightly uneven size (Fig. 62).

ATTRACTANT: No known record.

COMMENTS

B. bidentata is similar to *B. aeroginosa* (Drew and Hancock) in the characters listed in the comments on *B. aeroginosa* but differs from this species in possessing narrow lateral postsutural vittae tapering sharply posteriorly to end before upper pa. bristles, hind tibiae brown and costal band overlapping R_{2+3}. *B. decurtans* (May) and *B. bidentata* are identical in external body colour patterns. The absence of prsc. and sa. bristles in *B. decurtans* may not be significant and it is probably an aberrant *Bactrocera* species. Both species have similar trilobed apices on the aculeus but can still be separated on this character.

bryoniae complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for a broad costal band (confluent with or overlapping R_{4+5}) and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a dark basal band, mesonotum black, abdominal terga III–V orange-brown with variable dark colour patterns, males of some species attracted to cue lure.

Bactrocera (Bactrocera) bryoniae
(Tryon), n. comb. (Figs 63–5)

Chaetodacus bryoniae Tryon, 1927: 192.
Chaetodacus costalis Shiraki, 1933: 66–9; Perkins, 1938: 127 (syn.).
Strumeta bryoniae: Perkins, 1938: 127–8; May, 1963: 50.
Dacus (Strumeta) bryoniae: Hardy, 1951: 148–9; Drew, 1974a: 21–4.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: *C. bryoniae*, lectotype ♀ (D.3124) and 3 ♂ paralectotypes (D.3124) in QM; *C. costalis*, ♂ ♀ syntypes in NTU.

DISTRIBUTION

PREVIOUSLY RECORDED: Widespread and abundant throughout its range (type locality, Eidsvold, Queensland). Known from northern coastal areas of Western Australia, Northern Territory (including Melville and Bathurst Is), Papua New Guinea, New Britain, New Ireland and Lihir I.

NEW RECORDS: Torres Strait islands: Badu, Boigu, Darnley, Horn, Moa (Banks), Murray, Saibai, Stephens, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Large species; irregularly circular black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vitte present, medial postsutural vitta absent,

scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fulvous, microtrichia covering outer ½ of second costal cell only; abdominal terga III–V orange-brown with a medial and 2 lateral longitudinal dark bands joined along anterior margin of tergum III.

DESCRIPTION

FEMALE: Ovipositor basal segment of ovipositor red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.56:1. Apex of piercer very broad and rounded at tip, with 3 pairs of very small subapical bristles (Fig. 64). Spicules at distal end of middle segment narrow, scale-like with 2–4 short, broad, triangular dentations (Fig. 65).
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. bryoniae was described adequately by Drew (1974a). It is similar to other species in the *bryoniae* complex in possessing a broad costal band confluent with or overlapping R_{4+5} for its entire length, no infuscation on wing in addition to costal band and anal streak, lateral postsutural vittae present and medial postsutural vitta absent. It differs from these species in having costal band confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles, abdominal terga III–V red-brown with a broad, dark fuscous band along anterior margin of tergum III and covering lateral margins, anterolateral corners of terga IV and V fuscous and a medial longitudinal dark fuscous band over all 3 terga.

Drew (1978, 1982) listed *B. bryoniae* as a pest species in Queensland. This report was based on incorrect identifications. There are no records of this species reared from edible fruits and it cannot be considered of any economic importance.

Originally, Tryon (1927) designated a holotype, allotype and 2 paratypes but the specimens only have white labels marked "TYPE D/3124" and the description does not define which specimen is the holotype. A female and male are on 1 pin and 2 males on another pin. I am designating the female as the lectotype and the 3 males as paralectotypes. The specimens were collected at Eidsvold, Queensland by T.L. Bancroft.

Bactrocera (Bactrocera) epicharis (Hardy), n. comb.

Dacus (Strumeta) epicharis Hardy, 1970: 119–20; Drew, 1974a: 37.

MATERIAL EXAMINED

1 ♂ paratype, Malakata, Mussau I., June 1962, collected on Noona Dan Expedition.
LOCATION OF TYPE: Holotype ♂ in ZMC.

DISTRIBUTION

PREVIOUSLY RECORDED: Malakata, Mussau I. (type locality).
NEW RECORD: Shortland Is (Solomon Islands).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe equal in width to notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer corner of second costal cell only; abdominal terga mostly black.
ATTRACTANT: No known record.

COMMENTS

B. epicharis was described adequately by Hardy (1970) with additional notes by Drew (1974a). It is similar to the other species in the *bryoniae* complex in the characters listed in the comments on *B. bryoniae* but differs in having the costal band confluent with R_{4+5}, abdominal terga mostly black, microtrichia in outer corner of second costal cell only, legs with femora mostly dark fulvous, fore and mid tibiae dark fulvous and hind tibiae fuscous.

Bactrocera (Bactrocera) latissima, n. sp. (Fig. 66)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute (1230 m), attracted to cue lure, 10.xi.1980, A. Allison.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 2 ♂♂, Gabensis, on Lae–Bulolo road, 18–22.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♂, Mt Kaindi (1230 m), 15.x.1980, A. Allison; 1 ♂, 18.xii.1980, Mt Missim (1400 m) and 1 ♂, 19.iii.1981, Mt Missim (1350 m), A. Allison. Western Highlands Province: 1 ♂, 8.ix.1980 and 1 ♂, 21.x.1980, Kuk Agriculture Research Institute, Mt Hagen, B. Thistleton. All paratypes attracted to cue lure.
LOCATION OF TYPES: Holotype (T.10495) in QM; 1 paratype in ANIC; 1 paratype in DPI(PNG); 5 paratypes in DPI.

DISTRIBUTION

Known from Morobe and Western Highlands Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; small oval facial spots

present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripes medium sized (reaching midway between anterior margin of notopleural calli and anterior npl. bristles), scutellum yellow; wing with a broad fuscous costal band and narrow fuscous anal streak, costal cells fulvous, microtrichia in outer ⅓ to ¾ of second costal cell only; abdominal tergum III black and terga IV–V orange-brown with broad lateral and medial longitudinal dark bands connected along anterior ½ of tergum IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.47 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small oval black spots; length of face 0.55 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 7–9 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.38 mm; 0.93 mm.

Thorax mesonotum black except brown markings as follows: below and behind lateral postsutural vittae; along mesonotal suture; between humeral and notopleural calli; inside humeral calli. Pleural areas dark fuscous to black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 moderately broad lateral postsutural vittae ending at or just before upper pa. bristles. Postnotum dark fuscous to black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except fore and mid tibiae pale fuscous, hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibae each with an apical black spur.

Wings length 7.2 mm; costal cells fulvous; microtrichia in outer ⅓ to ¾ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending midway between extremities of R_{4+5} and M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except anterolateral corners dark fuscous and a broad transverse black band which narrows laterally to end before lateral margins; tergum III black; terga IV and V orange-brown except broad lateral longitudinal bands which are black on tergum IV and dark fuscous on tergum V and a broad medial longitudinal dark fuscous band over both terga. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. latissima is similar to the other species in the *bryoniae* complex in the characters listed in the comments on *B. bryoniae*. It differs from these species in having the costal band confluent with R_{4+5}, lateral postsutural vittae ending before the upper pa. bristles, abdominal tergum III black, terga IV and V orange-brown with broad lateral longitudinal bands which are black on tergum IV and dark fuscous on tergum V, a broad medial longitudinal dark fuscous band on terga IV and V joining with the lateral bands along anterior margin of tergum IV.

Bactrocera (Bactrocera) paramusae, n. sp.
(Fig. 67)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 15.iv.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂ (29.ii.1980), Upper Stony logging area, Bulolo, P. Daur; 2 ♂♂ (May–June, 1971) and 1 ♂ (August, 1971), Bubia, J. Maiyel; 12 ♂♂ (22.vi.1980), Oomsis Forestry Reserve and 2 ♂♂ (18–22.vi.1980), Gabensis, Lae–Bulolo road, R.A.I. Drew and D.W. Currey; 1 ♂ (12.iii.1981), Mt Missim (1450 m), A. Allison. Central District: 2 ♂♂ (9–13.iii.1970), Mt Lawes (250 m) and 1 ♂ (3.iii.1970), Brown River, T.L. Fenner;

1 ♂ (5.i.1974), Hombrom Bluff and 1 ♂ (19.i.1974), Crystal Rapids, J. Stibick; 1 ♂ (25.vi.1980), Bisianumu, Sogeri Plateau, 1 ♂ (25.vi.1980), Rouna Power Station No. 2, near Sogeri, 3 ♂♂ (25.vi.1980), Kokoda road, 3 ♂♂ (26.vi.1980), Moresby–Bereina road, 51 km NW Port Moresby, 1 ♂ (26.vi.1980), Moresby–Bereina road, 88 km NW Port Moresby, R.A.I. Drew and D.W. Currey. Northern District: 1 ♂ (27.v.1966), Popondetta, T.V. Bourke. Western Highlands District: 1 ♂ (20.xi.1978), Kuk Tea Research Institute, Mt Hagen, B. Thistleton. Western District: 2 ♂♂ (17.xi.1980), Nomad, P. Senat. Milne Bay District: 3 ♂♂ (4–10.viii.1980), Goodenough I., P. Spradbury. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10496) and 2 paratypes (T.10497–T.10498) in QM; 10 paratypes in ANIC; 4 paratypes in BMNH; 4 paratypes in DPI(PNG); 20 paratypes in DPI.

DISTRIBUTION

Widespread in rainforests in the Morobe Province, Central District, Northern District, Western Highlands District, Western District and Goodenough I., Papua New Guinea.

DIAGNOSIS

Medium sized species; small circular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad dark fuscous costal band and anal streak, costal cells fuscous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.55 mm. Frons of even width, length 1.46 times breadth; fulvous with fuscous to dark fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous to dark fuscous. Face fulvous with small circular black spots; length of face 0.43 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–11 well developed black bristles each side. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.33 mm; 0.75 mm.

Thorax mesonotum black except brown markings as follows: below and behind lateral postsutural vittae; along mesonotal suture; between humeral and notopleural calli; inside humeral calli. Pleural areas fuscous except a black area on sternopleuron and red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae narrowing posteriorly to end just before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except basal ¼ of hind tibiae pale fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.1 mm; costal cells fuscous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except dark fuscous subcostal cell, broad dark fuscous costal band confluent with R_{4+5} and ending just beyond extremity of that vein, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous to fuscous; tergum II orange-brown except for a narrow transverse fuscous band across anterior margin but not reaching lateral margins; terga III–V orange-brown except for an irregular transverse very pale fuscous marking across anterior margin which expands over lateral margins of tergum III. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. paramusae is similar to the species in the *bryoniae* complex in the characters listed in the comments on *B. bryoniae*. It differs from these species in having the costal band confluent with R_{4+5}, abdominal terga II–V almost uniformly orange-brown with at most pale fuscous anterolateral margins on tergum II and across anterior and lateral margins of tergum III.

Bactrocera (Bactrocera) quadrisetosa (Bezzi), n. comb. (Fig. 68)

Chaetodacus quadrisetosus Bezzi, 1928: 102–4.
Dacus (Zeugodacus) quadrisetosus Drew, 1973: 33.

MATERIAL EXAMINED
Holotype ♂, labelled "New Hebrides, Santo, 30.Xi.1923, H.W. Simmonds", and bearing another label in Bezzi's handwriting "*Chaetodacus quadrisetosus* type male n. sp.".
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION
Vanuatu (formerly New Hebrides), type locality, Esperitu Santo.

DIAGNOSIS
Medium sized species; large oval black facial spots present; humeral and notopleural calli yellow (anterodorsal corners of humeral calli pale fuscous); mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells; abdominal terga III–V black except for orange-brown bordering a medial longitudinal fuscous band on posterior regions of each tergum.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.48 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump covered by a number of short dark setae; orbital bristles dark fuscous: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large oval black spots; length of face 0.48 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fuscous, yellow along eye margins; occipital row with 7–8 strong black bristles each side. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong red-brown dorsal bristle on segment 2; length of segments: 0.23 mm; 0.35 mm.

Thorax mesonotum black except dark fuscous behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli (anterodorsal corners pale fuscous) notopleural calli; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin almost straight; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder including broad ventral margins black); 2 lateral postsutural vittae narrowing slightly posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all coxae fuscous; fore, mid and apical ½ of hind femora fuscous (basal ½ hind femora fulvous); fore tibiae fuscous, mid tibiae fulvous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II with a transverse black band across anterior ½ widening to cover lateral margins, posterior ½ orange-brown; a narrow orange-brown band along suture between terga I and II but not reaching lateral margins; terga III–V mostly black except for orange-brown bordering a medial fuscous band on posterior areas of each tergum, on tergum V the orange-brown extends along posterior margin. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS
B. quadrisetosa was originally described from 1 male; Drew (1973) could not locate it but it has been found in BMNH.

Although this species was placed in subgenus *Zeugodacus* by Drew (1973), this is incorrect as it possesses a short surstylus lobe and a deep concavity on the posterior margin of abdominal sternum V. It has all the characters of *Bactrocera* except for possessing 4 sc. bristles (2 in *Bactrocera*) and is provisionally placed in this subgenus. It is similar to *B. varipes* (Malloch) in the general colour patterns of the thorax, abdomen, wing and legs, the costal cell colour and microtrichia pattern. It differs from this species in having anterodorsal corners of humeral calli pale fuscous, 4 sc. bristles,

a narrow basal band on the scutellum and fore tibiae fuscous.

Bactrocera (Bactrocera) simulata (Malloch), n. comb. (Fig. 69)

Dacus simulatus Malloch, 1939a: 241.
Dacus (*Bactrocera*) *simulatus*: Drew, 1974a: 83–5.

MATERIAL EXAMINED
Holotype ♂; a large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION
PREVIOUSLY RECORDED: Mali Ali Valley, Nggela I., Solomon Islands (type locality).
NEW RECORDS: Bougainville I. (PNG); Shortland Is, New Georgia I., Guadalcanal I. (Solomon Islands) and Vanuatu (formerly New Hebrides).

DIAGNOSIS
Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe equal in width to notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fulvous, microtrichia in outer ½ of second costal cell only; abdominal terga III–V black except for orange-brown either side of a medial longitudinal black band on tergum V and posterior ½ of tergum IV.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. simulata was described adequately by Drew (1974a). It is similar to the other species in the *bryoniae* complex in the characters listed in the comments on *B. bryoniae* but differs in having the costal band overlapping R_{4+5} for its entire length.

Bactrocera (Bactrocera) varipes (Malloch), n. comb. (Fig. 70)

Dacus varipes Malloch, 1939a: 240–1.
Dacus (*Strumeta*) *varipes* Drew, 1974a: 96–8.

MATERIAL EXAMINED
Holotype ♂ and 1 ♀ paratype, Tulagi, Florida I., Solomon Islands, December 1932, R.J.A.W. Lever; 1 ♂ and 1 ♀ in BMNH collected at Guadacanal I.
LOCATION OF TYPES: Holotype and 2 ♀ paratypes in BMNH.

DISTRIBUTION
PREVIOUSLY RECORDED: Tulagi, Florida I., Solomon Islands (type locality).
NEW RECORD: Guadalcanal I. (Solomon Islands).

DIAGNOSIS
Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad black basal band; wing with a broad fuscous costal band and anal streak, costal cells fulvous, microtrichia covering both costal cells; abdominal terga mostly black.
ATTRACTANT: No known record.

COMMENTS
B. varipes was described adequately by Drew (1974a). It is similar to the other species in the *bryoniae* complex in the characters listed in the comments on *B. bryoniae* but differs in having costal band confluent with R_{4+5}, abdominal terga mostly black, dense microtrichia covering all of both costal cells, legs fulvous with fore and mid femora and apical ½ of hind femora and hind tibiae fuscous.

This species was described originally from a type male, allotype and 2 female paratypes (Malloch 1939a), three of which are in BMNH.

distincta complex

DEFINITION OF COMPLEX: *Bactrocera* species with infuscation on wing as a transverse band across centre in addition to costal band and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, scutellum entirely yellow or with at most infuscation between apical bristles, males of some species attracted to cue lure.

Bactrocera (Bactrocera) ampla (Drew), n. comb. (Fig. 71)

Dacus (*Strumeta*) *amplus* Drew, 1971: 55–6.

MATERIAL EXAMINED
2 ♂ paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6942) in QM.

DISTRIBUTION
Known only from Keravat, New Britain (type locality).

DIAGNOSIS
Large species; medium sized black facial spots present; humeral calli yellow; notopleural calli dark fuscous to black; mesonotum black, mesopleural stripe reaching anterior npl. bristle, lateral

postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad dark fuscous costal band (expanding to cover apical portion of wing) and anal streak, a very broad dark fuscous band across wing recurved along CuA1, costal cells dark fulvous, microtrichia covering all of second costal cell and outer ½ of first cell; abdominal terga II–V orange-brown except for a broad medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum II.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. ampla was described adequately by Drew (1971). It is similar to *B. decumana* (Drew) and *B. curreyi* (*distincta* complex) in possessing a broad band across centre of wing, mesonotum black with lateral postsutural vittae and humeral and notopleural calli not joined by a lateral yellow band. It differs from *B. curreyi* in possessing yellow humeral calli and from *B. decumana* in having the transverse band across wing recurved along CuA1, lateral postsutural vittae ending at upper pa. bristles and abdomen with a broad medial and 2 broad lateral longitudinal black bands on terga II–V.

Bactrocera (Bactrocera) anomala (Drew), n. comb. (Fig. 72)

Dacus (*Strumeta*) *anomalus* Drew, 1971: 57–9.

MATERIAL EXAMINED

A series of paratypes in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6943) in QM.

DISTRIBUTION

Known only from Efate (type locality, Vila) and Malekula Is, Vanuatu (formerly New Hebrides).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a narrow transverse fuscous band across wing enclosing both crossveins, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V fulvous except for a broad medial and 2 irregular lateral longitudinal glossy black bands.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. anomala was described adequately by Drew (1971). It is similar to *B. atriliniellata* and *B. distincta* (Malloch) (*distincta* complex) in possessing lateral postsutural vittae ending before upper pa. bristles, a narrow transverse fuscous band across wing, mesopleural stripe not extending to humeral callus, mesonotum black with humeral and notopleural calli yellow and not joined by a lateral yellow band. It is also similar to *B. distincta* in possessing a fuscous spot on apex of scutellum. It differs from *B. atriliniellata* in having the transverse band across wing narrower and curved and the apex of the scutellum fuscous and from *B. distincta* in having costal cells fulvous, microtrichia in outer corner of second costal cell only, costal band paler towards centre of wing, legs fulvous except apical 4 segments of all tarsi fuscous and hind tibiae dark fulvous, abdominal terga fulvous with a broad medial and 2 irregularly shaped lateral longitudinal glossy black bands on terga III–V.

Bactrocera (Bactrocera) atriliniellata, n. sp. (Fig. 73)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, Lae–Bulolo road, attracted to cue lure, 22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Central District: 1 ♂, Kokoda road, near Kokoda and 1 ♂, Bisianumu, Sogeri, 25.vi.1980, R.A.I. Drew and D.W. Currey. Morobe Province: 2 ♂♂, Mt Kaindi (1200-fb-m), 25.v.1981, A. Allison; 1 ♂, Namie Creek, Mt Kaindi (1650 m), 27.iii.1981, A. Allison; 1 ♂, Mt Missim (1550 m), 20.xi.1980, A. Allison. All paratypes attracted to cue lure.
LOCATION OF TYPES: Holotype (T.10499) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 4 paratypes in DPI.

DISTRIBUTION

Known from Central District and Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, 2 narrow lateral postsutural vittae ending before upper pa. bristles, scutellum yellow; legs fulvous except hind tibiae fuscous; wing with a narrow fuscous costal band and a narrow fuscous transverse band across centre which encloses both crossveins, costal cells pale fuscous, microtrichia covering fore margin of first costal cell and most

of second costal cell; abdominal terga III–V orange-brown with a narrow medial and moderately broad lateral longitudinal dark bands on all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.45 mm. Frons of even width, length 1.57 times breadth; fulvous without dark markings or fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fulvous or fuscous. Face fulvous with medium sized oval black spots present; length of face 0.43 mm. Genae fulvous, small fuscous subocular spot present; fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 6–7 well developed black bristles. Antennae with segments 1 and 2 fulvous; segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.75 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, extending midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae ending before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae fuscous; remaining segments fulvous except hind tibiae fuscous; mid tibiae each with an apical black spur; rows of long dark setae on dorsal surfaces of fore femora.

Wings length 5.7 mm; costal cells pale fuscous (second cell paler), microtrichia along fore margin of first costal cell and covering most of second costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow fuscous transverse band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band along posterior margin but not reaching lateral margins; tergum II orange-brown except for a broad transverse dark fuscous to black band across anterior ½ and expanding over lateral margins. Terga III–V orange-brown with moderately broad lateral longitudinal bands which are dark fuscous on tergum III and fuscous on terga IV and V, and a narrow medial longitudinal band which is fuscous on terga III and IV and black on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. atriliniellata is similar to *B. anomala* (Drew) and *B. distincta* (Malloch) (*distincta* complex) in having lateral postsutural vittae ending before upper pa. bristles, transverse fuscous band across wing narrow, mesopleural stripe not extending to humeral callus, mesonotum black with lateral postsutural vittae, humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from these species in having a yellow scutellum without fuscous on apex and the transverse fuscous band across wing straight and wider (expanding to cover the outer ⅓ of discoidal cell).

Bactrocera (Bactrocera) curreyi, n. sp.
(Figs 74–77)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western Highlands Province: Kuk Agricultural Research Station, Mt Hagen, attracted to Willison's lure, 27.xii.1978, B. Thistleton.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂ (14.vii.1957) and 1 ♂ (17.vii.1957), Bubia, J.H. Ardley; 1 ♂ (cue lure), Markham Valley road (28 km from Lae), 22.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♂ (cue lure), Gabensis, Lae–Bulolo road, 18–22.vi.1980, R.A.I. Drew and D.W. Currey. East Sepik Province: 18 ♂♂, Maprik, Oct.–Dec. 1957, Malaria Control Section. Western Highlands Province: 1 ♂ (16.xii.1980) and 1 ♂ (30.xii.1980), Mt Hagen, attracted to cue lure, B. Thistleton. Central District: 1 ♂ (cue lure), Rigo, 24.vi.1980, R.A.I. Drew and D.W. Currey. Gulf Province: 1 ♂ (7.vii.1981), Aro, H. Iupa; 2 ♂♂ (17.vii.1981) and 1 ♂ (29.vii.1981), Ihu, H. Iupa. INDONESIA, Irian Jaya: 1 ♀, Ned. New Guinea, 30.x.1960, R.T. Simon Thomas.

LOCATION OF TYPES: Holotype (T.10500) and 1 paratype

(T.10501) in QM; 5 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI(PNG); 21 paratypes in DPI.

DISTRIBUTION

Known from Irian Jaya and the following Provinces in Papua New Guinea: Morobe, East Sepik, Western Highlands, Central and Gulf.

DIAGNOSIS

Small dark species; medium sized pear shaped black facial spots present; humeral calli fuscous; notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, 2 lateral postsutural vittae ending at upper pa. bristles, scutellum yellow; legs with femora fulvous except for fuscous on apical ⅓, fore tibiae fuscous, mid tibiae pale fuscous, hind tibiae dark fuscous; wing with a narrow fuscous costal band and a broad transverse fuscous band across centre which encloses both crossveins, costal cells colourless, microtrichia in outer corner of second costal cell only; terga III–V black laterally tending dark fuscous centrally except orange-brown posterocentrally on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.6 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.5 mm. Genae fulvous, large fuscous subocular spot present; dark red-brown bristle present. Occiput pale fuscous, yellow along eye margins; occipital row with 4–9 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fuscous; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.30 mm; 0.90 mm.

Thorax mesonotum black except dark brown below lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli and above mid coxae. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder including ventral margins black); 2 lateral postsutural vittae narrowing slightly posteriorly to end at upper pa. bristles. Humeral calli fuscous. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark red-brown.

Legs coxae dark fuscous; all femora fulvous except fuscous on apical ⅓; fore tibiae fuscous, mid tibiae pale fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.9 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band almost reaching R_{4+5} and overlapping this vein at its apex, a broad transverse fuscous band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad transverse dark fuscous band across anterior ½ and widening over lateral margins; terga III–V black laterally tending dark fuscous centrally except orange-brown posterocentrally on tergum IV and centrally on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, abdominal sternum V with a deep concavity on posterior margin.

FEMALE: As for males except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment dark fuscous, dorsoventrally flattened and tapering posteriorly in dorsal view. Apex of piercer broad, rounded at tip and curved upwards (as in *B. tinomiscii*) with 4 pairs of subapical bristles (2 large and 2 small) (Figs 75, 76). Spicules at distal end of middle segment wide with 1 central elongate broad dentation and 2–4 smaller lateral dentations (Fig. 77).

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. curreyi is similar to *B. latilineata* (*fulvicauda* complex) in general body and wing colour patterns but differs in having dark fuscous humeral calli.

This species is named after Mr D.W. Currey, Brisbane, who assisted with major collections of Dacinae in Papua New Guinea.

Bactrocera (Bactrocera) decumana
(Drew), n. comb. (Fig. 78)

Dacus (Strumeta) decumanus Drew, 1972b: 205–6.

MATERIAL EXAMINED
A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6989) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: Bougainville I. (type locality, Daru Village).
NEW RECORD: Shortland Is (Solomon Islands).

DIAGNOSIS
Large species; large oval black facial spots present; humeral calli yellow; notopleural calli black; mesonotum glossy black, mesopleural stripe extending to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad dark fuscous costal band and anal streak, a broad dark fuscous transverse band across wing, costal cells dark fulvous, microtrichia covering second costal cell and outer ½ of first cell; abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal black bands.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. decumana was described adequately by Drew (1972b). It is similar to *B. ampla* (Drew) (*distincta* complex) in possessing dark fuscous to black notopleural calli, mesonotum black with yellow humeral calli, humeral and notopleural calli not joined by a lateral yellow band and a broad transverse fuscous band across wing but differs in having the transverse band across wing not recurved along CuA_1, lateral postsutural vittae ending before upper pa. bristles, abdomen with a broad medial longitudinal black band on terga II–V and 2 broad lateral longitudinal black bands on terga III–V.

Bactrocera (Bactrocera) distincta
(Malloch), n. comb. (Figs 79–81)

Dacus distinctus Malloch, 1931: 259–60.
Strumeta distincta: Perkins, 1939: 6.
Dacus (Strumeta) distinctus: Drew, 1974a: 34–6.

MATERIAL EXAMINED
Holotype ♂; a large series of specimens in DPI (see DISTRIBUTION); 1 ♀ in BMNH labelled "Lautoka, Fiji, 28.xi.1929, H. Phillips, bred ex fruit of *Chrysophyllum cainito*".
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION
Widespread and generally abundant in Fiji, Western Samoa (type locality, Upolu), Eastern Samoa and Tonga.

DIAGNOSIS
Medium sized species; small fuscous facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vittae absent, scutellum yellow except fuscous on apex; wing with a broad dark fuscous costal band and anal streak, a broad transverse dark fuscous band across wing, costal cells dark fuscous, microtrichia covering second costal cell only; abdominal terga II–V orange-brown except for a broad medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum II and posterior margin of tergum V.

DESCRIPTION
FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment black, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.6:1. Apex of piercer with 1 pair of well developed subapical keels and 4 pairs of subapical bristles (Fig. 80). Spicules at distal end of middle segment, narrow, elongate, triangular and occasionally with a small lateral dentation on 1 side (Fig. 81).

HOST PLANTS
NEW RECORDS: *Burckella richii* (Sapotaceae), Tongatapu, 11.x.1974, W. Pierce; *Chrysophyllum cainito* (Sapotaceae), Fiji.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. distincta was described adequately by Drew (1974a). It is similar to *B. anomala* (Drew) and *B. atriliniellata* (*distincta* complex) in having lateral postsutural vittae ending before upper pa. bristles, transverse band across wing narrow, mesopleural stripe not extending to humeral callus, mesonotum black with humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from *B. atriliniellata* in having fuscous on apex of scutellum and transverse band across wing narrow and curved and from *B. anomala* in having costal cells dark fuscous, microtrichia covering all of second costal cell, costal band entirely dark fuscous, legs fulvous except apex of hind tibiae and

apical 4 segments of all tarsi fuscous, abdominal terga II–V with a broad transverse black band on base of tergum II and a broad medial and 2 broad lateral longitudinal black bands over all 4 terga.

Bactrocera (Bactrocera) fergussoniensis, n. sp. (Fig. 82)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Milne Bay Province: Fergusson I., 20.vi.1970, T.L. Fenner.
LOCATION OF TYPE: Holotype (T.10502) in QM.

DISTRIBUTION

Known only from Fergusson I., Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized circular black facial spots present; humeral calli yellow; notopleural calli dark fuscous to black; mesonotum black, mesopleural stripe broad reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak and a broad transverse fuscous band across centre enclosing both crossveins, costal cells fuscous with microtrichia covering second and most of first costal cell; abdominal terga II–V orange-brown except for a broad transverse black band across anterior ½ of tergum II and a broad medial and 2 broad lateral longitudinal fuscous to dark fuscous bands over all 4 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.75 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; fulvous bristle present. Occiput black dorsally, fulvous ventrally and along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong fulvous dorsal bristle on segment 2; length of segments: 0.25 mm; 0.38 mm.

Thorax mesonotum and pleural areas black without pale markings. Yellow markings as follows: humeral calli; broad mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 moderately broad parallel sided lateral postsutural vittae ending at upper pa. bristles. Notopleural calli dark fuscous to black. Postnotum black. Scutellum yellow except for broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.8 mm; costal cells fuscous; microtrichia covering second and most of first costal cell; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and overlapping this vein at its apex to end between extremities of R_{4+5} and M, broad transverse fuscous band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band across posterior margin but not reaching lateral margins; terga II–V orange-brown except for a broad transverse black band across anterior ½ of tergum II, a broad medial and 2 broad lateral longitudinal bands which are dark fuscous on posterior ½ of tergum II, all of tergum III and fuscous on terga IV and V. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS

B. fergussoniensis is similar to *B. pseudodistincta* (Drew) and *B. propedistincta* (*distincta* complex) in possessing coloured costal cells, costal band confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles and mesopleural stripe not extending to humeral callus. It differs from *B. propedistincta* in having a distinct pattern of longitudinal dark bands on abdomen and from *B. pseudodistincta* in having fuscous costal cells, microtrichia covering second and most of first costal cell; abdomen with broad lateral dark margins on terga I–V.

Bactrocera (Bactrocera) furvilineata, n. sp.
(Fig. 83)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, attracted to cue lure, 22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Central District: 3 ♂♂ (25.vi.1980), Kokoda road, near Kokoda; 1 ♂ (25.vi.1980) Bisianumu, near Sogeri; 1 ♂ (24.vi.1980), Rigo road, 32 km SE Port Moresby; 1 ♂ (26.vi.1980), Moresby–Bereina road, 51 km NW Port Moresby; all attracted to cue lure and collected by R.A.I. Drew and D.W. Currey; 1 ♂, Mt Lawes, attracted to Willison's lure, 9–13.iii.1970, T.L. Fenner. Morobe Province: 7 ♂♂ (22.vi.1980), Oomsis Forestry Reserve, R.A.I. Drew and D.W. Currey; 1 ♂ (22.vi.1980), Markham Valley road, 28 km from Lae, R.A.I. Drew and D.W. Currey; 1 ♂ (29.iii.1981), Namie Creek, Mt Kaindi (1650 m), A. Allison; all attracted to cue lure. Western Highlands Province: 1 ♂ (17.xi.1981), Kuk A.R.I., Mt Hagen, attracted to cue lure, B. Thistleton.

LOCATION OF TYPES: Holotype (T.10503) and 1 paratype (T.10504) in QM; 4 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI(PNG); 9 paratypes in DPI.

DISTRIBUTION

Known from Central District, Morobe and Western Highlands Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching almost to anterior npl. bristles, 2 broad lateral postsutural vittae ending at upper pa. bristles, scutellum yellow; legs with all femora orange-brown tending pale fuscous on apical ⅓, fore and mid tibiae pale fuscous, wing with a narrow costal band and a narrow transverse fuscous band across centre enclosing both crossveins, hind tibiae fuscous, costal cells fulvous, microtrichia covering most of second costal cell; abdominal terga II–V orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum II and with a broad medial and 2 lateral longitudinal dark bands on terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized oval black spots present; length of face 0.48 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista dark fuscous (fulvous basally); length of segments: 0.20 mm; 0.35 mm; 0.90 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae ending at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae orange-brown, mid and hind coxae fuscous; all femora orange-brown, tending pale fuscous on apical ⅓; fore and mid tibiae pale fuscous, hind tibiae fuscous; all tarsi fulvous; rows of long dark setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells pale fuscous, microtrichia covering most of second costal cell; remainder of wings colourless except fuscous subcostal cell; narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow transverse fuscous band across centre of wing and enclosing both crossveins, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; terga II–V orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum II, but not reaching lateral margins, anterolateral corners of tergum II dark fuscous, lateral margins of tergum III dark fuscous, lateral margins of terga IV and V pale fuscous to fuscous, a broad medial longitudinal band which is dark fuscous on tergum II and black on terga III–V. A pair of oval fuscous shining spots on tergum V. Posterior lobe of

surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. furvilineata is similar to *B. latilineata* (*fulvicauda* complex) and *B. rhabdota* (*distincta* complex) in possessing costal band overlapping R_{2+3} but not confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles, narrow transverse fuscous band across wing, mesonotum with humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from these species in having costal cells pale fuscous, transverse band across wing narrow and covering only outer corner of discoidal cell, abdominal terga II–V orange-brown except for a broad medial longitudinal dark band over all 4 terga and 2 moderately broad lateral longitudinal bands which are dark fuscous on tergum III and fuscous to pale fuscous on terga IV and V.

Bactrocera (Bactrocera) morobiensis, n. sp.
(Fig. 84)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Gabensis, Lae–Bulolo road, attracted to cue lure, 18–22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 2 ♂♂ (cue lure) and 4 ♂♂ (Willison's lure), Bubia, September–October 1971, K. Gorea; 3 ♂♂ (cue lure), Bubia, May–June 1971, J. Maiyel; 1 ♂ (Willison's lure), Morobe District, August 1971, J. Maiyel; 1 ♂ (cue lure), Gabensis, Lae–Bulolo road, 18–22.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♂ (cue lure), Oomsis Forestry Reserve, 22.vi.1980, R.A.I. Drew and D.W. Currey. East Sepik Province: 1 ♂, Maprik, Oct.–Dec.1957, Malaria Control Section.

LOCATION OF TYPES: Holotype (T.10505) and 1 paratype (T.10506) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 8 paratypes in DPI.

DISTRIBUTION

Known from the Morobe and East Sepik Provinces, Papua New Guinea.

DIAGNOSIS

Pale coloured medium sized species; small irregularly oval pale fuscous to dark fuscous facial spots present; humeral and notopleural calli yellow and connected by a broad yellow band; mesonotum red-brown with irregular fuscous markings present, mesopleural stripe reaching almost to anterior npl. bristle, 2 lateral postsutural vittae ending before upper pa. bristles, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow costal band and a broad transverse fuscous band across centre enclosing both crossveins, costal cells fulvous, microtrichia in outer corner of second costal cell only; abdominal terga II–V orange-brown with shining spots on tergum V fuscous.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.57 times breadth; fulvous with pale fuscous ventrally; anteromedial hump covered by short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with small irregularly oval spots which vary in colour from pale fuscous to dark fuscous; length of face 0.55 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–8 well developed bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.35 mm; 0.85 mm.

Thorax mesonotum red-brown with irregular fuscous markings between humeral and notopleural calli and inside lateral postsutural vittae. Pleural areas pale fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad band connecting humeral and notopleural calli; broad mesopleural stripe reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 parallel sided lateral postsutural vittae ending before upper pa. bristles. Postnotum pale fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 6.7 mm; costal cells fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell; narrow fuscous costal band almost reaching R_{4+5} and crossing this vein at its apex, a broad transverse fuscous band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous with a narrow transverse orange-brown band across posterior

margin; terga II–V orange-brown. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. morobiensis is similar to *B. unifasciata* (Malloch) (*distincta* complex) in having the humeral and notopleural calli joined by a lateral yellow band but differs from this species in having the mesonotum mostly red-brown and abdominal terga mostly orange-brown.

Bactrocera (Bactrocera) oblineata, n. sp.
(Fig. 85)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, attracted to cue lure, 22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 3 ♂♂ (cue lure), Markham Valley road (28 km from Lae), 22.vi.1980, R.A.I. Drew and D.W. Currey; 3 ♂♂ (cue lure), Oomsis Forestry Reserve, 22.vi.1980, R.A.I. Drew and D.W. Currey; 3 ♂♂ (30.x.1980) and 1 ♂ (6.xi.1980), Mt Missim (1100 m), attracted to cue lure, A. Allison; 1 ♂, Mt Missim (1250 m) and 1 ♂, Mt Missim (1350 m), 20.xi.1980, attracted to cue lure, A. Allison. Milne Bay Province: 1 ♂, Gurney, 16–23.vii.1977, A. Eteboyo; 1 ♂ (Dak Pot trap), Waigani, 16–23.vii.1977, A. Eteboyo. Central Province: 2 ♂♂ (cue lure), Cape Rodney, 9–16.vii.1977, A. Eteboyo; 1 ♂ (cue lure), Kokoda road, near Kokoda, 25.vi.1980, R.A.I. Drew and D.W. Currey.

LOCATION OF TYPES: Holotype (T.10507) and 1 paratype (T.10508) in QM; 4 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI (PNG); 9 paratypes in DPI.

DISTRIBUTION

Known from the Central, Milne Bay and Morobe Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, 2 lateral postsutural vittae ending at upper pa. bristles, scutellum yellow; legs with femora fulvous except apical ⅓ of each fuscous, fore tibiae fuscous, mid tibiae fulvous except basal ⅓ fuscous, hind tibiae dark fuscous; wing with a broad costal band confluent with R_{4+5} and a broad transverse fuscous band across centre which encloses both crossveins, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V black except orange-brown posterocentrally on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.45 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black : 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized pear shaped black spots present; length of face 0.4 mm. Genae fulvous, black subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.11 mm; 0.33 mm; 0.85 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder including broad ventral margins black); 2 lateral postsutural vittae narrowing slightly posteriorly to end at upper pa. bristles. Postnotum black. Scutellum yellow except for black basal band of medium width. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all femora fulvous with apical ⅓ fuscous; fore tibiae fuscous, mid tibiae fulvous with basal ⅓ fuscous, hind tibiae dark fuscous; all tarsi fulvous; mid tibiae each with an apical black spur; rows of long black setae on dorsal surfaces of fore femora.

Wings length 5.9 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell; broad fuscous costal band confluent with R_{4+5} and overlapping this vein at its apex (there is a pale fuscous stripe above R_{4+5} distal to r–m crossvein); a broad transverse fuscous band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia

around A1 + CuA2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II fulvous with a broad transverse dark fuscous band across anterior ½ widening to cover lateral margins; terga III–V black except orange-brown posterocentrally on tergum IV and centrally on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. oblineata is similar to *B. fergussoniensis*, *B. propedistincta* and *B. pseudodistincta* (Drew) (*distincta* complex) in possessing the costal band confluent with R4+5, lateral postsutural vittae ending at the upper pa. bristles, transverse band across wing narrow, mesopleural stripe not extending to humeral callus, mesonotum black with humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from these species in having colourless costal cells and abdominal terga black except orange-brown posterocentrally on terga IV and V.

Bactrocera (Bactrocera) propedistincta, n. sp. (Fig. 86)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Bubia, near Lae, 19.vii.1957, J.H. Ardley.

Paratype, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Lae (Blevins Block), 25.vii.1957, J.H. Ardley.

LOCATION OF TYPES: Holotype (T.10509) in QM; paratype in DPI.

DISTRIBUTION

Known only from near Lae, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized circular black facial spots present; humeral calli yellow; apical ½ notopleural calli yellow (remainder fuscous); mesonotum black; mesopleural stripe of medium width reaching to the anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent; scutellum yellow; legs with all segments fulvous; wing with a broad fuscous costal band confluent with R4+5 and broad fuscous anal streak, costal cells fuscous with microtrichia covering all of second costal cell and outer ½ of first costal cell; abdominal terga I–V uniformly orange-brown with at most a very pale and narrow medial longitudinal band on terga III and IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.9 mm. Frons narrowing slightly posteriorly, length 1.76 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized circular black spots; length of face 0.48 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput red-brown, yellow along eye margins; occiptial row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.35 mm; 0.88 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, around mesonotal suture and between humeral and notopleural calli. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; apical ½ notopleural calli (basal ½ fuscous); medium sized mesopleural stripe, reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅓ lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae ending at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.7 mm; costal cells fuscous; microtrichia covering all of second costal cell and outer ½ of first costal cell; remainder of wings colourless except for fuscous subcostal cell, broad fuscous costal band confluent with R4+5 and overlapping this vein towards its extremity, a broad transverse fuscous band across centre of wing and enveloping both crossveins, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A1 + CuA2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than

long. Terga I–V uniformly orange-brown with at most a very pale fuscous and narrow medial longitudinal band on terga III and IV. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a very deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS
B. propedistincta is similar to *B. fergussoniensis* and *B. pseudodistincta* (Drew) (*distincta* complex) in possessing coloured costal cells, costal band confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles, transverse band across wing narrow, mesopleural stripe not extending to humeral callus, humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from these species in having the abdominal terga uniformly orange-brown with at most a very pale fuscous and narrow medial longitudinal band on terga III and IV.

Bactrocera (Bactrocera) pseudodistincta (Drew), n. comb. (Fig. 87)

Dacus (*Strumeta*) *pseudodistinctus* Drew, 1971: 79–81.

MATERIAL EXAMINED
A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6957) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: New Britain (type locality, Keravat), New Ireland and Lihir I.
NEW RECORDS: Papua New Guinea: Central District (Mt Lawes, 250 m); Morobe Province, May 1971, J. Maiyel. Torres Strait islands: Boigu, Darnley, Saibai, Yam (records from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; small black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad costal band and anal streak, a broad transverse fuscous band across wing, first costal cell fulvous, second costal cell fuscous, microtrichia in outer ½ of second costal cell only; abdominal terga II–V fulvous except for a broad medial longitudinal dark fuscous band over all 4 terga and 2 broad lateral longitudinal fuscous bands over terga III–V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. pseudodistincta was described adequately by Drew (1971). It is similar to *B. fergussoniensis* and *B. propedistincta* (*distincta* complex) in having coloured costal cells, costal band confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles, transverse band across wing narrow, mesopleural stripe not extending to humeral callus, humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from *B. propedistincta* in having a distinct pattern of longitudinal dark bands on the abdomen and from *B. fergussoniensis* in having first costal cell fulvous and second costal cell fuscous, microtrichia covering outer ½ of second costal cell only and abdomen with broad lateral dark margins on terga III–V.

Bactrocera (Bactrocera) rhabdota, n. sp. (Fig. 88)

TYPE SPECIMENS
Holotype ♂, PAPUA NEW GUINEA, Central District: Kokoda road, near Kokoda, attracted to cue lure, 25.vi.1980, R.A.I. Drew and D.W. Currey.
Paratypes, PAPUA NEW GUINEA, Central District: 10 ♂♂, Kokoda road, near Kokoda, 25.vi.1980, R.A.I. Drew and D.W. Currey; 4 ♂♂, Bisianumu, Sogeri, 25.vi.1980, R.A.I. Drew and D.W. Currey. Morobe Province: 1 ♂, Upper Stony logging area, Bulolo, 18.ii.1980, P. Daur; 1 ♂, Mt Susu, Bulolo, 5.v.1980, P. Daur; 1 ♂, Upper Manki logging area, Bulolo, 15.iv.1980, P. Daur; 1 ♂, Kunai Creek, Mt Kaindi (1450 m), 10.xi.1980, A. Allison; 1 ♂ (1100 m) and 1 ♂ (1550 m), Mt Missim, 30.x.1980, A. Allison; 1 ♂ (1200 m), 1 ♂ (1340 m) and 1 ♂ (1350 m), Mt Missim, 20.xi.1980, A. Allison; 1 ♂ (1550 m) Mt Missim, 11.xii.1980, A. Allison. Western Highlands Province: 1 ♂ (6.x.1980), 1 ♂ (28.x.1980), 1 ♂ (16.xii.1980), Mt Hagen, B. Thistleton. All above paratypes attracted to cue lure. East Sepik Province: 7 ♂♂, Maprik, Oct.–Dec.1957, Malaria Control Centre.
LOCATION OF TYPES: Holotype (T.10510) and 2 paratypes (T.10511–T.10512) in QM; 8 paratypes in ANIC; 2 paratypes in BMNH; 2 paratypes in DPI(PNG); 20 paratypes in DPI.

DISTRIBUTION
Known from the following Provinces in Papua New Guinea: Central, Morobe, Western Highlands and East Sepik.

DIAGNOSIS
Medium sized species; small to medium oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching almost to anterior npl. bristle, 2 lateral postsutural vittae ending at upper pa. bristles, scutellum yellow; legs fulvous except hind tibiae fuscous; wing with a narrow costal band and a broad transverse fuscous band across centre of

wing enclosing both crossveins, costal cells fulvous, microtrichia in outer corner of first costal cell and most of second costal cell; abdominal terga III–V orange-brown with at most a small fuscous spot on anterolateral margins of tergum III and a narrow medial longitudinal fuscous to black band on either terga IV and V or terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small to medium oval black spots present; length of face 0.5 mm. Genae fulvous, fuscous subocular spot present; fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.89 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae narrowing over posterior ½ to end at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae fuscous; remaining segments fulvous except hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 5.9 mm; costal cells fulvous (second cell slightly paler); microtrichia in outer corner of first costal cell and most of second costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad transverse fuscous band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a narrow fuscous transverse band along anterior margin but not reaching lateral margins. Terga III–V orange-brown with no dark markings or with dark markings as follows: a small fuscous spot on anterolateral margins of tergum III; a narrow medial longitudinal fuscous to black band of varying development on terga IV and V or terga III–V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. rhabdota is similar to *B. furvilineata* (*distincta* complex) and *B. latilineata* (*fulvicauda* complex) in possessing the costal band overlapping R_{2+3} but not confluent with R_{4+5}, lateral postsutural vittae ending at upper pa. bristles, transverse band across wing narrow, mesopleural stripe not extending to humeral callus, humeral and notopleural calli yellow and not joined by a lateral yellow band. It differs from *B. furvilineata* in having costal cells fulvous and transverse band across wing expanding to cover outer ⅓ of discoidal cell and from *B. latilineata* in having the abdominal terga mostly orange-brown with occasional small fuscous anterolateral corners on tergum III and an irregular narrow fuscous band on terga III–V or IV and V.

Bactrocera (Bactrocera) unifasciata (Malloch), n. comb. (Fig. 89)

Dacus unifasciatus Malloch, 1939a: 233–4.
Dacus (Strumeta) unifasciatus Drew, 1974a: 93–4.

MATERIAL EXAMINED

Holotype ♂, Kaukau, Guadalcanal I., Solomon Islands, August 1934, R.A. Lever.

LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Kaukau, Guadalcanal I., Solomon Islands (type locality).

DIAGNOSIS

Medium sized species; small oval black facial spots present; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum black, mesopleural stripe slightly wider than

notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad transverse fuscous band across wing, costal cells pale fulvous, microtrichia covering second costal cell only; abdominal terga III–V orange-brown with a medial and 2 lateral longitudinal black bands.
ATTRACTANT: No known record.

COMMENTS
B. unifasciata was described adequately by Drew (1974a). It is similar to *B. morobiensis* (*distincta* complex) in having the humeral and notopleural calli joined by a lateral yellow band but differs in having the mesonotum mostly black and abdominal terga III–V orange-brown with a broad medial and 2 moderately broad lateral longitudinal black bands over all 3 terga.

dorsalis complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for a narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells colourless or with a pale tint and without dense microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with narrow dark basal band, mesonotum black (or with a distinct black lanceolate pattern), abdominal terga III–V with a medial longitudinal dark band and variable dark patterns on lateral margins, males attracted to methyl eugenol.

Bactrocera (Bactrocera) abdolonginqua (Drew), n. comb. (Fig. 90)

Dacus (*Strumeta*) *abdolonginquus* Drew, 1971: 50–2.

MATERIAL EXAMINED
A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6939) in QM.

DISTRIBUTION
Keravat, New Britain (type locality).

DIAGNOSIS
Large species; large oval black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and broad fuscous anal streak, costal cells extremely pale fulvous, microtrichia in outer corner of second costal cell only; abdomen elongate-oval, terga II–V orange-brown with a narrow medial longitudinal fuscous band over all 4 terga and 2 lateral longitudinal fuscous bands over terga III–V.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. abdolonginqua was described adequately by Drew (1971). It is similar to *B. dapsiles* (*dorsalis* complex) and *B. laticosta* (*aemula* complex) in possessing a mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, costal cells with a pale fulvous tint, lateral postsutural vittae ending at or behind upper pa. bristle, mesonotum black and wings colourless except for costal band and anal streak. It differs from *B. laticosta* in having costal band moderately broad reaching midway between R_{2+3} and R_{4+5} and from *B. dapsiles* in having abdomen elongate-oval, costal band of uniform width, lateral postsutural vittae parallel sided and ending behind upper pa. bristles and abdomen with a narrow medial longitudinal pale fuscous band on terga II–V and 2 moderately broad lateral longitudinal pale fuscous bands on terga III–V.

Bactrocera (Bactrocera) cacuminata (Hering), n. comb. (Figs 91–93)

Strumeta cacuminata Hering, 1941a: 46–7; May, 1963: 44–5, 50, 69–70.
Dacus tryoni var. *solani* Jarvis, 1922: 247 (nomen nudum).
Chaetodacus dorsalis: Tryon (nec. Hendel), 1927: 194–6 (misidentification).
Chaetodacus dorsalis var. *major* Tryon, 1927: 195 (nomen nudum).
Strumeta solani Perkins and May, 1949: 14–6; Hardy, 1951: 149 (syn.).
Dacus (*Strumeta*) *cacuminatus*: Hardy, 1951: 149–52.
Dacus (*Bactrocera*) *cacuminatus*: Drew, 1982: 24–6.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION); Hering's and Tryon's type specimens.
LOCATION OF TYPES: *S. cacuminata*, lectotype ♂ and paralectotype ♀ in BMNH; *D. tryoni* var. *solani*, no types designated; *C. dorsalis* var. *major*, 1 ♂ and 1 ♀ syntype (D. 3126) in QM; *S. solani*, 2 ♂ and 2 ♀ syntypes (D. 3125, "plesiotypes" of *C. dorsalis* Tryon) in QM.

DISTRIBUTION
Occurs in large populations throughout eastern Australia from Cape York in the north to the East Gippsland district in the south; type locality, Brisbane.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dark red-brown with a dark fuscous to black lanceolate pattern, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except broad dark fuscous to black medial and lateral longitudinal bands joined along anterior margin of tergum III.

DESCRIPTION

FEMALE: Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.93:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (Fig. 92). Spicules at distal end of middle segment of medium width, scale-like, with a row of 9–15 small thin dentations of approximately equal size (Fig. 93).

HOST PLANTS

NEW RECORDS: *Elaeocarpus* sp. (Elaeocarpaceae) and *Disoxylum* sp. (Meliaceae), Cairns, north Queensland, Dec. 1976, B. McCulloch.
ATTRACTANT: Methyl eugenol.

COMMENTS

Originally, Hering (1941a) designated a male and female type to be placed in HNHM. These specimens are in BMNH: type female labelled "Stanthorpe, Q., 10.3.25, F.A. Perkins"; type male labelled "Brisbane, Q., 10.10.33, F.A. Perkins". They each bear another label "Purch. from E.M. Hering, B.M. 1965–270". Because Hering did not designate a holotype, I designate the male as lectotype and the female as paralectotype.

Tryon (1927) mentioned a variety *major* but did not describe it. Therefore the name is unavailable (Article 12c of the International Code of Zoological Nomenclature). Perkins and May (1949) proposed the name *S. solani* for the misidentified *C. dorsalis* Tryon (nec. Hendel), but described it as a new species. Although no types were designated, Tryon's "plesiotypes" of *C. dorsalis* are part of their type series (Article 72b (ii) of the International Code of Zoological Nomenclature).

May (1953) recorded *B. cacuminata* from capsicum and tomato, the latter based on a few specimens on 1 occasion. Since no further specimens have been obtained in Australia for these or other commercial fruits, these 2 records remain doubtful. Drew (1982) listed this species as economic on the basis of May's (1953) record.

B. cacuminata was described adequately by Hardy (1951) and Drew (1982). It is similar to *B. opiliae* (Drew and Hardy) (*dorsalis* complex) in having the mesonotum not entirely black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, costal cells colourless with microtrichia in outer corner of second costal cell only and lateral postsutural vittae ending at upper pa. bristles. It differs from this species in having the costal band confluent with R_{2+3} and widening slightly between extremity of R_{2+3} and apex of wing. This is the only South Pacific species that has a costal band that is identical to *B. dorsalis* (Hendel)—oriental fruit fly.

Bactrocera (Bactrocera) dapsiles, n. sp.
(Figs 94–96)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Kaindi (1800 m), attracted to methyl eugenol, 16.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 6 ♂♂, Wau Ecology Institute (1600 m), attracted to methyl eugenol, 16.vi.1980, R.A.I. Drew and D.W. Currey; 2 ♂♂ (25.iii.1980), 2 ♂♂ (28.iii.1980), 1 ♂ (6.iv.1980), Upper Manki logging area, Bulolo, attracted to methyl eugenol, P. Daur; 2 ♂♂ (12.ii.1980) and 1 ♂ (7.iii.1980), Upper Stony logging area, Bulolo, attracted to methyl eugenol, P. Daur; 1 ♂ (26.v.1980) and 1 ♂ (2.vi.1980), Gumi logging area, Watut, attracted to methyl eugenol, P. Daur; 1 ♀ and 2 ♂♂ (17.vi.1980), Bulolo, hand collected on *Solanum mauritianum*, R.A.I. Drew and D.W. Currey; 2 ♀♀ (21.vi.1980), Bulolo, bred ex fruit of *Solanum mauritianum*, D.W. Currey; 3 ♀♀ and 1 ♂ (19.vi.1980), Bulolo, bred ex fruit of *Solanum mauritianum*, J. Simpson. Eastern Highlands Province: 3 ♂♂ (29.xi.1976), Highlands Agricultural Experiment Station, Aiyura (1550 m), B. Keoro; 1 ♂ (29.xi.1976) and 3 ♂♂ (30.xi.1976), Highlands Agricultural Experiment Station, Aiyura (1550 m), E.S.C. Smith. Western Highlands Province: 1 ♂ (13.i.1980), Mt Hagen, attracted to methyl eugenol, B. Thistleton. Simbu Province: 2 ♂♂ and 3 ♀♀ (9.v.1984), Karimui, hand collected on cardamom, J.W. Ismay.

LOCATION OF TYPES: Holotype (T.10513) and 2 paratypes (T.10514–T.10515) in QM; 8 paratypes in ANIC; 2 paratypes in BMNH, 2 paratypes in DPI(PNG); 24 paratypes in DPI.

DISTRIBUTION

Occurs in large populations at altitudes below 1800 m. It is known from the following Provinces in Papua New Guinea: Morobe, Eastern Highlands, Western Highlands and Simbu.

DIAGNOSIS

Medium sized species; small to medium irregularly oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae ending at upper pa. bristles, scutellum yellow; legs fulvous except a fuscous tint on basal ends of fore and mid tibiae and fuscous hind tibiae; wing with a dark fuscous costal band (overlapping R_{2+3}) and a narrow fuscous anal streak, costal cells very pale fulvous with microtrichia in outer corner of second costal cell; abdominal terga III–V orange-brown with a moderately broad medial longitudinal black band and either (1) anterolateral corners of tergum III dark fuscous and anterolateral corners of terga IV and V pale fuscous or (2) broad lateral black margins on tergum III which meet along anterior margin and with lateral margins of terga IV and V dark fuscous.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.45 mm. Frons narrowing slightly posteriorly, length 1.46 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small to medium irregularly oval black spots; length of face 0.48 mm. Genae fulvous, dark subocular spot present; red-brown to black bristle present. Occiput pale fuscous to fuscous, yellow along eye margins; occipital row with 4–7 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.75 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas black except brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 moderately broad lateral postsutural vittae narrowing slightly posteriorly to end at upper pa. bristles. (In a few specimens the vittae end just before the upper pa. bristles.) Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs coxae fuscous; all other segments fulvous except a fuscous tint on basal ends of fore and mid tibiae, fuscous on hind tibiae; mid tibiae each with an apical black spur; rows of long dark setae on dorsal surfaces of fore femora and long pale setae on ventral surfaces of fore femora.

Wings length 6.1 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except dark fuscous subcostal cell, narrow dark fuscous costal band overlapping R_{2+3} and widening around apex of R_{4+5} to end between extremities of R_{4+5} and M, a narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown with anterolateral corners fuscous to dark fuscous and with or without a narrow transverse dark fuscous to black band across anterior margin but not reaching lateral margins. Terga III–V vary between 2 extremes: (1) orange-brown with a moderately broad medial longitudinal black band, anterolateral corners of tergum III dark fuscous, anterolateral corners of terga IV and V pale fuscous; (2) orange-brown with a moderately broad medial longitudinal black band, broad lateral black margins on tergum III which meet along anterior margin, lateral margins of terga IV and V dark fuscous. A pair of oval shining spots which vary from orange-brown to fuscous on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment of ovipositor red-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.63:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 95). Spicules at distal end of middle segment of medium width with 8–12 small dentations of uneven length (Fig. 96).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. dapsiles is similar to *B. abdolonginqua* (Drew) (*dorsalis* complex) in having the costal band reaching midway between R_{2+3} and R_{4+5},

mesopleural stripe extending midway between anterior margin of notopleural callus and anterior npl. bristle, costal cells with a pale fulvous tint and lateral postsutural vittae ending at or behind upper pa. bristle. It differs from this species in possessing an oval shaped abdomen, abdominal terga III–V with a broad medial and 2 broad lateral longitudinal dark bands which are joined along anterior margin of tergum III, costal band expanded at apex and lateral postsutural vittae narrowing to end at the upper pa. bristle.

Bactrocera (Bactrocera) diallagma, n. sp.
(Fig. 97)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Lae side of escarpment, 69 km from Lae on Lae–Bulolo road, attracted to methyl eugenol, 19.vi.1980, R.A.I. Drew and D.W. Currey.

Paratype, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Mt Missim (1650 m), attracted to methyl eugenol, 30.x.1980, A. Allison.

LOCATION OF TYPES: Holotype (T.10516) in QM; paratype in DPI.

DISTRIBUTION

Known only from Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; small circular black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe equal in width to notopleural callus, lateral postsutural vittae narrow and ending just before upper pa. bristles, scutellum yellow; legs fuscous except tarsi fulvous; wing with a narrow fuscous costal band and anal streak, legs fuscous except tarsi fulvous; costal cells very pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V dark orange-brown except for a very narrow transverse dark fuscous band across anterior margin of tergum III, lateral margins of tergum III fuscous and a narrow medial longitudinal fuscous band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.55 mm. Frons of even width, length 1.46 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with small circular black spots; length of face 0.45 mm. Genae fulvous, fuscous subocular spot present; small red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–7 well developed bristles. Antennae with segments 1 and 2 red-brown, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.38 mm; 0.78 mm.

Thorax mesonotum black except dark brown below lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing slightly posteriorly to end just before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fuscous except tarsi fulvous; mid tibiae each with an apical black spur.

Wings length 6.1 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings with a fulvous tint except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II dark orange-brown except anterolateral corners fuscous and a narrow dark fuscous transverse band across anterior margin which ends before lateral margins; terga III–V dark orange-brown except for a very narrow dark fuscous transverse band across anterior margin of tergum III and broadening into anterolateral corners, lateral margins of tergum III fuscous, a narrow medial longitudinal fuscous band over all 3 terga. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. diallagma is similar to *B. mimulus* (*dorsalis* complex) and *B. aemula*, *B. consectorata*, *B.*

fuliginus (Drew and Hancock) and *B. inconstans* (*aemula* complex) in possessing coloured costal cells and lateral postsutural vittae ending before upper pa. bristles. It differs from these species in having a narrow mesopleural stripe equal in width to notopleural callus.

Bactrocera (Bactrocera) endiandrae (Perkins and May), n. comb. (Figs 98–100)

Strumeta endiandrae Perkins and May, 1949: 9–10; May, 1953: 16, 1963: 50, 74.
Dacus (*Strumeta*) *endiandrae*: Hardy, 1951: 152–4; Drew, 1974a: 36.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION); type series of Perkins and May.
LOCATION OF TYPES: Lectotype ♀ (T.5251) and 1 paralectotype ♂ (T.5252) in QM; 147 paralectotypes in UQ.

DISTRIBUTION
PREVIOUSLY RECORDED: Occurs in large populations in the rainforests of eastern Queensland (type locality, Cairns) and north-east New South Wales. Papua New Guinea at Morehead, Western District (Drew, 1974a).
NEW RECORDS: Papua New Guinea, Central Province: Sogeri, 5.x.1973, J. Stibick. Torres Strait islands: Badu, Boigu, Horn, Saibai, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS
Small to medium sized species; small oval to circular black facial spots present; humeral and notopleural calli yellow; legs fulvous except hind tibiae fuscous; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, legs fulvous except hind tibiae fuscous; costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a transverse dark fuscous to black band across base of tergum III, a medial longitudinal dark fuscous to black band on terga III–V and moderately broad lateral longitudinal bands which are generally fuscous to pale fuscous but may be darker.

DESCRIPTION
FEMALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.55 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small circular to oval black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 3–7 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.73 mm.

Thorax mesonotum dull black except brown below and behind lateral postsutural vittae, around mesonotal suture, between humeral and notopleural calli, inside humeral calli. Pleural areas fuscous to dark fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae narrowing slightly posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for anterolateral corners dark fuscous and a narrow dark fuscous transverse band across anterior area of tergum; terga III–V orange-brown except for a transverse dark fuscous to black band across base of tergum III, a medial longitudinal fuscous to black band on terga III–V and moderately broad lateral longitudinal bands which

are generally fuscous to pale fuscous but may be darker. Basal segment of ovipositor orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.48:1. Apex of piercer needle shaped with 4 pairs of small subapical bristles (Fig. 99). Spicules at distal end of middle segment of medium width with 8–10 dentations of uneven size (Fig. 100).

MALE: As for female except dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development; pecten present on abdominal tergum III.

HOST PLANTS

NEW RECORD: *Maranthes corymbosa* (Chrysobalanaceae), Bamaga, Cape York, Queensland, G.M. Sanewski.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. endiandrae is similar to *B. aemula*, *B. consectorata*, *B. fuliginus* (Drew and Hancock), *B. inconstans* (*aemula* complex) and *B. diallagma* and *B. mimulus* (*dorsalis* complex) in possessing lateral postsutural vittae ending before upper pa. bristles. It differs from all these species in having colourless costal cells. Perkins and May did not define type specimens in their description, based on "over one hundred specimens ..." Two specimens each labelled holotype in QM can be identified from label data as part of the original series: 1 female (T.5251), Cairns, Queensland, 16.x.1937, F.A. Perkins, bred from *Endiandra discolor*; 1 male (T.5252), Cairns, Queensland, 16.x.1937, F.A. Perkins, bred from *Endiandra discolor*. The remainder of the type series is in UQ. I designate the female (T.5251) as lectotype and the remaining specimens as paralectotypes.

Bactrocera (Bactrocera) mimulus, n. sp. (Fig. 101)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute, attracted to methyl eugenol, 31.iii. – 11.iv.1965, E.N. Marks.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 6 ♂♂ (18–22.vi.1980), Gabensis (on Lae–Bulolo road), R.A.I. Drew and D.W. Currey; 2 ♂♂ (12.ii.1980) and 1 ♂ (22.ii.1980), Upper Stony logging area, Bulolo, P. Daur; 1 ♂ (26.v.1980), Gumi Watut, P. Daur; 2 ♂♂ (19.vi.1980), Kassam Pass, R.A.I. Drew and D.W. Currey. All paratypes attracted to methyl eugenol.

LOCATION OF TYPES: Holotype (T.10517) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 10 paratypes in DPI.

DISTRIBUTION

Known only from Morobe Province, Papua New Guinea.

DIAGNOSIS

Small to medium sized species; medium sized subquadrate black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles, scutellum yellow; legs fulvous except fore tibiae fuscous and hind tibiae dark fuscous; wing with a broad fuscous costal band (reaching almost to R_{4+5}) and broad fuscous anal streak, costal cells very pale fulvous with microtrichia absent or covering most of second costal cell; abdominal terga III–V dark orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum III, a narrow medial longitudinal dark fuscous band and 2 narrow lateral longitudinal bands which are dark fuscous on tergum III and fuscous on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.05 mm. Frons narrowing slightly posteriorly, length 1.42 times breadth; fulvous with, at most, pale fuscous around orbital bristles; anteromedial hump covered by short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized subquadrate black spots; length of face 0.38 mm. Genae fulvous, pale fuscous subocular spot present; red-brown bristle present. Occiput fuscous, yellow along eye margins; occipital row with 4–8 bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.14 mm; 0.23 mm; 0.60 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae and dark fuscous between humeral and notopleural calli. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including ventral margins black); 2 lateral postsutural vittae

narrowing posteriorly to end just before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except fore tibiae fuscous and hind tibiae dark fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.8 mm; costal cells very pale fulvous; microtrichia covering most of second costal cell (in some specimens microtrichia are sparse); remainder of wings colourless or with a very pale fuscous tint, except fuscous subcostal cell, broad fuscous costal band almost reaching R_{4+5} and crossing this vein at its apex, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II dark orange-brown except for a transverse dark fuscous band across anterior ½ which expands over lateral margins; terga III–V dark orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum III, a narrow medial longitudinal fuscous band which ends in centre of tergum V, 2 narrow lateral longitudinal bands which are dark fuscous on tergum III and fuscous on terga IV and V. A pair of oval pale fuscous shining spots on tergum V. (There are some variations in the abdominal colour patterns, i.e. the lateral and longitudinal bands are sometimes reduced in size and intensity of colour.) Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. mimulus is similar to *B. aemula* (*aemula* complex) in possessing costal band overlapping R_{2+3}, no tint of fuscous colouration across wing membrane, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, costal cells with a pale fulvous tint and lateral postsutural vittae ending before upper pa. bristles. It differs from this species in having abdominal terga III–V dark orange-brown with narrow medial and longitudinal dark bands joined along anterior margin of tergum III and costal band almost confluent with R_{4+5}.

Bactrocera (Bactrocera) nigrescens (Drew), n. comb. (Fig. 102)

Asiadacus nigrescens Drew, 1968a: 23–4.
Dacus (*Strumeta*) *nigrescens*: Drew, 1972a: 21.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6576) in QM.

DISTRIBUTION

Occurs in large numbers in New Britain (type locality), New Ireland, Lihir and Bougainville Is.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe slightly broader than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown with black laterally on terga III and IV, fuscous on tergum V and a medial longitudinal black band over all 3 terga.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. nigrescens was described adequately by Drew (1968a). It is similar to *B. trivialis* (Drew) (*aemula* complex) in possessing an entirely black mesonotum, costal cells colourless and lateral postsutural vittae ending at or behind upper pa. bristles. It differs from this species in having prsc. bristles absent, abdominal terga III–V orange-brown with a broad medial longitudinal black band over all 3 terga and moderately broad black margins on tergum III.

Bactrocera (Bactrocera) opiliae (Drew and Hardy), n. comb. (Figs 103–105)

Dacus (*Bactrocera*) *opiliae* Drew and Hardy, 1981: 131–7.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8427) in QM.

DISTRIBUTION

Widespread throughout the northern regions of the Northern Territory (type locality, Darwin) and Western Australia. It is most prevalent in the coastal regions and Melville I. but expands further inland during the wet season.

DIAGNOSIS

Medium sized species; medium sized circular black facial spots present; humeral and notopleural calli yellow; mesonotum either uniformly dull black or red-brown with an irregular pattern of longitudinal dull black bands, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs mostly fulvous except fore tibiae very pale fuscous and hind tibiae pale fuscous to fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown and generally with a dark fuscous to black transverse band across anterior margin of tergum III, expanding to cover lateral margins and a medial longitudinal dark fuscous to black band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.52 times breadth; fulvous with, at most, pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots; length of face 0.43 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–7 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.25 mm; 0.75 mm.

Thorax mesonotum either uniformly dull black or red-brown with a pattern of longitudinal dull black markings. Pleural areas red-brown except dull black on sternopleuron and along anterior and posterior margins of mesopleural stripe. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except fore tibiae very pale fuscous and hind tibiae pale fuscous to fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.5 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band only slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I orange-brown; tergum II orange-brown tending fulvous along posterior margin each side of centre line and with transverse fuscous lines across centre of tergum; terga III–V orange-brown and generally with a dark fuscous to black transverse band across anterior margin of tergum III expanding to cover lateral margins, a medial longitudinal dark fuscous to black band over all 3 terga and ending before posterior margin of tergum V. The area and intensity of dark colour on terga III–V often varies and is sometimes reduced to pale fuscous along anterior margin of tergum III and fuscous to dark fuscous on the medial longitudinal band. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.68:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (Fig. 104). Spicules at distal end of middle segment of medium width with a row of 8–10 thin dentations of approximately equal size (Fig. 105).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. opiliae (Drew and Hardy) is similar to *B. cacuminata* (Hering) (*dorsalis* complex) in having the mesonotum red-brown with a distinct black pattern (not entirely black), mesopleural stripe reaching midway between anterior margin of

notopleural callus and anterior npl. bristle, costal cells colourless and lateral postsutural vittae ending at or behind upper pa. bristles. It differs from this species in having the costal band overlapping R_{2+3} and the black pattern on the mesonotum not distinctly lanceolate as in *B. cacuminata*.

fagraea complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells without dense microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad dark basal band ¼ to ½ width of scutellum, mesonotum generally red-brown with or without dark markings, males of some species attracted to cue lure.

Bactrocera (Bactrocera) fagraea (Tryon), n. comb. (Figs 106–108)

Chaetodacus fagraea Tryon, 1927: 188–90.
Dacus (Strumeta) fagraeus: Hardy, 1951: 154–5.
Strumeta fagraea: May, 1963: 45, 50.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: Lectotype ♂ (D.3122) and paralectotype ♀ (D.3122) in QM.

DISTRIBUTION

Known only from rainforests in north-east Queensland, north from Ayr (type locality, Babinda), common on the Atherton Tableland.

DIAGNOSIS

Medium sized species; medium sized subquadrate black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae narrow and ending before upper pa. bristles, scutellum yellow with a very broad red-brown basal band; legs fulvous except hind tibiae pale fuscous; wing with a narrow pale fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga I–V orange-brown except tending fulvous posterolaterally on tergum II, a narrow very pale fuscous medial longitudinal stripe on tergum V and posterior ½ of tergum IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.57 times breadth; fulvous with, at most, pale fuscous around s.or. bristles and on anteromedial hump; latter covered by a large number of short dark setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle dark fuscous. Vertex fulvous. Face fulvous with medium sized subquadrate black spots; length of face 0.45 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–5 red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 narrow lateral postsutural vittae tapering slightly posteriorly to end before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for broad red-brown basal band equal in width to ⅓ the depth of the scutellum. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles generally well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 6.0 mm; costal cells fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, pale fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V orange-brown except tending fulvous along posterior margin of tergum II each side of medial line, a narrow very pale fuscous medial longitudinal line on tergum V and posterior of tergum IV. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus

short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 1.22:1. Apex of piercer needle shaped with 4 pairs of small subapical bristles (Fig. 107). Spicules at distal end of middle segment of medium width with 9–13 dentations of uneven size, with the largest of medium length (Fig. 108).

ATTRACTANT: Cue lure, Willison's lure (probably a weak attraction to these lures because of low numbers taken in traps).

COMMENTS

B. fagraea is similar to *B. halfordiae* (Tryon), *B. kraussi* (Hardy), *B. rufescens* (May), *B. russeola* (Drew and Hancock) (*fagraea* complex) in having the mesonotum mostly red-brown, scutellum with a broad basal dark band (¼ to ½ width of scutellum), costal cells with microtrichia in outer portion of second costal cell only, wing not infuscated except for costal band and anal streak, lateral postsutural vittae present and medial postsutural vitta absent. It differs from all these species in having abdominal tergum V without dark shining spots and dark basal band on scutellum approximately ⅓ length of scutellum.

Originally, Tryon (1927) designated 2 types now in QM. One severely damaged female (head, abdomen and 1 wing missing) has 3 labels: "TYPE D/3122", "Babinda, Q. 26.6.25, R.W.M.", "Edmund Jarvis, Coll. Ex.". The other, a male has 3 labels: "ALLOTYPE D/3122", "Babinda, Q., 24.6.25, R.W.M.", "Edmund Jarvis, Coll. Ex.". It is doubtful that the type labels were placed on the specimens by Tryon as they are of the style used by QM. Therefore some uncertainty exists as to whether or not Tryon designated a holotype. Consequently, I designate the male labelled allotype as lectotype and the other as paralectotype.

Bactrocera (Bactrocera) halfordiae (Tryon), n. comb. (Figs 109–111)

Chaetodacus halfordiae Tryon, 1927: 190–1.
Chaetodacus gurneyi Perkins, 1934: 41–2; May, 1953: 52 (syn.).
Dacus (Strumeta) halfordiae: Hardy, 1951: 155–6.
Strumeta halfordiae: May, 1963: 45–6, 50.
Dacus (Bactrocera) halfordiae: Drew, 1982: 29–31.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); Tryon's and Perkins' type specimens; large series of specimens (in NSW) labelled Narara, New South Wales, bred from White Ash berries and Cheesewood berries, 4.2.1910 and 1910 respectively.

LOCATION OF TYPES: *C. halfordiae*, lectotype ♀ (D.3123) and paralectotype ♂ (D.3123) in QM; *C. gurneyi*, 52 ♂ ♀ syntypes in UQ, 1 ♂ syntype in NSW.

DISTRIBUTION

The endemic distribution of *B. halfordiae* is from south-east Queensland (approximately 26° S) where it occurs mostly at higher altitudes (type locality, Southport), to the Sydney area of New South Wales. It does not occur further north where *B. kraussi* (Hardy), a closely related species, occupies hosts in the same genera. *B. halfordiae* is unique in having a subtropical to temperate distribution. There are 2 specimens in the Macleay Collection, University of Sydney, collected in the Sydney area between 1830 and 1850.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum pale red-brown with irregular dark markings, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad red-brown basal band extending to centre; wing with a narrow fuscous costal band and broad fuscous anal streak, coastal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga generally orange-brown with fuscous on lateral margins of all terga and the shining oval spots on tergum V dark brown to fuscous.

DESCRIPTION

FEMALE: Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.76:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 110). Spicules at distal end of middle segment of medium width with 8–11 small dentations (Fig. 111).

ATTRACTANT: No known record.

COMMENTS

B. halfordiae was described adequately by Drew (1982). It is similar to all other species in the *fagraea* complex in the characters listed in the comments on *B. fagraea* (Tryon). It differs from *B. rufescens* (May) in lacking a medial dark band

on the abdominal terga, from *B. fagraea* (Tryon) and *B. russeola* (Drew and Hancock) in having lateral dark markings on abdominal terga III and IV and *B. kraussi* (Hardy) in having the mesonotum and abdominal terga uniformly red-brown, fuscous lateral margins on abdominal terga III and IV narrow, mesopleural stripe not wider than notopleural callus and lateral postsutural vittae narrow and narrowing sharply posteriorly.

B. halfordiae appears to be of no economic importance, no commercial host records having been obtained since May (1953). The commercial host records of *B. halfordiae* may be incorrect as early workers confused the identity of this species with *B. tryoni*.

Originally, Tryon (1927) designated types as follows: "Type.—Regis. No. D.3123, male and female". On the female specimen there is a white card with "TYPE D/3123" and on the male specimen a white card with "ALLOTYPE D/3123". For the same reason given in the comments on *B. fagraea*, I designate the specimen labelled type as lectotype and the other specimen as paralectotype.

Bactrocera (Bactrocera) kraussi (Hardy), n. comb. (Figs 112–114)

Dacus (Strumeta) kraussi Hardy, 1951: 156–9.
Strumeta kraussi: May, 1953: 56–8; May, 1957a: 34; May, 1960: 197; May, 1963: 46–7, 50.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ in NMNH.

DISTRIBUTION

PREVIOUSLY RECORDED: Rainforests along the eastern coast of north Queensland (type locality, Deeral).
NEW RECORD: Torres Strait islands: Moa (Banks) (record from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized oval facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregularly shaped lateral longitudinal pale fuscous to fuscous bands, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad red-brown to fuscous basal band; wing colourless or with a pale fulvous tint and a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fulvous to fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III and IV fuscous and tergum V fulvous except for broad lateral dark fuscous margins on terga III and IV and broad fuscous lateral margins on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.6 times breadth; fulvous with, at most, pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short dark setae; orbital bristles red-brown: 1 s.or., 2 s.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized oval black spots; length of face 0.45 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–7 well developed bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.73 mm.

Thorax mesonotum red-brown with broad lateral longitudinal pale fuscous to fuscous bands. Pleural areas fuscous, tending red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior 3/5 lower hypopleural calli (remainder fuscous); 2 lateral postsutural vittae narrowing slightly posteriorly to end at or before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for broad fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all coxae fuscous; femora fulvous except fore and mid femora tending red-brown apically and hind femora tending red-brown to pale fuscous apically; remaining segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells pale fulvous to fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless or with a pale fuscous tint except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin;

dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; tergum II fulvous except for a broad transverse fuscous band along anterior margin and widening to cover lateral margins; terga III and IV fuscous and tergum V fulvous except for irregularly shaped broad lateral longitudinal bands which are dark fuscous on terga III and IV and fuscous on tergum V. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.15:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 113). Spicules at distal end of middle segment wide with 9 or 10 dentations, usually 2 or 3 elongate and wide and the remainder small (Fig. 114).

HOST PLANTS

NEW RECORDS: *Syzygium rubrimolle* (Myrtaceae), Lake Boronto, near Somerset, Bamaga (Cape York, Queensland), December 1974, D.J. Rogers (in 1 sample associated with *B. jarvisi* (Tryon) and *B. tryoni* (Froggatt) and in another with *B. jarvisi*); *Syzygium* sp. (Myrtaceae), on Somerset road (27 km from Bamaga), Cape York, Queensland, December 1974, D.J. Rogers. *Notolaea* sp. (Oleaceae), Lake Boronto, Lockerbie, near Somerset (Cape York, Queensland), December 1974, D.J. Rogers (mostly heavily infested and in 1 sample associated with *B. jarvisi* and *B. neohumeralis* (Hardy)). *B. kraussi* is closely related to *B. halfordiae* (Tryon) and occupies the host niche in North Queensland that *B. halfordiae* occupies in south-east Queensland.

ATTRACTANT: Cue lure.

COMMENTS

B. kraussi is similar to all other species in the *fagraea* complex in the characters listed in the comments on *B. fagraea* (Tryon). It differs from *B. rufescens* (May) in lacking a medial dark band on abdomen, from *B. fagraea* and *B. russeola* (Drew and Hancock) in having lateral fuscous markings on abdominal terga III and IV and from *B. halfordiae* (Tryon) in having a red-brown mesonotum with or without fuscous markings, abdomen usually fuscous over terga III and IV and laterally on tergum V, mesopleural stripe 1½ times the width of notopleural callus and lateral postsutural vittae parallel sided.

Bactrocera (Bactrocera) rufescens (May), n. comb. (Fig. 115)

Strumeta rufescens May, 1967 : 81–2.

MATERIAL EXAMINED

Holotype ♂ and 1 ♂ paratype, Kuranda, north Queensland, 16.vi.1964, R. Grattidge.

LOCATION OF TYPES: Holotype (T.6545) in QM; paratype in DPI.

DISTRIBUTION

Kuranda, north Queensland (type locality).

DIAGNOSIS

Small to medium sized species; medium sized pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe equal in width to notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad red-brown basal band equal in width to ⅓ the length of the scutellum; legs fulvous with hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a medial longitudinal dark fuscous band and 2 broad lateral longitudinal dark fuscous bands over all 3 terga and joined along anterior margin of tergum III by a paler fuscous area.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.55 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.38 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle prsent. Occiput fulvous, yellow along eye margins; occipital row with 5 weak pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.28 mm; 0.63 mm.

Thorax mesonotum red-brown without dark markings. Pleural areas pale fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder including broad ventral margins red-brown); 2 narrow lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for broad red-brown basal band equal in width to at least ⅓ the length of the scutellum. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical fuscous spur.

Wings length 5.3 mm, costal cells fulvous; microtrichia in outer corner of second costal cell only; remainder of wings with a pale fuscous tint except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I red-brown; tergum II red-brown tending fulvous along posterior margin either side of midline; terga III–V orange-brown except for a medial longitudinal dark fuscous band and 2 broad lateral longitudinal dark fuscous bands over all 3 terga and joined by a pale fuscous area along anterior margin of tergum III. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. rufescens is similar to all other species in the *fagraea* complex in the characters listed in the comments on *B. fagraea* (Tryon). It differs from these species in having a well defined medial black vitta on terga III–V.

Bactrocera (Bactrocera) russeola
(Drew and Hancock), n. comb. (Fig. 116)

Dacus (Bactrocera) russeolus Drew and Hancock, 1981: 80–1.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.8303) in QM.

DISTRIBUTION

Paluma (type locality), The Crater, Wallaman Falls and Maiden Hair Fern Gully (Mt Spec). This species is known only from high altitudes in north Queensland.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with or without fuscous markings, mesopleural stripe equal in width to notopleural callus, lateral postsutural vittae present; medial postsutural vitta absent, scutellum yellow with a broad red-brown basal band reaching to centre; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia in outer corner of second costal cell only; abdominal terga uniformly red-brown with oval shining spots on tergum V dark fuscous to black.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. russeola was described adequately by Drew and Hancock (1981). It is similar to all other species in the *fagraea* complex in the characters listed in the comments on *B. fagraea* (Tryon). It differs from *B. rufescens* (May) in lacking a medial black band on the abdomen, from *B. halfordiae* (Tryon) and *B. kraussi* (Hardy) in having abdominal terga III–V uniformly pale coloured without dark markings and from *B. fagraea* in having a pair of dark shining spots on abdominal tergum V, mesonotum red-brown and dark basal band on scutellum about ½ length of the scutellum.

frauenfeldi complex

DEFINITION OF COMPLEX: *Bactrocera* species with wing with a narrow transverse fuscous band enclosing both crossveins and almost no costal band infuscation apical to this cross band, costal cells coloured, medial postsutural vitta absent, scutellum yellow with a triangular black marking on dorsal surface sometimes reduced to a broad basal band, mesonotum shining black, abdominal terga either entirely shining black or with orange-brown bordering a medial longitudinal shining black band on terga III–V, males attracted to cue lure.

Bactrocera (Bactrocera) caledoniensis, n. sp. (Fig. 117)

TYPE SPECIMENS

Holotype ♂, NEW CALEDONIA: Sarramea, attracted to cue lure, 6–9.i.1970, P. Cochereau.

Paratype, NEW CALEDONIA: 1 ♂, Sarramea, attracted to cue lure, 6–9.i.1970, P. Cochereau.

LOCATION OF TYPES: Holotype (T.10518) in QM; paratype in DPI.

DISTRIBUTION

Known only from New Caledonia.

DIAGNOSIS

Small to medium sized species; facial spots absent; humeral calli yellow (anterodorsal corners black); notopleural calli yellow; mesonotum shining black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles, medial postsutural vitta absent, scutellum yellow with a broad triangular basal band; legs fulvous except hind tibiae very pale fuscous; wing with a narrow very pale fuscous costal band and broad fuscous anal streak, a narrow fuscous transverse band across wing and enclosing both crossveins, costal cells very pale fulvous with microtrichia in outer corner of second costal cell only; all abdominal terga shining black except for a narrow dark fuscous transverse band across posterior margin of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons narrowing slightly posteriorly, length 1.76 times breadth; fulvous without dark markings, anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark markings: length of face 0.43 mm. Genae fulvous, large brown subocular spot present; black bristle present. Occiput black, fulvous along eye margins; occipital row with 3–7 strong black bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong dark fulvous dorsal bristle on segment 2; length of segments: 0.13 mm; 0.25 mm.

Thorax mesonotum shining black without pale markings. Pleural areas shining black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli (except anterodorsal margin shining black); notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices shining black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end before upper pa. bristles. Postnotum shining black. Scutellum yellow except for a broad triangular basal band equal in width to about ⅓ the length of the scutellum. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except hind tibiae very pale fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.4 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow very pale fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow transverse fuscous band across wing and enclosing both crossveins, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga shining black except for a narrow transverse dark fuscous band across posterior margin of tergum V. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. caledoniensis is similar to *B. frauenfeldi* (Schiner), *B. parafrauenfeldi* and *B. trilineola*, n. nom. for *B. triseriata* (Drew) not Curran (see later in this complex), in having a black mesonotum, narrow transverse fuscous band across wing and enclosing both crossveins, almost no costal band infuscation apical to cross band, costal cells coloured, medial postsutural vitta absent and scutellum with a triangular black marking on dorsal surface. It differs from these species in having humeral calli mostly yellow and the black basal band on the scutellum about ⅓ the length of the scutellum.

Bactrocera (Bactrocera) frauenfeldi (Schiner), n. comb. (Figs 118–120)

Dacus frauenfeldi Schiner, 1868: 262; Froggatt, 1909: 96; Malloch, 1939a: 232–3.

Strumeta frauenfeldi: Perkins, 1938: 128–9.
Dacus (Strumeta) frauenfeldi: Hardy and Adachi, 1954: 168–9; Hardy, 1968: 138 (lectotype designation); Drew, 1974a: 41–5.
Dacus (Bactrocera) frauenfeldi: Drew, 1982: 27–9.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Lectotype ♀ and paralectotype ♀ in NHMV (Hardy, 1968). There is 1 ♀ paralectotype in BMNH labelled "Paratype", "Navara-R, Linard Insel", "Frauenfeldi, Alte Sammlung", "Type". (Navara-R = Novara Reise (Voyage of the Novara); Linard Insel = Linard Island; Alte Sammlung = Old Collection. The latter label is in the style of the Vienna Museum.

DISTRIBUTION
PREVIOUSLY RECORDED: Large populations from Cape York (Queensland) to Papua New Guinea, islands of the Bismarck Archipelago, Bougainville I., Solomon Islands and Stuart I. (type locality).
NEW RECORDS: Torres Strait islands: Badu, Boigu, Darnley, Dauan, Hammond, Horn, Moa (Banks), Murray, Prince of Wales, Saibai, Stephens, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; large black facial spots present; humeral calli black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a black triangle on dorsal surface; wing with a narrow extremely pale fuscous costal band and broad fuscous anal streak, a narrow fuscous transverse band across wing, costal cells pale fuscous, microtrichia covering most of second costal cell; abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal black bands.

DESCRIPTION
FEMALE: Ovipositor basal segment dark red-brown to fuscous, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.69:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 119). Spicules at distal end of middle segment of medium width with 8–12 dentations of uneven size with the largest of medium length (Fig. 120).

HOST PLANTS
NEW RECORDS: *Manilkara kauki* (Sapotaceae), Sue I. 1980, G. Sanewski; *Syzygium branderhorstii* (Myrtaceae), Darnley I. 1980, G. Sanewski; *Terminalia catappa* (Combretaceae) in Torres Strait islands. It was observed ovipositing in ripe papaya on Murray I. May 1986, J. Turner. This species could become a serious pest when horticultural industries are developed within its geographic range.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. frauenfeldi was described adequately by Drew (1974a). It is similar to *B. parafrauenfeldi* and *B. trilineola* in having black humeral calli and a black triangular marking on dorsal surface of scutellum extending to the apex but differs in possessing lateral postsutural vittae and with the black markings on the scutellum generally with a distinct triangular shape reaching the apex as a point.
B. albistrigata (de Meijere), regarded as a synonym of *B. frauenfeldi* by Hardy and Adachi (1954), is a distinct species. It possesses yellow humeral calli and is confined to South East Asia.

Bactrocera (Bactrocera) parafrauenfeldi, n. sp.
(Fig. 121)

TYPE SPECIMENS
Holotype ♂, AUSTRALIA, Northern Territory: Smith Point, Cobourg Peninsula, attracted to cue lure, 31.i.1982, R.A.I. Drew and A.J. Allwood.
Paratypes, AUSTRALIA, Northern Territory: 1 ♂ (28.i.1982) and 1 ♂ (31.i.1982), Smith Point, Cobourg Peninsula, attracted to cue lure, R.A.I. Drew and A.J. Allwood; 2 ♂♂ (19.iv.1977), Smith Point, Cobourg Peninsula, attracted to cue lure, A.J. Allwood; 1 ♂ (8.xii.1975), Melville I., attracted to Willison's lure, A.J. Allwood.
LOCATION OF TYPES: Holotype (T.10519) in QM; 1 paratype in ANIC; 4 paratypes in DPI.

DISTRIBUTION
Known from Cobourg Peninsula and Melville I. (Northern Territory), Australia.

DIAGNOSIS
Dark coloured medium sized species; medium sized oval black facial spots present; humeral calli glossy black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae absent or present as a very short narrow tawny coloured spot, scutellum yellow with a very broad medial glossy black band; legs fulvous except apical ⅔–¾ of fore femora and apical ⅓ of hind femora glossy black, fore and mid tibiae fuscous and hind tibiae dark fuscous; wing with a distinct costal band absent and a narrow transverse fuscous band

across centre which encloses both crossveins, costal cells pale fuscous, microtrichia covering most of second costal cell only; abdominal terga II–V orange-brown except for a broad medial and 2 broad lateral longitudinal glossy black bands.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.89 times breadth; fulvous with dark fuscous around orbital bristles and on anteromedial hump; latter covered with a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fuscous. Ocellar triangle black. Vertex dark fuscous. Face fulvous with medium sized oval black spots not reaching epistoma; length of face 0.43 mm. Genae fulvous, dark fuscous subocular spot present; black bristle present. Occiput black, yellow along eye margins; occipital row with 5–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.80 mm.

Thorax mesonotum and pleural areas glossy black with no brown markings. Yellow markings as follows: notopleural calli; mesopleural stripe of medium width, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a very small spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder, including ventral margin, black). Lateral postsutural vittae absent or, if present; they are very short, narrow, tawny coloured spots ending well before sa. bristles. Humeral calli glossy black. Postnotum glossy black. Scutellum yellow except for a broad medial glossy black band which encloses the apical bristles. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae dark fuscous, mid and hind coxae black; fore femora fulvous, mid femora with apical ⅔–¾ black (remainder fulvous), hind femora with apical ⅓ black (remainder fulvous), fore tibiae fuscous, mid tibiae fuscous tending paler apically, hind tibiae dark fuscous; tarsi fulvous except apical 4 segments of fore tarsi and apical 3 segments of hind tarsi fuscous; mid tibiae each with an apical black spur; rows of long dark setae on dorsal surfaces of fore femora.

Wings length 5.1 mm; costal cells pale fuscous; microtrichia covering most of second costal cell only; remainder of wings colourless except fuscous subcostal cell, a narrow transverse fuscous band across wing enclosing both crossveins, a broad fuscous anal streak ending at wing margin (the costal band is absent except for a very pale tint along costal margin in some specimens); dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I glossy black; terga II–V orange-brown except for 2 broad lateral and a broad medial longitudinal glossy black bands extending over all terga. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. parafrauenfeldi is similar to *B. trilineola* in having lateral postsutural vittae absent and with the black marking on the scutellum as a broad black band enveloping both apical bristles but differs in possessing medium sized oval black facial spots, costal cells darker (pale fuscous), microtrichia covering most of second costal cell, costal band entirely absent beyond subcostal cell, femora fulvous with apical ⅔–¾ of mid femora and apical ½ of hind femora black, fore and mid tibiae fuscous and hind tibiae dark fuscous.

Bactrocera (Bactrocera) trilineola n. nom. (Figs 122–124)

Not *Dacus triseriatus* Curran, 1927: 87.
Dacus (Strumeta) triseriatus Drew, 1971: 90–2.

MATERIAL EXAMINED

A large series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6964) in QM.

DISTRIBUTION

Known from the following islands in Vanuatu (formerly New Hebrides): Efate (type locality, Vila), Malekula and Espiritu Santo.

DIAGNOSIS

Medium sized species; face entirely glossy black; humeral calli fuscous to black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum glossy black with lateral margins yellow; wing with a narrow extremely pale fuscous costal vein and broad fuscous anal streak, a narrow fuscous transverse band across wing, costal cells

extremely pale fuscous, microtrichia covering outer ½ of second costal cell only; abdominal terga mostly glossy black except for 2 broad longitudinal fulvous bands on terga II–V either side of a broad medial longitudinal glossy black band.

DESCRIPTION

FEMALE: Ovipositor basal segment fuscous, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.1:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 123). Spicules at distal end of middle segment of medium width with 5–10 dentations of uneven size (Fig. 124).

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. trilineola was described adequately by Drew (1971). It is similar to all other species in the *frauenfeldi* complex in the characters listed in the comments on *B. caledoniensis*. It differs from *B. caledoniensis* and *B. frauenfeldi* (Schiner) in possessing a glossy black face and in lacking lateral postsutural vittae and from *B. parafrauenfeldi* in having a glossy black face, costal cells extremely pale fuscous, microtrichia in outer ½ of second costal cell only, costal band present but very pale beyond subcostal cell and legs fulvous except apical ⅓ of hind femora and hind tibiae fuscous. The apex of piercer and the spicules on the middle segment of the ovipositor are similar in *B. frauenfeldi* and *B. trilineola*, however the apex of piercer is slightly more pointed in *B. trilineola*.

fulvicauda complex

DEFINITION OF COMPLEX: *Bactrocera* species with infuscation on wing as a transverse band across centre region in addition to costal band and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, scutellum entirely yellow; males of some species attracted to methyl eugenol.

Bactrocera (Bactrocera) fulvicauda (Perkins), n. comb. (Figs 125–127)

Strumeta fulvicauda Perkins 1939: 13–15.
Dacus (Strumeta) fulvicaudus: Drew, 1974a: 47–50.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♀ (T.11137) in QM.

DISTRIBUTION

Widespread throughout the lowland rainforests of Papua New Guinea (type locality, Mt Lamington).

DIAGNOSIS

Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad transverse fuscous band across wing, costal cells fulvous, microtrichia covering most of second costal cell and outer corner of first costal cell; abdominal terga III–V vary from mostly black to red-brown with broad medial and lateral longitudial black bands (Figs 125A, B).

DESCRIPTION

FEMALE: Ovipositor basal segment red-brown, elliptical in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 2.17:1. Apex of piercer wide narrowing sharply to a point with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 126). Spicules at distal end of middle segment of medium width with 1 or 2 very long, broad dentations and 1–4 small lateral dentations (Fig. 127).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. fulvicauda was described adequately by Drew (1974a). It is similar to *B. pulchra* (Tryon) and *B. unistriata* (Drew) (*fulvicauda* complex) in possessing humeral and notopleural calli yellow, not joined by a lateral yellow band and a transverse band across wing broad covering outer ⅓–½ of discoidal cell, but differs in having the mesopleural stripe broad and extending to the humeral callus.

Bactrocera (Bactrocera) latilineata, n. sp. (Fig. 128)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western Highlands Province: Mt Hagen, attracted to methyl eugenol, 13.i.1980, B. Thistleton.

Paratype, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Mt Missim (1550 m), attracted to cue lure, 19.iii.1981, A. Allison.

LOCATION OF TYPES: Holotype (T.10520) in QM; paratype in DPI.

DISTRIBUTION

Known from Mt Hagen and Mt Missim, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots small and pear shaped; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe narrow (just slightly wider than notopleural callus), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, a broad transverse fuscous band across wing which encloses both crossveins, first costal cell fulvous, second costal cell pale fulvous, microtrichia covering second costal cell; abdominal terga III–V red-brown except for a broad medial and 2 broad lateral longitudinal dark bands which join along anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small pear shaped black spots; length of face 0.48 mm. Genae fulvous, brown sub-ocular spot present; red-brown bristle present. Occiput fuscous, fulvous along eye margins; occiptal row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong red-brown dorsal bristle on segment 2; length of segments: 0.15 mm; 0.30 mm.

Thorax mesonotum black except dark brown below and behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, slightly wider than notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder black); 2 narrow parallel sided lateral postsutural vittae ending at upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except fore tibiae pale fuscous, hind tibiae dark fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.1 mm; first costal cell fulvous, second costal cell pale fulvous; microtrichia along anterior margin of first costal cell and covering second costal cell except posterior margin; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad transverse fuscous band across wing which encloses both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band across posterior margin but not reaching lateral margins; tergum II orange-brown except for a broad transverse black band across anterior margin which changes to dark fuscous as it widens to cover lateral margins; terga III–V red-brown except for 2 broad lateral longitudinal dark fuscous bands which join along anterior margin of tergum III, a moderately broad medial longitudinal band which is dark fuscous on tergum III and black on terga IV and V. A pair of oval red-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Uncertain.

COMMENTS

B. latilineata is similar to *B. furvilineata* and *B. rhabdota* (*distincta* complex) in possessing yellow humeral and notopleural calli not joined by a lateral yellow band, mesopleural stripe not extending to humeral callus, transverse band across wing narrow (covering less than ⅓ of discoidal cell), lateral postsutural vittae ending at upper pa. bristles and costal band overlapping R_{2+3} but not confluent with R_{4+5}. It differs from *B. furvilineata* in having fulvous costal cells and a wider transverse band across wing and from *B. rhabdota* in having abdominal terga III–V red-brown except for 2 broad lateral longitudinal dark fuscous bands, a broad medial longitudinal band which is dark fuscous to black on terga IV and V and connected to the lateral bands across anterior margin of tergum III.

Bactrocera (Bactrocera) pulchra Tryon
(Fig. 129)

Bactrocera pulcher Tryon, 1927: 206–7.
Dacus (Strumeta) pulcher: Hardy, 1951: 165–7.
Strumeta pulcher: May, 1963: 50.

MATERIAL EXAMINED

Holotype ♂, Glasshouse Mts, south-east Queensland; 1 ♂, Atherton Tableland, north Queensland, ex *Planchonella* sp., September 1949, N.L.H. Krauss (on loan from UH).
LOCATION OF TYPE: Holotype (D.5163) in QM.

DISTRIBUTION

Known from the Glasshouse Mountains (type locality), south-east Queensland (Tryon, 1927) and Atherton Tableland, north Queensland (Hardy, 1951).

DIAGNOSIS

Medium sized species; large pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe just wider than notopleural callus, lateral postsutural vittae narrow and short, medial postsutural vitta absent, scutellum yellow with a broad black basal band; legs entirely fulvous; wing with a broad fuscous costal band and anal streak, a broad transverse fuscous band across centre of wing, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III and IV black, tergum V fulvous with anterolateral corners dark fuscous, a narrow black transverse band across anterior margin and extending into a narrow short medial longitudinal black band.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.9 mm. Frons narrowing slightly posteriorly, length 1.43 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump covered by a large number of short pale setae; orbital bristles fuscous: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large pear shaped black spots; length of face 0.55 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput black, fulvous along eye margins; occipital row with 6–7 strong dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.45 mm; 0.93 mm.

Thorax mesonotum dull black except brown markings as follows: below and behind lateral postsutural vittae, inside lateral postsutural vittae, around mesonotal sutures, between humeral and notopleural calli. Pleural areas black, tending pale below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, slightly wider than notopleural callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing posteriorly to end well before upper pa. bristles. Postnotum black. Scutellum yellow except for broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous; mid tibiae each with an apical black spur.

Wings length 6.8 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and overlapping this vein at apex of wing, broad fuscous transverse band across centre of wing and enclosing both crossveins, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II fulvous except for a broad transverse black band across anterior ½ and widening to cover lateral margins; terga III and IV black; tergum V fulvous except anterolateral corners dark fuscous, a narrow transverse black band across anterior margin and developing into a small narrow medial longitudinal black band. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. pulchra is similar to *B. unistriata* (Drew) in having yellow humeral and notopleural calli not joined by a lateral yellow band, mesopleural stripe not extending to humeral callus and transverse band across wing broad (covering at least outer ⅓ of discoidal cell). It differs from this species in having the mesopleural stripe narrow (equal in width to notopleural callus), lateral postsutural vittae narrow and ending before upper pa. bristles, costal cells fuscous and covered with a dense mass of microtrichia.

Originally, Tryon (1927) listed a single specimen (Reg. No. D. 1084) as the type. In QM there is 1 male with 2 white labels marked "D. 1084" and "D/5163", this is the holotype.

May (1953) stated that specimens of this species "have been trapped in the Nambour–Palmwoods area, close to the type locality, but no hosts have been located in southern Queensland." Intensive male lure and bacterial bait trapping in recent years (Drew, unpub. data) in the type locality has failed to capture this species. If it still exists in south-east Queensland its population must be extremely small. Tryon incorrectly used the masculine form *pulcher* with *Bactrocera*. The correct feminine form is *pulchra*.

Bactrocera (Bactrocera) unistriata (Drew), n. comb. (Fig. 130)

Dacus (Strumeta) unistriatus Drew, 1971: 96–8.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6969) in QM.

DISTRIBUTION

Widely distributed throughout New Britain (type locality, Keravat), New Ireland and Lihir I.

DIAGNOSIS

Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a transverse fuscous band across wing which is narrow along r–m crossvein and widening over posterior ½ of wing, costal cells pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga II–V generally fulvous with a narrow medial longitudinal fuscous band running over all 4 terga and 2 broad lateral longitudinal dark fuscous bands over terga III–V.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. unistriata was described adequately by Drew (1971). It is similar to *B. pulchra* (Tryon) in the characters listed in the comments on this species but differs in having a broader mesopleural stripe (ending midway between anterior margin of notopeural callus and anterior npl. bristle), lateral postsutural vittae broad and ending at upper pa. bristles, costal cells pale fulvous with microtrichia in outer portion of second costal cell only.

furfurosa complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for a broad costal band (confluent with or overlapping R_{4+5}) and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a dark basal band, mesonotum red-brown with or without dark markings, abdominal terga III–V orange-brown with variable dark colour patterns, males of some species attracted to cue lure.

Bactrocera (Bactrocera) furfurosa, n. sp. (Fig. 131)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, attracted to methyl eugenol, 22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Upper Manki logging area, Bulolo, 25.iii.1980, P. Daur; 1 ♂, Kassam Pass, 19.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♂ (5.i.1981), Mt Missim (1200 m) and 1 ♂ (5.iii.1981), Mt Missim (1250 m), A. Allison. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10521) in QM; 1 paratype in ANIC; 3 paratypes in DPI.

DISTRIBUTION

Known from Oomsis, Bulolo, Kassam Pass and Mt Missim, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots small and irregularly oval; humeral and notopleural calli yellow; mesonotum dark red-brown with 2 narrow lateral longitudinal dark bands, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells with a very pale fulvous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V black except for a narrow medial longitudinal fuscous band over tergum V and posterior ¼ of tergum IV and dark orange-brown either side of this medial band.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.65 mm. Frons of even width, length 1.48 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles dark fuscous: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with small irregularly oval black spots; length of face 0.48 mm. Genae fulvous, pale brown subocular spot present; dark fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 7–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.30 mm; 0.85 mm.

Thorax mesonotum dark red-brown except for 2 narrow lateral longitudinal fuscous lines and oval

fuscous markings between humeral and notopleural calli. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior ⅔ lower hypopleural calli (remainder dark fuscous); 2 lateral postsutural vittae of medium width, narrowing sharply posteriorly to end before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for a narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all femora fulvous; fore and mid tibiae pale fuscous, hind tibiae fuscous; all tarsi fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells with a very pale fulvous tint; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} (paler between R_{2+3} and R_{4+5}) and ending beyond extremity of this vein, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown with a broad transverse fuscous band across anterior ½ but not reaching lateral margins; terga III–V black except for a narrow medial longitudinal fuscous band over tergum V and posterior ¼ of tergum IV and dark orange-brown each side of this medial band. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure (the methyl eugenol record on the holotype is assumed in error).

COMMENTS

B. furfurosa is distinct from all other species of the *furfurosa* and *notatagena* complexes in having costal cells colourless or with a very pale tint.

Bactrocera (Bactrocera) nigrovittata, n. sp.
(Figs 132–134)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Bulolo, on inflorescence of *Dendrobium bifalce*, 31.vi.1979, N. Howcroft.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 2 ♂♂ (31.vi.1979), Bulolo, on inflorescence of *Dendrobium bifalce*, N. Howcroft; 1 ♀ (2.vii.1979), Robbies Creek, Stony logging area, Bulolo, under leaf of *Musa* sp., H. Ivagai; 1 ♂ (19.vi.1979), Upper Stony logging area, Bulolo, on leaf of *Bambusa* sp., H. Ivagai; 1 ♂ (17.vi.1980), Oomsis logging area, bred ex *Endiandra* sp., R.A.I. Drew and D.W. Currey; 1 ♂ (19.vi.1980), Bulolo, bred ex *Solanum torvum*, J. Simpson; 1 ♂ and 1 ♀ (21.vi.1980), Bulolo, bred ex *Solanum* sp., D.W. Currey; 1 ♂, Station logging area, Bulolo, attracted to sugar, 2.ii.1980, Tom Dama.

LOCATION OF TYPES: Holotype (T.10522) in QM; 2 paratypes in ANIC; 1 paratype in DPI(PNG); 6 paratypes in DPI.

DISTRIBUTION

Known only from Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots very large and oval; humeral and notopleural calli yellow; mesonotum pale fuscous to fuscous with an indefinite broad medial longitudinal black band, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad dark fuscous costal band and anal streak, costal cells fuscous, dense microtrichia covering both costal cells; abdominal terga III–V black except for a narrow transverse orange-brown band across posterior margin of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.44 times breadth; fulvous with fuscous around oribtal bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with very large oval black spots; length of face 0.55mm. Genae fulvous, large fuscous subocular spot present; black bristle present. Occiput fuscous, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 fuscous except fulvous on lower

margin; a strong dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.22 mm; 0.36 mm; 0.90 mm.

Thorax mesonotum pale fuscous to fuscous with an indefinite broad medial longitudinal black band. Pleural areas dark fuscous except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior ⅔ lower hypopleural calli (remainder dark fuscous), 2 narrow parallel sided lateral postsutural vittae ending at upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow dark fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all coxae dark fuscous; femora dark fuscous except apical ⅓ of hind femora pale fuscous; fore and hind tibiae pale fuscous, mid tibiae fulvous; all tarsi fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.9 mm; costal cells fuscous, dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint, dark fuscous subcostal cell, broad dark fuscous costal band confluent with R_{4+5} and overlapping this vein at its extremity, broad dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad transverse black band across anterior ½ and widening to cover lateral margins; terga III–V black except for a narrow transverse orange-brown band across posterior margins of tergum V. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment fuscous, rounded in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.45:1. Apex of piercer broad with a very slight subapical keel (Fig. 133). Spicules at distal end of middle segment small and narrow with 4–7 dentations of uneven length (Fig. 134). ATTRACTANT: No known record.

COMMENTS

B. nigrovittata is similar to *B. notatagena* (May) (*notatagena* complex) and *B. ustulata* (*furfurosa* complex) in possessing fuscous costal cells covered with dense microtrichia and humeral calli entirely yellow but differs in having lateral postsutural vittae ending at pa. bristles, abdominal terga mostly black, femora generally dark fuscous and tibiae fuscous (except mid tibiae fulvous).

Bactrocera (Bactrocera) obfuscata, n. sp. (Fig. 135)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 1.iv.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 4 ♂♂, Upper Manki logging area, Bulolo, 1.iv.1980, P. Daur; 1 ♂ (25.ii.1980) and 1 ♂ (6.iv.1980), Upper Manki logging area, Bulolo, P. Daur; 3 ♂♂, Oomsis Forestry Reserve, 22.vi.1980, R.A.I. Drew and D.W Currey; 1 ♂ (20.xi.1980) and 1 ♂ (4.vi.1981), Mt Missim (1400 m), A. Allison. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10523) and 1 paratype (T.10524) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 7 paratypes in DPI.

DISTRIBUTION

Known only from the Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized pear shaped facial spots present; humeral and notopleural calli yellow; mesonotum fuscous with irregular dark fuscous patterns, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells pale fuscous, microtrichia covering outer ½ of second costal cell only; abdominal terga III–V dark fuscous except for narrow orange-brown areas either side of a narrow medial longitudinal fuscous band on tergum V and most of tergum IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.39 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar

triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.45 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput pale fuscous, fulvous along eye margins; occipital row with 2–5 well developed black bristles. Antennae with segments 1 and 2 fulvous (except pale fuscous laterally on segment 2), segment 3 fulvous except fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.35 mm; 0.88 mm.

Thorax mesonotum fuscous to dark fuscous with irregular paler patterns. Pleural areas dark fuscous except fuscous below humeral calli. Yellow markings as follows: humeral calli (anterior ⅓ plus lower margin fuscous); notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior 5/9 lower hypopleural calli (remainder including broad ventral margin dark fuscous); 2 lateral postsutural vittae of medium width narrowing slightly posteriorly to end behind, at or just before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow dark fuscous basal band. Bristles: sc. 2 (3 in holotype); prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except apices of fore and hind femora red-brown to pale fuscous, basal ½ of fore and hind tibiae dark fuscous (apical ½ fuscous); rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.9 mm; costal cells pale fuscous; microtrichia covering outer ½ of second costal cell only; remainder of wings with a very pale tint across membrane, fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} (but paler between R_{2+3} and R_{4+5}), broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad transverse dark fuscous band across anterior ⅔ and widening to cover lateral margins; terga III–V mostly dark fuscous except for narrow orange-brown areas either side of a narrow medial longitudinal fuscous band on tergum V and most of tergum IV. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a moderately deep concavity on posterior margin. ATTRACTANT: Cue lure.

COMMENTS

B. obfuscata is similar to *B. popondettiensis* in possessing pale coloured costal cells without microtrichia in first cell. It differs from this species in having humeral calli with anterior ⅓ fuscous, costal cells pale fuscous with microtrichia in outer ½ of second costal cell only, mesonotum dark fuscous with paler patterns, legs fulvous except apices of fore and hind femora red-brown to pale fuscous and fore and hind tibiae fuscous (darker basally).

Bactrocera (Bactrocera) popondettiensis, n. sp. (Fig. 136)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Northern District: Popondetta, 28.x.1966, T.V. Bourke.
LOCATION OF TYPE: Holotype (T.10525) in QM.

DISTRIBUTION

Known only from Popondetta, Northern District, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots medium sized and pear shaped; humeral and notopleural calli yellow; mesonotum fuscous, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad pale fuscous costal band and anal streak, costal cells pale fulvous, microtrichia covering all of second costal cell and outer corner of first costal cell; abdominal terga III–V orange-brown with a broad transverse fuscous band across anterior ½ of tergum III and 2 broad lateral and a moderately broad medial longitudinal fuscous bands over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.52 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle fuscous. Vertex fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.43 mm. Genae fulvous, pale brown

subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–5 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista dark fuscous (fulvous basally); length of segments: 0.18 mm; 0.33 mm; 0.73 mm.

Thorax mesonotum fuscous except brown below and behind lateral vittae. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous); 2 broad lateral postsutural vittae narrowing slightly posteriorly to end at upper pa. bristles. Postnotum fuscous. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except hind tibiae pale fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.3 mm; costal cells pale fulvous, microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except fuscous subcostal cell, broad pale fuscous costal band confluent with R_{4+5} and ending midway between extremities of R_{4+5} and M, broad pale fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except anterolateral corners dark fuscous and a broad transverse fuscous band narrowing laterally to end before lateral margins; terga III–V orange-brown except for a broad transverse fuscous band across anterior ½ of tergum III, 2 broad lateral longitudinal bands which are fuscous on tergum III and pale fuscous on terga IV and V and a moderately broad medial longitudinal fuscous band over all 3 terga. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. popondettiensis is similar to *B. obfuscata* in the characters listed in the comments on this species. It differs from *B. obfuscata* in having costal cells pale fulvous with microtrichia covering all of second costal cell, humeral calli entirely yellow, mesonotum uniformly fuscous and legs fulvous except hind tibiae pale fuscous.

Bactrocera (Bactrocera) ustulata, n. sp.
(Fig. 137)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, attracted to cue lure, 22.vi.1980, R.A.I. Drew and D.W. Currey.

Paratype, PAPUA NEW GUINEA, Central District: 1 ♂, Rigo road (32 km from Port Moresby), attracted to cue lure, 24.vi.1980, R.A.I. Drew and D.W. Currey.

LOCATION OF TYPES: Holotype (T.10526) in QM; paratype in DPI.

DISTRIBUTION

Known from the Morobe Province and Central District, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots medium sized and pear shaped; humeral and notopleural calli yellow; mesonotum pale fuscous with dark fuscous to black patterns, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells; abdominal terga III–V orange-brown except for a very narrow indefinite medial longitudinal pale fuscous band and 2 broad lateral longitudinal dark fuscous to black bands over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.52 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–6 well developed black bristles. Antennae

with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.78 mm.

Thorax mesonotum pale fuscous except for 2 lateral longitudinal dark fuscous to black bands running from near prsc. bristles to anterior margin, dark fuscous along inner posterolateral margins of lateral postsutural vittae and between humeral and notopleural calli. Pleural areas fuscous except red-brown below humeral calli and black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopelural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior 3/5 lower hypopleural calli (remainder fuscous); 2 lateral postsutural vittae of medium width, narrowing posteriorly to end before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except fore tibiae pale fuscous, hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells fuscous; microtrichia covering second and most of first costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} but paler above this vein, broad fuscous anal streak ending at margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad transverse fuscous band across anterior ⅓ and widening to cover lateral margins; terga III–V orange-brown except for a very narrow indefinite medial longitudinal pale fuscous band and 2 broad lateral longitudinal bands which are dark fuscous to black on tergum III and dark fuscous on terga IV and V (these bands meet along anterior margin of tergum III at which point they are dark fuscous). A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a moderately deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. ustulata is similar to *B. notatagena* (May) (*notatagena* complex) and *B. nigrovittata* (*furfurosa* complex) in having yellow humeral calli and fuscous costal cells covered with dense microtrichia. It differs from *B. nigrovittata* in having the lateral postsutural vittae ending before the upper pa. bristles, abdominal terga not entirely dark coloured and legs not entirely fuscous. It differs from *B. notatagena* in having the mesonotum pale fuscous with 2 lateral longitudinal dark fuscous to black bands, legs fulvous except fore tibiae pale fuscous and hind tibiae fuscous, abdominal terga III–V with an indefinite narrow medial longitudinal pale fuscous band and broad lateral longitudinal bands which are black on tergum III and dark fuscous on terga IV and V.

mayi complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells colourless and without microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a narrow dark basal band, mesonotum red-brown with or without dark colour patterns, abdominal terga III–V without distinct dark colour patterns on lateral margins, males attracted to methyl eugenol.

Bactrocera (Bactrocera) mayi (Hardy), n. comb. (Figs 138–140)

Not *Dacus bilineatus* Walker, 1860: 150.
Strumeta bilineata Perkins and May, 1949: 7–8; May, 1953: 14, 1963: 43–4, 50.
Dacus (*Strumeta*) *mayi* Hardy, 1951: 161–2 (replacement name).
Dacus (*Bactrocera*) *mayi*: Drew, 1982: 31–3.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); type series of Perkins and May.

LOCATION OF TYPES: Lectotype ♀ (T.5249) and 1 paralectotype ♂ (T.5250) in QM; 145 paralectotypes in UQ.

DISTRIBUTION

PREVIOUSLY RECORDED: Large populations throughout the entire coastal and subcoastal areas of Queensland (type locality, Cairns), particularly associated with rainforests.

NEW RECORDS: Torres Strait islands: Badu, Horn, Saibai, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dark red-brown with fuscous markings, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V dark red-brown with a narrow medial longitudinal black band, pale fuscous colouration over all 3 terga joined along anterior margin of tergum III by a transverse dark fuscous band.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment dark red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.61:1. Apex of piercer needle shaped with 4 pairs of small subapical bristles (Fig. 139). Spicules at distal end of middle segment narrow with 2 or 3 large elongate dentations (Fig. 140). ATTRACTANT: Methyl eugenol.

COMMENTS

B. mayi is similar to *B. pallida* (Perkins and May) and *B. tenuifascia* (May) (*mayi* complex) in possessing colourless costal cells, abdominal terga III–V with a distinct medial longitudinal fuscous band, wings colourless except for narrow costal band and anal streak, mesonotum red-brown, medial postsutural vitta absent, lateral postsutural vittae present, humeral and notopleural calli yellow. It differs from *B. pallida* in having a broad anal streak and the mesonotum and abdomen red-brown to dark red-brown. It differs from *B. tenuifascia* in having the lateral postsutural vittae narrow and tapering sharply posteriorly, abdominal terga dark red-brown, mesonotum dark red-brown with a pair of longitudinal parallel black bands centrally.

Perkins and May (1949) did not define type specimens, stating only that the species was "described from a series of over one hundred specimens." Two specimens each labelled holotype in QM can be identified from label data as part of the original series: 1 female (T.5249), Cairns, Queensland, 12.ix.1937, F.A. Perkins, bred from *Sideroxylon obovatum*; 1 male (T.5250), Cairns, Queensland, 12.ix.1937, F.A. Perkins, bred from *Sideroxylon obovatum*. The remainder of the type series is in UQ. I designate the female (T.5249) as lectotype and the remaining specimens as paralectotypes.

Hardy (1951) noted that the name *bilineata* was preoccupied in *Dacus* and proposed the name *mayi* as a replacement. Although now placed in *Bactrocera*, a junior secondary homonym replaced before 1961 is permanently invalid (Article 59b of the International Code of Zoological Nomenclature).

Bactrocera (Bactrocera) pallida (Perkins and May), n. comb. (Figs 141–143)

Strumeta pallidus Perkins and May, 1949: 10–12; May, 1963: 47, 50.
Dacus (*Strumeta*) *pallidus*: Hardy, 1951: 164–5.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); type series of Perkins and May.
LOCATION OF TYPES: Lectotype ♀ (T.5254) in QM; 12 ♂ ♀ paralectotypes in UQ.

DISTRIBUTION

PREVIOUSLY RECORDED: Although the type specimens were recorded from Cairns (type locality) and Brisbane, *B. pallida* now appears to be restricted to the Atherton Tableland and the coastal rainforest areas of Queensland north from Ayr and the Northern Territory.
NEW RECORDS: Torres Strait islands: Badu, Thursday, Yam (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibae pale fuscous; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V pale orange-brown except for a transverse fuscous to dark fuscous band along anterior margin of tergum III and a medial longitudinal fuscous to dark fuscous band over all 3 terga and 2 lateral longitudinal bands which are pale fuscous on tergum III and paler fuscous on tergum IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.42 times breadth; fulvous with pale

fuscous around orbital bristles; anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.48 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–5 bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.78 mm.

Thorax mesonotum generally red-brown without dark markings but occasionally there are longitudinal pale fuscous irregular spots. Pleural areas red-brown with fuscous on sternopleuron and along anterior margin of mesopleural stripe. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, generally reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 lateral postsutural vittae narrowing slightly posteriorly to end at or just before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 5.7 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous; tergum II orange-brown tending fulvous along posterior margin either side of midline, with a narrow pale fuscous to fuscous transverse line. Terga III–V pale orange-brown except for a narrow transverse fuscous to dark fuscous band across anterior margin of tergum III, a moderately broad medial longitudinal fuscous to dark fuscous band over all 3 terga and 2 lateral longitudinal bands of medium width which are pale fuscous on tergum III and paler fuscous on tergum IV. A pair of oval pale orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.79:1. Apex of piercer needle shaped with 4 pairs of small subapical bristles (2 large and 2 small) (Fig. 142). Spicules at distal end of middle segment of medium width with 5 to 9 small dentations of uneven length (Fig. 143).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. pallida is similar to *B. mayi* (Hardy) and *B. tenuifascia* (May) in the characters listed under the comments on *B. mayi*. It differs from these species in having a narrow anal streak, mesonotum pale red-brown and abdominal terga pale orange-brown.

Perkins and May did not designate type specimens in their description. The authors stated that the species was "described from a series of 16 specimens." One female labelled holotype (T.5254), Cairns, Queensland, 29.iii.1938, F.A. Perkins, bred from *Sarcocephalus cordatus*, is in QM and from label data can be identified as part of the original type series. Twelve specimens are in UQ with label data conforming with the type series. Because label data alone is not satisfactory for establishing a holotype, I designate the female specimen (T.5254) as lectotype and the remaining specimens as paralectotypes. Usually Perkins and May placed holotype labels on a male and female of each species.

Bactrocera (Bactrocera) tenuifascia (May), n. comb. (Figs 144–146)

Strumeta tenuifascia May, 1965: 64–6.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6315) in QM.

DISTRIBUTION

Known from Berrimah and Nightcliff (type locality) in the Northern Territory and the northern part of Western Australia.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a narrow transverse pale fuscous to dark fuscous band along anterior margin of tergum III and widening to cover lateral margins of that tergum and a medial longitudinal dark fuscous to black band over all 3 terga but ending in centre of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.59 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fuscous. Face fulvous with medium sized oval black spots; length of face 0.5 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–6 red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.78 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 moderately broad lateral postsutural vittae narrowing posteriorly to end at upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.3 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I and II red-brown tending fulvous along posterior margin of tergum II either side of midline; terga III–V orange-brown except for a narrow transverse pale fuscous to dark fuscous band along anterior margin of tergum III and widening to cover lateral margins, and a medial longitudinal dark fuscous to black band over terga III–V but ending in centre of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.84:1. Apex of piercer needle shaped and slightly pointed at tip with 4 pairs of small subapical bristles (Fig. 145). Spicules at distal end of middle segment of medium width, some with 6–8 small dentations of equal size and others with 3–6 elongate broad dentations of uneven size (Fig. 146).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. tenuifascia is similar to *B. mayi* (Hardy) and *B. pallida* (Perkins and May) (*mayi* complex) in the characters listed in the comments on *B. mayi*. It differs from *B. pallida* in having a broad anal streak and *B. mayi* in having broad parallel sided lateral postsutural vittae, mesonotum red-brown and seldom marked with fuscous colouration and abdominal terga red-brown.

musae complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, lateral postsutural vittae present; medial postsutural vitta absent, costal cells colourless and

without microtrichia, scutellum mostly yellow with a narrow dark basal band, mesonotum mostly black, abdominal terga III–V mostly orange-brown, males attracted to methyl eugenol.

Bactrocera (Bactrocera) bancroftii (Tryon), n. comb. (Figs 147–149)

Chaetodacus bancroftii Tryon, 1927: 199–201.
Strumeta bancroftii: May, 1963: 43, 50.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.
LOCATION OF TYPES: Lectotype ♂ (D.3130) and 2 ♀ paralectotypes (D.3130) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Coastal areas of Queensland (type locality, Gympie district).
NEW RECORDS: Torres Strait islands: Badu, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized circular black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow except with a pale fuscous to fuscous apical spot in some specimens; legs entirely fulvous; wing with a narrow fuscous costal band and a broad fuscous anal streak, costal cells very pale fulvous with microtrichia in outer corner of second costal cell only; all abdominal terga uniformly orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.63 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized circular black spots; length of face 0.5 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 5–6 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.33 mm; 0.80 mm.

Thorax mesonotum generally dull black except brown below and behind lateral postsutural vittae, around mesonotal suture, between humeral and notopleural calli, inside humeral calli (in some specimens there is a red-brown area on posterior margin of mesonotum). Pleural areas red-brown except fuscous along anterior margin of mesopleural stripe and black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior ⅔ lower hypopleural calli (remainder dark fuscous); 2 broad parallel sided lateral postsutural vittae ending at upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band and a pale fuscous to fuscous apical spot in some specimens. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.0 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga uniformly orange-brown except posterior margin of tergum II tending fulvous. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering slightly posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.45:1. Apex of piercer broad and needle shaped with 4 pairs of small subapical bristles (Fig. 148). Spicules at distal end of middle segment of medium width with 10–14 small dentations of uneven length (Fig. 149).
ATTRACTANT: Weakly attracted to methyl eugenol.

COMMENTS

B. bancroftii is similar to *B. contermina* and *B. contigua* (*assita* complex) in possessing a black mesonotum with yellow humeral and notopleural calli, scutellum with a narrow black basal band, lateral postsutural vittae present, medial postsutural vitta absent, pale fulvous costal cells, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle and facial spots distinct. It differs from these species in having abdominal terga III–V uniformly orange-brown, distinct brown spot on apex of scutellum, costal band narrower than subcostal cell beyond extremity of R_{2+3} and in the shape of the apex of the piercer and spicules on the middle segment of the ovipositor.

Tryon (1927) designated a holotype, allotype and 1 paratype without defining which specimen is the holotype, and each specimen bears white labels marked "TYPE D/3130". I designate the male as lectotype and the 2 females as paralectotypes.

Bactrocera (Bactrocera) musae

(Tryon), n. comb. (Figs 150–152)

Chaetodacus musae Tryon, 1927: 197–9.
Dacus ornatissimus Froggatt, 1909: 93 (partim, paralectotypes only); Drew 1974a: 64.
Chaetodacus tryoni var. *musa* Tryon, 1927: 187-8 (nomen nudum).
Chaetodacus musae var. *dorsopicta* Tryon, 1927: 198.
Dacus (*Strumeta*) *musae*: Hardy, 1951: 162–4; Drew, 1974a: 63–6.
Strumeta musae: May, 1953: 58–9, 1963: 50, 66–7.
Dacus (*Bactrocera*) *musae*: Drew, 1982: 35–8.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: *C. musae*, lectotype ♀ (D.3128), 1 ♂, 2 ♀ paralectotypes (D.3128) and 1 ♂ paralectotype (D.3129) in QM; *D. ornatissimus*, 5 paralectotypes (both sexes) in NSW; var. *musa* and var. *dorsopicta*, no types designated.

DISTRIBUTION

PREVIOUSLY RECORDED: Occurs in large populations along the eastern coast of Queensland north from Mt Spec, 65 km north from Townsville (type locality, Meringa), Papua New Guinea and associated islands, Bismarck Archipelago and the Solomon Islands.

NEW RECORDS: Torres Strait islands: Badu, Boigu, Darnley, Dauan, Hammond, Horn, Moa (Banks), Murray, Prince of Wales, Saibai, Stephens, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present; medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V may vary from uniformly orange-brown to orange-brown with a fuscous to black medial longitudinal band and fuscous to black anterolateral corners on tergum III (Fig. 150 A–E).

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dosoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.89:1. Apex of piercer needle shaped with 3 or 4 pairs of subapical bristles (Fig. 151). Spicules at distal end of middle segment narrow to medium in width with 3–6 dentations, 2–3 long and narrow and the remainder small (Fig. 152).

HOST PLANTS

NEW RECORDS: *Syzygium bamagense* (Myrtaceae), Lockerbie and Cape York, Queensland, December 1974, D.J. Rogers.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. musae was described adequately by Drew (1974a, 1982). It is similar to *B. finitima* and *B. tinomiscii* (*assita* complex) in possessing a black mesonotum with lateral postsutural vittae present and ending at pa. bristles and medial postsutural vitta absent, humeral and notopleural calli yellow, scutellum yellow with a narrow dark basal band and costal cells colourless. It differs from *B. tinomiscii* in having the costal band dark and extending well below R_{2+3}, apex of piercer of ovipositor not curved upwards and subapical sensory bristles on piercer of ovipositor consisting of 2 large and 2 small each side and from *B. finitima* in having the costal band not extending almost to R_{4+5}, piercer of ovipositor narrowing sharply between gonopore and apex and spicules at distal end of middle segment with up to 5 large dentations and occasional small dentations.

Tryon (1927) defined 2 holotypes, an allotype

and 2 paratypes, now in QM with white labels: 1 female with "TYPE D/3128" and "Meringa Q, 8.6.26, Ex. Banana"; 1 female "TYPE D/3128" and "Meringa Q, 8.6.26, Ex. Banana"; 1 male and 1 female on the same pin "TYPE D/3128" and "Geralton, Host. Banana, Bred in office 12.10.1909"; 1 male "TYPE D/3129" and "Native Banana, Cardwell, 12.i.26". Since the type status of each specimen is unclear, I designate 1 female (D.3128) as lectotype (a single female on one pin and labelled lectotype) and the remaining 4 specimens as paralectotypes. In the same paper, prior to the description of *B. musae* as a species, Tryon mentioned a var. *musa* of *tryoni* (Froggatt) but did not describe it except by host data. Therefore the name is unavailable (Article 12c of the International Code of Zoological Nomenclature). Tryon also described a var. *dorsopicta* of *B. musae* in a footnote. This name is valid but the variety is not distinguishable from typical *B. musae*.

Bactrocera (Bactrocera) prolixa, n. sp.
(Fig. 153)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Western District: Nomad, attracted to methyl eugenol, 17.xi.1980, P. Senat. LOCATION OF TYPE: Holotype (T.10527) in QM.

DISTRIBUTION

Known only from Nomad, Western District, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present; medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdomen elongate-oval, abdominal terga II–V orange-brown except for narrow pale fuscous margins on tergum V and a very narrow medial longitudinal pale fuscous band on anterior ⅔ of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.52 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered with a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–5 well developed fuscous bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong fulvous dorsal bristle on segment 2; length of segments: 0.23 mm; 0.33 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, along mesonotal suture, between humeral and notopleural calli, inside humeral calli. Pleural areas dark fuscous to black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder including broad ventral margins dark fuscous to black); 2 lateral postsutural vittae of medium width and narrowing posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.8 mm; costal cells colourless; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I and sterna I and II as wide as long. Tergum I dark fuscous except for a very narrow transverse orange-brown band across posterior margin but not reaching lateral margins; terga II–V orange-brown except for an irregularly shaped transverse fuscous pattern across anterior margin of tergum II, narrow lateral pale fuscous margins on tergum V and a very narrow

medial longitudinal pale fuscous band on anterior ⅔ of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Methyl eugenol.

COMMENTS

B. prolixa is similar to *B. brevistriata* (Drew) and *B. commina* (*assita* complex) in possessing a black mesonotum, humeral and notopleural calli yellow, scutellum yellow with a narrow dark basal band, wings colourless except for costal band and anal streak and lateral postsutural vittae ending before upper pa. bristles. It differs from *B. commina* in having costal cells colourless and abdominal terga II–V mostly orange-brown and from *B. brevistriata* in having the abdomen elongate-oval with terga II–V uniformly orange-brown and costal band overlapping R_{2+3}.

nigella complex

DEFINITION OF COMPLEX: *Bactrocera* species generally with clear wing membrane except for costal band and anal streak, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a narrow dark basal band, mesonotum and abdominal terga entirely black, males attracted to methyl eugenol.

Bactrocera (Bactrocera) batemani, n. sp. (Fig. 154)

TYPE SPECIMENS

Holotype ♂, AUSTRALIA, south-east Queensland: Mt Glorious, attracted to methyl eugenol, 25.i.1978, B. McCulloch.

Paratypes, AUSTRALIA, south-east Queensland: 2 ♂♂ (25.i.1978), Mt Glorious, B. McCulloch; 1 ♂ (12.ix.1978) and 1 ♂ (19.ix.1978), Mt Glorious, M. Romig; 10 ♂♂ (16.xii.1981), Mt Glorious (650 m), R.A.I. Drew; 1 ♂ (24.v.1976) and 1 ♂ (5.iv.1977), Cooloola, B. McCulloch; 1 ♂ (30.ix.1977), Cooloola, D. Hancock; 1 ♂ (14.xi.1978), Brisbane, G. Hooper. North Queensland: 7 ♂♂ (9.ii.1975), Finch Hatton Gorge, R.A.I. Drew. All paratypes attracted to methyl eugenol.

LOCATION OF TYPES: Holotype (T.10528) and 1 paratype (T.10529) in QM; 8 paratypes in ANIC; 2 paratypes in BMNH; 14 paratypes in DPI.

DISTRIBUTION

Occurs primarily in the high altitude rainforests throughout eastern Queensland, some specimens have been collected at lower altitudes in Brisbane, Cooloola and Finch Hatton Gorge.

DIAGNOSIS

Medium sized black species; medium sized oval facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering outer ⅓ of second costal cell only; abdominal terga III–V black.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.64 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized oval black spots not reaching epistoma; length of face 0.53 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 5–7 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.28 mm; 0.88 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 4/7 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and narrowing sharply posteriorly to end well before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; all other segments fulvous except hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells fuscous,

microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except dark fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} except for a narrow colourless area above R_{4+5} (this band is pale fuscous between R_{2+3} and R_{4+5}), broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band across posterior margin, but not reaching lateral margins; tergum II orange-brown except for a broad transverse black band across anterior margin and expanding to cover lateral margins; terga III–V black except for a narrow transverse dark fuscous band across posterior margin of tergum V. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. batemani is similar to *B. anthracina* (Drew) (*anthracina* complex) in possessing coloured costal cells with microtrichia in outer corner of second costal cell only, mesonotum and abdominal terga mostly black and wings colourless except for costal band and anal streak but differs in having the lateral postsutural vittae narrowing sharply to end before the upper pa. bristles and all leg segments fulvous except hind tibiae fuscous.

This species is named after Dr M.A. Bateman, Sydney, in recognition of his contributions to fruit fly research during the past 30 years.

Bactrocera (Bactrocera) kelaena, n. sp.
(Fig. 155)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central District: Moresby–Bereina road (88 km from Port Moresby), attracted to methyl eugenol, 26.Vi.1980, R.A.I. Drew and D.W. Currey. LOCATION OF TYPE: Holotype (T.10530) in QM.

DISTRIBUTION

Known only from Central District, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized irregularly oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe broad extending to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia covering all of both costal cells; abdominal terga III–V uniformly black.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.52 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump with a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized irregularly oval black spots; length of face 0.45 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fuscous, fulvous along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.78 mm.

Thorax mesonotum black except brown behind lateral postsutural vittae. Pleural areas black without pale markings. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe (extending to humeral callus dorsally), continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅓ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and ending at upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black except for the prsc. which are very small.

Legs all coxae dark fuscous; femora fulvous except hind femora tending fuscous on apex; fore and mid tibiae fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.0 mm; costal cells fuscous; microtrichia covering second and most of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except for a narrow transverse orange-brown band along intersegmental line between terga I and II but not reaching lateral margins; tergum II orange-brown except for a broad transverse black band across anterior ⅓ and widening to cover lateral margins; terga III–V uniformly black. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. kelaena is similar to *B. caliginosa* (Hardy) (*anthracina* complex) in possessing coloured costal cells with dense microtrichia covering all of second and most of first costal cells, wings colourless except for costal band and anal streak, mesonotum and abdominal terga mostly black but differs in having lateral postsutural vittae parallel sided and ending at upper pa. bristles, scutellum with a narrow dark basal band and mesopleural stripe reaching humeral callus above.

Bactrocera (Bactrocera) nigella
(Drew), n. comb. (Fig. 156)

Strumeta nigella Drew, 1968b: 78–9.
Dacus (*Strumeta*) *nigellus*: Drew, 1972a: 21.

MATERIAL EXAMINED
A series of specimens (including 1 paratype) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6612) in QM.

DISTRIBUTION
Known only from Mt Kaindi and Wau (type locality), Morobe Province, Papua New Guinea.

DIAGNOSIS
Medium sized species; small black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, first costal cell colourless, second costal cell colourless with fulvous distally and along subcostal vein, microtrichia in outer corner of second costal cell only; abdominal terga III–V black.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. nigella was described adequately by Drew (1968b). It is similar to *B. terminaliae* and *B. aterrima* (Drew) (*anthracina* complex) in having a black mesonotum, abdominal terga mostly black and costal cells colourless or almost colourless. It differs from *B. aterrima* in possessing a narrower mesopleural stripe (not extending past the midline between anterior margin of notopleural callus and anterior npl. bristle) and lateral postsutural vittae extending to upper pa. bristles and from *B. terminaliae* in having all leg segments fulvous except hind tibiae fuscous and small triangular facial spots.

notatagena complex

DEFINITION OF COMPLEX: *Bactrocera* species without well defined fuscous patterns on wing membrane except for broad costal band (confluent with R_{4+5}) and anal streak, costal cells covered with microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a narrow dark basal band, males of some species attracted to methyl eugenol.

Bactrocera (Bactrocera) notatagena
(May), n. comb. (Fig. 157)

Strumeta notatagena May, 1952: 337–9; May, 1963: 50.

MATERIAL EXAMINED
Holotype ♀; a series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype (T.5277) in QM.

DISTRIBUTION
Known only from Atherton and coastal areas around Cairns (type locality), north Queensland, Australia.

DIAGNOSIS
Medium sized species; large elongate-oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregular pale fuscous to fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous and in some specimens fore and mid femora pale fuscous to fuscous; wing with a broad fuscous costal band and anal streak, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III and IV red-brown and tergum V fulvous except for broad lateral longitudinal bands which are dark fuscous on terga III and IV, anterolaterally on tergum V and red-brown posterolaterally on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.6 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large elongate-oval black spots in antennal furrows; length of face 0.38 mm. Genae fulvous, dark fuscous subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.75 mm.

Thorax mesonotum red-brown with irregular pale fuscous to fuscous patterns. Pleural areas fuscous to dark fuscous. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural (posterior apices dark fuscous); anterior ⅔ lower hypopleural calli (remainder dark fuscous); 2 lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for dark fuscous basal band which varies in width. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all coxae dark fuscous; remaining segments fulvous except hind tibiae pale fuscous and in some specimens the fore and mid femora pale fuscous to fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.8 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint, except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; tergum II fulvous except for broad transverse fuscous band across anterior ⅓ and widening to cover lateral margins; terga III and IV red-brown and tergum V fulvous except for broad lateral longitudinal dark bands which are dark fuscous on terga III, IV and anterolateral corners of V and red-brown posterolaterally on tergum V. A pair of oval red-brown shining spots on tergum V. Basal segment of ovipostior fuscous, conical, oval in transverse cross section and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.71:1.

ATTRACTANT: No known record. Earlier record of attraction to methyl eugenol (Drew and Hooper, 1981) is doubtful.

COMMENTS

B. notatagena is similar to *B. ustulata* and *B. nigrovittata* (*furfurosa* complex) in possessing entirely yellow humeral calli and costal cells fuscous and covered with dense microtrichia. It differs from *B. nigrovittata* in having the lateral postsutural vittae ending before the upper pa. bristles, leg segments not entirely fuscous and abdominal terga not entirely dark coloured and from *B. ustulata* in having the mesonotum red-brown with a dark fuscous lanceolate pattern, abdominal terga III–V with broad lateral longitudinal dark fuscous bands and legs with fore and mid femora and hind tibiae fuscous.

Originally, May (1952) designated only a female holotype. Three males in QM labelled allotype and paratypes respectively (designated by May, 1957b) and two specimens in DPI labelled paratypes were not part of the original type series, and cannot be considered types.

Bactrocera (Bactrocera) romigae (Drew and Hancock), n. comb. (Fig. 158)

Dacus (*Bactrocera*) *romigae* Drew and Hancock, 1981: 75–7.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8295) in QM.

DISTRIBUTION

Widespread throughout Cape York Peninsula, Queensland (type locality, Iron Range).

DIAGNOSIS

Medium sized species; large black facial spots present; posterior ⅔ of humeral calli yellow (anterior ⅓ fuscous); notopleural calli yellow; mesonotum dark red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad dark fuscous costal band and broad fuscous anal streak,

costal cells fuscous, dense microtrichia covering both costal cells; abdominal tergum III dark fuscous, terga IV and V with broad lateral longitudinal dark fuscous bands, tergum V with a broad medial longitudinal fuscous band and the shining spots on tergum V are generally fuscous to dark fuscous.
ATTRACTANT: Methyl eugenol.

COMMENTS

B. romigae was described adequately by Drew and Hancock (1981). It is similar to *B. nigrovittata* and *B. ustulata* (*furfurosa* complex) and *B. notatagena* (May) (*notatagena* complex) in possessing fuscous costal cells covered by dense microtrichia but differs in having the anterior ⅓ of each humeral callus fuscous and the posterior ⅔ yellow.

quadrata complex

DEFINITION OF COMPLEX: *Bactrocera* species without well defined fuscous patterns on wing membrane except for narrow costal band and anal streak, costal cells without microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V with narrow indistinct dark coloured patterns on lateral margins of some or all of these terga, males attracted to cue lure.

Bactrocera (Bactrocea) antigone
(Drew and Hancock), n. comb. (Fig. 159)

Dacus (*Bactrocera*) *antigone* Drew and Hancock, 1981: 59–61.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8248) in QM.

DISTRIBUTION

Known only from Cape York Peninsula, Queensland (type locality, Iron Range).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad medial longitudinal dark fuscous to black band and 2 narrow lateral longitudinal fuscous to dark fuscous bands.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. antigone was described adequately by Drew and Hancock (1981). It is similar to *B. erubescentis* (Drew and Hancock) and *B. peninsularis* (Drew and Hancock) (*quadrata* complex) in possessing mesonotum and abdominal terga basically orange-brown or red-brown with a medial fuscous stripe on terga III–V, narrow lateral dark colour patterns on some or all of these terga and wings colourless except for costal band and anal streak. It differs from these species in having broad lateral fuscous markings on terga III–V and the medial longitudinal band well defined over all 3 terga.

Bactrocera (Bactrocera) aurantiaca
(Drew and Hancock), n. comb. (Fig. 160)

Dacus (*Bactrocera*) *aurantiacus* Drew and Hancock, 1981: 62–3.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8254) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Known from the tip of Cape York Peninsula, Queensland (type locality, Lockerbie) and the Torres Strait islands: Horn and Yam.
NEW RECORD: Papua New Guinea, East Sepik District: 2 ♂♂, Maprik, Oct.–Dec., 1957, collector unknown.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum orange-brown with or without dark markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga mostly fulvous with a narrow transverse fuscous to black band across anterior margin of tergum III, narrow lateral dark margins on terga III–V and a narrow medial longitudinal dark band on terga IV and V.
ATTRACTANT: Cue lure.

COMMENTS

B. aurantiaca was described adequately by Drew and Hancock (1981). It is similar to *B. quadrata* (May) (*quadrata* complex) in having the medial longitudinal fuscous band only on terga IV and V, in addition to the characters defining the *quadrata* complex but differs in having an orange-brown mesonotum, abdominal terga III–V with a very narrow lateral fuscous margin and femora and tibiae fulvous.

Bactrocera (Bactrocera) erubescentis
(Drew and Hancock), n. comb. (Fig. 161)

Dacus (Bactrocera) erubescentis Drew and Hancock, 1981: 64–6.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8259) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Known from Cape York Peninsula, Queensland (type locality, Weipa) and Badu I. (Torres Strait islands).
NEW RECORD: Papua New Guinea, Central Province: 1 ♂, 32 km from Port Moresby on the Rigo road, 24.vi.1980, R.A.I. Drew and D.W. Currey.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V orange-brown with a narrow transverse dark band across anterior margin of tergum III, narrow dark lateral margins and a medial longitudinal dark band over all 3 terga.
ATTRACTANT: Cue lure.

COMMENTS

B. erubescentis was described adequately by Drew and Hancock (1981). It is similar to *B. antigone* (Drew and Hancock) and *B. peninsularis* (Drew and Hancock) in possessing a distinct medial longitudinal fuscous band on terga III–V in addition to the characters defining the *quadrata* complex. It differs from *B. antigone* in having broad lateral fuscous margins on tergum III and narrower dark margins on terga IV and V and from *B. peninsularis* in having the lateral postsutural vittae tapering posteriorly, costal band almost confluent with R_{4+5} and hind tibiae fuscous on basal ⅔.

Bactrocera (Bactrocera) peninsularis
(Drew and Hancock), n. comb. (Fig. 162)

Dacus (Bactrocera) peninsularis Drew and Hancock, 1981: 70–2.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8263) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Known from Cape York Peninsula, Queensland (type locality, Lockerbie) and the Torres Strait islands: Badu, Horn, Moa, Prince of Wales.
NEW RECORDS: Papua New Guinea, Western District: 1 ♂, Morehead, 27–29.viii.1970, T. Fenner. Torres Strait islands: Boigu, Murray, Saibai, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe ending just before anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless to very pale fulvous, microtrichia in outer 1/2 of second costal cell only; abdominal terga III–V orange-brown with red-brown to pale fuscous on lateral margins of tergum III.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. peninsularis was described adequately by Drew and Hancock (1981). It is similar to *B. antigone* (Drew and Hancock) and *B. erubescentis* (Drew and Hancock) in the characters listed in the comments on *B. erubescentis*. It differs from *B. antigone* in having broad lateral fuscous margins only on tergum III and from *B. erubescentis* in having broad parallel sided lateral postsutural vittae, narrow costal band and just overlapping R_{2+3} and hind tibiae fulvous.

Some specimens of *B. peninsularis* from the Torres Strait islands show dark abdominal colour patterns as in *B. barringtoniae* (Tryon).

The host of *B. barringtoniae* (*Barringtonia calyptrata*) is also known from some Torres Strait islands: Dauan, Hammond, Murray and Thursday. The 2 species are maintained pending study of host reared specimens from the area.

Bactrocera (Bactrocera) quadrata (May), n. comb. (Fig. 163)

Strumeta quadrata May, 1962b: 530–2; May, 1963: 50.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPES: Holotype ♂ (T.5897) in QM; 9 paratypes in QM and 37 paratypes in DPI.

DISTRIBUTION

PREVIOUSLY RECORDED: Eastern coastal areas of Queensland (type locality, Atherton).

NEW RECORDS: Papua New Guinea, Central District: 1 ♂, Ninoa Estate, 30.xi.1973, J. Stibick; 1 ♂, Crystal Rapids, 5.xi.1973, J. Stibick; 23 ♂♂, Sogeri Plateau, June 1980, R.A.I. Drew and D.W. Currey. West New Britain: 3 ♂♂, Dami Oil Palm Station, collector unknown. Torres Strait islands: Saibai, Sue, Horn (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; large oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present and reaching upper pa bristles, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and anal streak, costal cells very pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad transverse fuscous band across anterior margin of tergum III and a medial longitudinal fuscous band on terga IV and V and 2 broad lateral longitudinal bands which are dark fuscous on tergum III and very pale fuscous on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.59 times breadth; fulvous with at most, pale fuscous around orbital bristles; anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large oval black spots; length of face 0.48 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 5–6 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum red-brown without dark markings. Pleural areas pale fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices pale fuscous); anterior 3/5 lower hypopleural calli (remainder pale fuscous); 2 lateral postsutural vittae ending at upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown except sa. weak or absent in some specimens.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except hind tibiae pale fuscous and apices of femora darker fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 5.7 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} amd M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad transverse pale fuscous band across anterior ½ and widening to cover lateral margins; terga III–V orange-brown except for a broad transverse fuscous band across anterior margin of tergum III, a medial longitudinal fuscous band on terga IV and V, 2 broad lateral longitudinal bands which are dark fuscous on tergum III and very pale fuscous on terga IV and V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. quadrata is similar to *B. aurantiaca* (Drew and Hancock) (*quadrata* complex) in possessing a medial longitudinal fuscous band on terga IV and V in addition to the character defining the *quadrata* complex but differs in having a red-brown mesonotum, lateral fuscous margins only on abdominal tergum III and apices of all femora and hind tibiae fuscous.

recurrens complex

DEFINITION OF COMPLEX: *Bactrocera* species with infuscation on wing as an S-shaped band in addition to costal band and anal streak, mesopleural stripe broad reaching humeral callus dorsally, lateral postsutural vittae present, medial postsutural vitta absent, scutellum entirely yellow; males of some species attracted to cue lure.

Bactrocera (Bactrocera) absidata, n. sp.
(Fig. 164)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Mt Susu, Bulolo, hand collected in flight, 13.ii.1979, H. Ivagai.

LOCATION OF TYPE: Holotype (T.10531) in QM.

DISTRIBUTION

Known only from Mt Susu, Bulolo, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized oval facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe broad reaching humeral callus, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, a narrow U-shaped fuscous band across wing, costal cells very pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga II–V orange-brown.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.75 mm. Frons narrowing slightly posteriorly, length 1.4 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a few short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots present; length of face 0.5 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–4 small red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista red-brown (fulvous basally); length of segments: 0.23 mm; 0.38 mm; 0.93 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, above mesopleural suture and inside humeral calli. Pleural areas red-brown below humeral calli and above mid coxae, dark fuscous anterior and posterior to mesopleural stripes, black on sternopleuron and above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripes, reaching humeral callus dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight, upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae, rounded posteriorly and ending behind upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; mid tibiae each with an apical red-brown spur; rows of long pale setae on dorsal and ventral surfaces of fore femora.

Wings length 6.8 mm; costal cells very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow U-shaped fuscous band across wing, broad fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; terga II–V orange-brown except for irregular narrow pale fuscous markings along intersegmental lines and on lateral margins. A pair of oval orange-brown shining spots on tergum V. Visible portion of oviscape orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.48:1. Aculeus strongly sclerotized, red-brown and without lobes at its tip.

ATTRACTANT: No known record.

COMMENTS

B. absidata is similar to *B. resima* (Drew) (*recurrens* complex) in having a U-shaped fuscous band across wing between costal band and hind margin but differs in having abdominal terga III–V orange-brown with narrow pale fuscous lateral margins.

Bactrocera (Bactrocera) anfracta, n. sp.

(Fig. 165)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Milne Bay District: D'Entre Casteaux I., 17–25.vi.1970, T.L. Fenner.

Paratypes, PAPUA NEW GUINEA, Milne Bay District: 1 ♂, 17–25.vi.1970, D'Entre Casteaux I., T.L. Fenner. Western District; 1 ♂, 28.vii.1970, Weam road, Morehead, attracted to Willison's lure, T.L. Fenner. TORRES STRAIT: 1 ♂, Saibai I., July 1976, G. Maroske; 2 ♂♂, Saibai I., attracted to cue lure, 27.x.1979, G. Sanewski; 2 ♂♂, Saibai I., attracted to cue lure, January 1980, D. Currey.

LOCATION OF TYPES: Holotype (T.10532) in QM; 1 paratype in ANIC; 6 paratypes in DPI.

DISTRIBUTION

Known from the Western and Milne Bay Districts, Papua New Guinea and Saibai I. (Torres Strait islands).

DIAGNOSIS

Medium sized species; medium sized circular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe broad reaching humeral callus, scutellum yellow; wing with a broad fulvous costal band and anal streak, a broad S-shaped fulvous band across wing, costal cells very pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga II–V fulvous except for red-brown to pale fuscous lateral margins on tergum III and a narrow medial longitudinal red-brown to pale fuscous band over all 4 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.85 mm. Frons of even width, length 1.93 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots present; length of face 0.53 mm. Genae fulvous, pale fuscous subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–6 pale bristle. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista fuscous (fulvous basally); length of segments: 0.23 mm; 0.35 mm; 0.93 mm.

Thorax mesonotum black except red-brown below and behind lateral postsutural vittae. Pleural areas fuscous except red-brown below humeral calli and black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder dark fuscous); 2 broad parallel sided lateral postsutural vittae, ending behind upper pa. bristles. Postnotum fuscous to dark fuscous. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and pale red-brown.

Legs all segments fulvous; mid tibiae each with an apical black spur; rows of long pale setae on dorsal and ventral surfaces of fore femora.

Wings length 5.8 mm; costal cells very pale fulvous (second cell paler); microtrichia in outer corner of second costal cell only; remainder of wings colourless except fulvous subcostal cell, broad fulvous costal band confluent with R_{4+5} (except for a colourless spot between R_{2+3} and R_{4+5} distal to r–m crossvein), a broad S-shaped fulvous band across wing, a broad fulvous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous to black; terga II–V fulvous except for a narrow medial longitudinal red-brown to pale fuscous band ending in centre of tergum V and narrow red-brown to pale fuscous lateral margins on tergum III. A pair of oval fulvous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. anfracta is similar to *B. redunca* (Drew) in possessing broad parallel sided lateral postsutural vittae ending at or behind upper pa. bristles, wing markings pale fuscous and abdominal terga III without a dark basal band joining lateral longitudinal dark bands but differs in having the abdominal terga mostly orange-brown with a narrow medial longitudinal fuscous band on terga

II–V and anterolateral corners of tergum II fuscous.

Bactrocera (Bactrocera) manskii (Perkins and May), n. comb. (Figs 166–168)

Strumeta manskii Perkins and May, 1949: 3–5.
Dacus (Strumeta) manskii: Hardy, 1951: 159–61.
Dacus (Strumeta) recurrens: Drew, 1974a: 78–9 (partim, material from Queensland).

MATERIAL EXAMINED

AUSTRALIA, Queensland: lectotype ♀ and paralectotype ♂ each labelled holotype, Cairns, bred from *Strychnos bancroftiana*, 12.ix.1937, F.A. Perkins; 43 paralectotypes (both sexes) in UQ with labels conforming with Perkins and May's (1949) type data; a large series in DPI from north Queensland collected in cue lure traps (see DISTRIBUTION); 3 ♀ ♀ and 2 ♂ ♂ bred from *Diospyros* sp., Lockerbie, Cape York, 14.x.1976, D. Currey.

LOCATION OF TYPES: Lectotype (T.5246) and 1 paralectotype (T.5245) in QM; 43 paralectotypes in UQ.

DISTRIBUTION

Common in rainforests on the Atherton Tableland and along the eastern coast of Queensland, north from Tully (type locality, Cairns) and Horn I. (Torres Strait islands).

DIAGNOSIS

Small to medium sized species; medium sized subquadrate facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with a pattern of fuscous to dark fuscous markings, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe broad reaching humeral callus, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad S-shaped fuscous band across wing, costal cells fuscous, microtrichia covering all of second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown except for a very broad medial and 2 broad lateral longitudinal dark bands over all 3 terga and connecting along anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.4 times breadth; fulvous with or without pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized subquadrate black spots; length of face 0.4 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput pale fuscous, fulvous along eye margins; occipital row with 4–6 well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.25 mm; 0.73 mm.

Thorax mesonotum red-brown with irregularly shaped longitudinal fuscous to dark fuscous markings (in some specimens these markings merge to cover most of the posterior area of the mesonotum) and large oval fuscous to dark fuscous markings between humeral and notopleural calli. Pleural areas fuscous to dark fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight or slightly concave, upper hypopleural calli (posterior apices fuscous to dark fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous to dark fuscous); 2 lateral postsutural vittae of medium width, narrowing posteriorly to end before upper pa. bristles. Postnotum fuscous to dark fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown to fuscous.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells fuscous, microtrichia covering all of second costal cell and ½ of first costal cell; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M, a broad fuscous S-shaped recurved band across wing, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous to dark fuscous; tergum II orange-brown except anterolateral corners dark fuscous and a dark fuscous to black transverse band which reaches lateral margins; terga III–V orange-brown except for a very broad medial longitudinal black band and 2 broad lateral longitudinal bands which are dark fuscous to black on terga III and IV and fuscous to dark fuscous on tergum V (these bands join along anterior margin of tergum III). A pair of oval fuscous shining spots on tergum V. Posterior lobe of

surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and narrowing posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.4:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 167). Spicules at distal end of middle segment wide with 13–16 small dentations of uneven length (Fig. 168).

HOST PLANTS
NEW RECORD: *Diospyros* sp. (Ebenaceae), Lockerbie, Cape York, 14.x.1976, D. Currey.
ATTRACTANT: Cue lure.

COMMENTS
B. manskii (Perkins and May) is distinct from *B. recurrens* (Hering). Hardy (1951) reported sending specimens of *B. manskii* to Dr. Hering for study who stated that the 2 species were separate. Hardy concluded that "it would be necessary to study specimens of *recurrens* from New Guinea in order to be sure that these are synonyms". May (1953), however, synonymised the 2 species without comparing the types and without studying specimens of *B. recurrens* from Papua New Guinea.

A large series of mature specimens (lure collected) from Papua New Guinea and northern Queensland are on hand. These are distinct but closely related species, *B. manskii* occurring in northern Queensland and *B. recurrens* restricted to Papua New Guinea.

B. manskii is similar to *B. recurrens* in possessing the same S-shaped fuscous band across wing but differs in having the mesonotum red-brown with a lanceolate fuscous pattern, lateral postsutural vittae narrow and ending before upper pa. bristles, abdominal terga III–V orange-brown with broad medial and lateral longitudinal fuscous bands joined along anterior margin of tergum III.

Originally, Perkins and May (1949) did not define type specimens but stated that the species was "described from a series of over fifty specimens bred from *Strychnos bancroftiana* Bail. by M.J. Manski at Cairns in September, 1937, and November, 1938". I designate the female specimen (T.5246) in QM as lectotype and the remaining 44 specimens as paralectotypes.

Bactrocera (Bactrocera) nigrescentis (Drew), n. comb. (Fig. 169)

Dacus (Strumeta) nigrescentis Drew, 1971: 72–4.

MATERIAL EXAMINED
A large series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6952) in QM.

DISTRIBUTION
Known from New Britain (type locality, Keravat), Lihir I. and Bougainville I.

DIAGNOSIS
Small species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a Z-shaped fuscous marking across wing, costal cells fuscous, microtrichia covering all of second costal cell and outer ⅓ of first costal cell; abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal glossy black bands joined along anterior margin of tergum III.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. nigrescentis was described adequately by Drew (1971). It is similar to *B. anfracta* and *B. redunca* (Drew) (*recurrens* complex) in possessing a Z-shaped fuscous band across wing. It differs from these species in having the lateral postsutural vittae short and ending well before the upper pa. bristles, wing patterns fuscous to dark fuscous and abdominal terga III–V with a broad medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum III.

Bactrocera (Bactrocera) recurrens (Hering), n. comb. (Fig. 170)

Strumeta (Bactrocera) recurrens Hering, 1941a: 47.
Strumeta recurrens: May, 1963: 50.
Dacus (Strumeta) recurrens: Drew, 1974a: 78–9 (partim, material from Papua New Guinea).

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ recorded in HNHM (unconfirmed by author).

DISTRIBUTION
PREVIOUSLY RECORDED: Papua New Guinea (type locality, Friedrich Wilhelmshafen).

NEW RECORD: Papua New Guinea, Milne Bay District: 1 ♂, Samari I., 17.iv.1970, E. Mann.

DIAGNOSIS

Small species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a narrow S-shaped fuscous band across wing, costal cells fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V fulvous with brown on lateral margins of tergum III and an indefinite pale fuscous medial longitudinal band over all 3 terga.
ATTRACTANT: Cue lure.

COMMENTS

B. recurrens was described adequately by Drew (1974a) except that the mesonotum (usually black) is occasionally red-brown with diffuse black markings of variable shape and size.

B. recurrens is similar to *B. manskii* (Perkins and May) (*recurrens* complex) in possessing an S- or Z-shaped fuscous band across wing but differs in having the mesonotum mostly black, lateral postsutural vittae broad and reaching upper pa. bristles, abdominal terga III–V orange-brown with a narrow medial longitudinal pale fuscous band and lateral margins of tergum III pale fuscous.

Bactrocera (Bactrocera) redunca (Drew), n. comb. (Fig. 171)

Dacus (*Strumeta*) *reduncus* Drew, 1971: 82–4.

MATERIAL EXAMINED

A large series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6958) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Vanuatu (formerly New Hebrides), (type locality, Vila, Efate I.) and Bougainville I.
NEW RECORDS: Torres Strait Islands: 5 ♂♂, Saibai I., September 1984; specimens from Boigu, Darnley and Yam (records from Plant Quarantine Survey). Also recorded from the Shortland Is (Solomon Islands).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad pale fuscous costal band and anal streak, an S-shaped fuscous band across wing, costal cells dark fulvous (second cell paler), microtrichia in outer corner of second costal cell only; abdominal terga II–V fulvous with a broad medial longitudinal glossy black band over all 4 terga and 2 broad lateral longitudinal glossy black bands over terga III–V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. redunca was described adequately by Drew (1971). It is similar to *B. anfracta* (*recurrens* complex) in possessing a Z-shaped fuscous band across wing, broad parallel sided lateral postsutural vittae reaching to or behind upper pa. bristles, wing patterns pale fuscous and abdominal tergum III without a broad dark band across anterior margin. It differs from this species in having the abdomen orange-brown with 2 broad lateral longitudinal black bands on terga III–V and a broad medial longitudinal black band on terga II–V.

Bactrocera (Bactrocera) resima (Drew), n. comb. (Fig. 172)

Dacus (*Strumeta*) *resimus* Drew, 1971: 85–6.

MATERIAL EXAMINED

Four paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6961) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Papua New Guinea, Sepik District (type locality, Ambunti).
NEW RECORD: Torres Strait islands: Saibai (record from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and broad pale fuscous anal streak, an indefinite U-shaped pale fuscous pattern across wing, first costal cell pale fulvous, second costal cell colourless, microtrichia in outer corner of second costal cell only; abdominal terga generally fulvous with a narrow medial longitudinal fuscous to black band over terga I–V and pale fuscous on lateral margins of tergum III.
ATTRACTANT: No known record.

COMMENTS

B. resima was described adequately by Drew (1971). It is similar to *B. absidata* (*recurrens* complex) in possessing a U-shaped fuscous band across wing between costal band and hind margin but differs from this species in having the abdominal terga mostly orange-brown with a medial longitudinal fuscous band on terga I–V and the lateral margins of tergum III brown.

silvicola complex

DEFINITION OF COMPLEX: *Bactrocera* species without well defined fuscous patterns on wing membrane except for narrow costal band and anal streak, costal cells without microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga III–V with distinct broad lateral dark fuscous to black markings on all terga, males attracted to cue lure.

Bactrocera (Bactrocera) abscondita
(Drew and Hancock), n. comb. (Fig. 173)

Dacus (*Bactrocera*) *absconditus* Drew and Hancock, 1981: 54–7.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8221) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Cape York Peninsula, north from Iron Range (type locality, Bamaga) and the Torres Strait islands: Moa (Banks), Thursday.

NEW RECORDS: Torres Strait islands: Badu, Boigu, Horn (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregular fuscous markings, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells very pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with broad lateral and medial longitudinal dark bands over all 3 terga and joining along anterior margin of tergum III.

ATTRACTANT: Cue lure.

COMMENTS

B. abscondita was described adequately by Drew and Hancock (1981). It is similar to *B. abundans* and *B. turneri* in possessing fulvous costal cells in addition to the characters defining the *silvicola* complex but differs from *B. turneri* in having the lateral postsutural vittae narrowing posteriorly and ending before or just reaching the upper pa. bristles and the mesonotum with only small fuscous patterns. It differs from *B. abundans* in having the mesopleural stripe reaching the anterior npl. bristle, the basal dark band on the scutellum always narrow and in lacking a coloured tint across the wing membrane.

Bactrocera (Bactrocera) abundans, n. sp.
(Fig. 174)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Missim (1650 m), attracted to cue lure, 30.x.1980, A. Allison.

Paratypes, PAPUA NEW GUINEA, Western Highlands Province, Mt Hagen: 1 ♂ (14.x.1980), 1 ♂ (4.xi.1980), 1 ♂ (18.xi.1980), 1 ♂ (22.iv.1981), 1 ♂ (28.iv.1981), B. Thistleton.

Morobe Province, Mt Missim (1100–1700 m): 1 ♂ (30.x.1980), 1 ♂ (18.xii.1980), 1 ♂ (30.x.1980), 1 ♂ (13.xi.1980), 15 ♂♂ (30.x.1980), 5 ♂♂ (13.xi.1980), 1 ♂ (20.xi.1980), 1 ♂ (19.ii.1981), A. Allison. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10533) and 1 paratype (T.10534) in QM; 8 paratypes in ANIC; 2 paratypes in BMNH; 1 paratype in DPI(PNG); 19 paratypes in DPI.

DISTRIBUTION

Known only from the higher altitude areas of Papua New Guinea (above 1200 m) having been recorded from Mt Missim (Morobe Province) and Mt Hagen (Western Highlands Province).

DIAGNOSIS

Medium sized species; medium sized irregularly oval to pear shaped black facial spots present; humeral and notopleural calli yellow; mesonotum dark red-brown with a complex pattern of dark fuscous markings, mesopleural stripe of medium width ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a fuscous tint through membrane and a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia generally in outer ⅓ of second cell only; abdominal terga III–V orange-brown except for a moderately broad medial and 2 broad lateral longitudial dark fuscous to black

bands over all 3 terga and joining along anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.42 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized pear shaped to irregularly oval black spots; length of face 0.48 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput pale fuscous, fulvous along eye margins; occipital row with 4–7 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum dark red-brown except dark markings as follows: fuscous across posterior region of mesonotum, a small dark fuscous area along inner posterior margins of lateral postsutural vittae, 3 narrow longitudinal dark fuscous patterns running full length of mesonotum, an irregularly oval dark fuscous pattern between humeral and notopleural calli. Pleural areas fuscous to dark fuscous. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior 3/5 lower hypopleural calli (remainder including broad ventral margins fuscous to dark fuscous); 2 narrow lateral postsutural vittae narrowing sharply posteriorly to end before upper pa. bristles. Postnotum fuscous to dark fuscous. Scutellum yellow except for narrow to broad fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous.

Legs fore coxae pale fuscous, mid and hind coxae fuscous; all femora fulvous, tending darker apically; fore tibiae pale fuscous, mid tibiae fulvous, hind tibiae fuscous; tarsal segments fulvous except apical 4 segments of all tarsi pale fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.6 mm; costal cells fulvous; microtrichia in outer corner of second costal cell only; remainder of wings with a very pale fuscous tint, fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development. (In some specimens the microtrichia cover most of second costal cell and the tint across the wing membrane is darker.)

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous centrally, black laterally; tergum II orange-brown except for a broad transverse fuscous band across anterior ½ and widening to cover lateral margins; terga III–V orange-brown except for a moderately broad medial and 2 broad lateral longitudinal dark fuscous to black bands joining along anterior margin of tergum III and continuing over all 3 terga. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. abundans is similar to *B. abscondita* (Drew and Hancock) and *B. turneri* in possessing fulvous costal cells in addition to the characters defining the *silvicola* complex. It differs from *B. turneri* in the lateral postsutural vittae narrowing posteriorly and ending before or just reaching the upper pa. bristles and the mesonotum with only small fuscous patterns and from *B. abscondita* in having the mesopleural stripe narrower (ending midway between anterior margin of notopleural callus and anterior npl. bristle), a fulvous tint across wing membrane and a broader red-brown basal band on the scutellum.

Bactrocera (Bactrocera) breviaculeus (Hardy), n. comb. (Figs 175–177)

Dacus (Strumeta) breviaculeus Hardy, 1951: 145–8.
Dacus (Bactrocera) breviaculeus: Drew, 1982: 20–1.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ in NMNH.

DISTRIBUTION

PREVIOUSLY RECORDED: Eastern coastal areas of Queensland, north from Rockhampton (type locality, Atherton).
NEW RECORDS: Papua New Guinea: Morehead

(Western Province), Sogeri and Hombrom Bluff (Central Province), Popondetta and Safia (Northern District). Torres Strait islands: Moa (Banks), Saibai, Sue, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells extremely pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with broad lateral longitudinal fuscous to black bands and a narrow medial longitudinal pale fuscous band on terga III–V.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment of ovipositor red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.52:1. Apex of piercer needle shaped, narrowing sharply to a point with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 176). Spicules at distal end of middle segment of medium width with 6–9 very small dentations (Fig. 177).

ATTRACTANT: Cue lure.

COMMENTS

B. breviaculeus was described adequately by Hardy (1951) and Drew (1982). It is similar to *B. cinnamea*, *B. quasisilvicola* and *B. rufofuscula* (Drew and Hancock) in possessing colourless costal cells, lateral postsutural vittae ending at or behind the upper pa. bristles and the costal band confluent with or overlapping R_{2+3}. It differs from these species in having the costal band confluent with R_{2+3} and abdominal terga III–V with an indistinct medial longitudinal fuscous stripe which is not joined with the lateral longitudinal fuscous bands along the anterior margin of tergum III.

Although *B. breviaculeus* was recorded from guava (Hardy, 1951) there is doubt about this record (May, 1953). Consequently, the classification of this species as economic (Drew, 1978, 1982) is incorrect.

Bactrocera (Bactrocera) cinnamea, n. sp.
(Fig. 178)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 15.iv.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 6 ♂♂ (1600 m) and 1 ♂ (1450 m), Mt Missim, 12.ii.1981, A. Allison; 3 ♂♂ (1600 m) and 1 ♂ (1650 m), Mt Missim, 5.ii.1981, A. Allison; 1 ♂ (1750 m), Mt Kaindi, 11.v.1981, A. Allison; 1 ♂, Upper Manki logging area, Bulolo, 15.iv.1980, P. Daur; all paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10535) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 9 paratypes in DPI.

DISTRIBUTION

Known only from Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots very small and irregular in shape; humeral and notopleural calli yellow; mesonotum with a broad medial longitudinal fuscous area surrounded laterally and posteriorly by irregular dark fuscous patterns, lateral postsutural vittae present; medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia covering outer corner of second costal cell only; abdominal terga III–V orange-brown except for a moderately broad medial and 2 broad lateral longitudinal dark bands over all 3 terga.

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.54 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with very small irregular fuscous to black spots; length of face 0.48 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput pale fuscous, fulvous along eye margins; occipital row with 4–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.33 mm; 0.83 mm.

Thorax mesonotum with a broad medial longitudinal fuscous area which does not reach

posterior margin and which is surrounded laterally and posteriorly by irregular dark fuscous patterns; dark fuscous below and behind lateral postsutural vittae; brown around mesonotal suture. Pleural areas dark fuscous to black except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end just before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4 (5 in holotype); all bristles well developed and dark red-brown.

Legs fore coxae, mid and hind coxae fuscous; all other segments fulvous except fore tibiae pale fuscous and hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells colourless or with a very pale fulvous tint; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad dark fuscous transverse band across anterior 1/2 and widening to cover lateral margins; terga III–V orange-brown except for a moderately broad medial longitudinal band which is dark fuscous on terga III and IV and black on tergum V, 2 broad lateral longitudinal bands which are dark fuscous on terga III and IV and fuscous on tergum V (these bands meet along anterior margin of tergum III at which point they are fuscous). A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a moderately deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. cinnamea is similar to *B. rufofuscula* (Drew and Hancock) in possessing colourless costal cells, lateral postsutural vittae ending at or behind the upper pa. bristles, costal band overlapping R_{2+3}, abdominal terga III–V with lateral and medial longitudinal dark bands joined along anterior margin of tergum III, mesonotum red-brown with dark markings and legs with femora entirely fulvous. It differs from this species in having the face with very small pale spots, mesonotum with a broad medial longitudinal fuscous area surrounded laterally and posteriorly by irregular dark fuscous to black patterns and abdominal terga covered by a dense golden pubescence.

Bactrocera (Bactrocera) quasisilvicola, n. sp. (Fig. 179)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central District: Rigo road (32 km from Port Moresby), attracted to cue lure, 24.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Central District: 2 ♂♂, Rigo road (32 km from Port Moresby), attracted to cue lure, 24.vi.1980, R.A.I. Drew and D.W. Currey.

LOCATION OF TYPES: Holotype (T.10536) in QM; 1 paratype in ANIC; 1 paratype in DPI.

DISTRIBUTION

Known only from Central District, Papua New Guinea.

DIAGNOSIS

Medium sized species; large irregularly oval facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, lateral postsutural vittae present; medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V dark orange-brown except for a medial and 2 broad lateral longitudinal dark bands connected along anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.67 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large irregularly oval black spots; length of face 0.48 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 5–7 well developed black

bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.28 mm; 0.80 mm.

Thorax mesonotum red-brown with no dark markings. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing onto sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 parallel sided lateral postsutural vittae of medium width, ending at upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent or very small; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except apices of all femora fuscous, hind tibiae fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 5.5mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black laterally, fuscous centrally; tergum II orange-brown except for a broad transverse dark fuscous band across anterior ⅓ and widening to cover lateral margins; terga III–V dark orange-brown except for a medial longitudinal band which is fuscous on tergum III and dark fuscous on terga IV and V, 2 broad lateral longitudinal bands which are dark fuscous on tergum III and fuscous on terga IV and V (there is a narrow fuscous area joining these longitudinal bands along anterior margin of tergum III). A pair of oval dark orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. quasisilvicola is similar to *B. cinnamea* and *B. rufofuscula* (Drew and Hancock) in possessing colourless costal cells, lateral postsutural vittae ending at or behind the upper pa. bristles, costal band overlapping R_{2+3} and abdominal terga III–V with medial and lateral longitudinal fuscous bands joined along anterior margin of tergum III. It differs from these species in having the mesonotum uniformly red-brown without dark markings, costal band narrowing beyond extremity of R_{2+3} and legs with apices of all femora and hind tibiae fuscous.

Bactrocera (Bactrocera) rufofuscula
(Drew and Hancock), n. comb. (Fig. 180)

Dacus (Bactrocera) rufofusculus Drew and Hancock, 1981: 77–9.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8301) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Cape York Peninsula, north from Iron Range (type locality, Captain Billy Creek, near Shelburne Bay).

NEW RECORDS: Torres Strait islands: Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum dark red-brown with a pair of longitudinal fuscous bands, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a narrow medial and 2 broad lateral longitudinal dark bands over all 3 terga and joining along anterior margin of tergum III.

ATTRACTANT: Cue lure.

COMMENTS

B. rufofuscula was described adequately by Drew and Hancock (1981). It is similar to *B. cinnamea* in possessing colourless costal cells, lateral postsutural vittae ending at or behind upper pa. bristles, costal band overlapping R2+3, abdominal terga III–V with lateral and medial longitudinal dark bands joined along anterior margin of tergum III, mesonotum with dark markings and legs with

femora entirely fulvous but differs in having large oval black facial spots, mesonotum dark red-brown with fuscous lateral longitudinal bands and abdominal terga without a dense golden pubescence.

Bactrocera (Bactrocera) silvicola (May), n. comb. (Fig. 181)

Strumeta silvicola May, 1962a: 68–71; May, 1963: 48, 50.

MATERIAL EXAMINED

Holotype ♂; a large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype (T.5861) in QM.

DISTRIBUTION

Occurs on the Atherton Tableland (type locality) and along the eastern coast of Queensland, north from Cairns. It has not been recorded from the Torres Strait islands where *B. abscondita* (Drew and Hancock), a closely related species occurs.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except fore tibiae pale fuscous and hind tibiae fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a very broad medial longitudinal black band and 2 broad lateral longitudinal black bands over all 3 terga and joined along anterior ½ of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.67 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized oval black spots; length of face 0.43 mm. Genae fulvous, dark fuscous subocular spot present; dark fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.65 mm.

Thorax mesonotum red-brown except pale fuscous on posterolateral corners and between humeral and notopleural calli. Pleural areas fuscous to dark fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior 3/5 lower hypopleural calli (remainder including narrow ventral margins fuscous); 2 lateral postsutural vittae tapering posteriorly to end just before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except fore tibiae pale fuscous and hind tibiae fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.9 mm; costal cells pale fuscous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad fuscous to dark fuscous band across anterior ½ of tergum and widening to cover lateral margins; terga III–V orange-brown except for a very broad medial longitudinal black band and 2 broad lateral longitudinal black bands over all 3 terga and joined along anterior ½ of tergum III by a dark fuscous area. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. silvicola is similar to *B. breviaculeus* (Hardy), *B. cinnamea*, *B. quasisilvicola* and *B. rufofuscula* (Drew and Hancock) in possessing costal cells colourless or with a very pale tint in addition to the characters defining the *silvicola* complex but differs in having the lateral postsutural vittae

ending well before the upper pa. bristles and the costal band overlapping R_{2+3} by a distinct margin.

Bactrocera (Bactrocera) turneri, n. sp.
(Figs 182–184)

TYPE SPECIMENS

Holotype ♂, TORRES STRAIT: Murray I., attracted to bacteria lure, 28.iv.1986, J. Turner.

Paratypes, PAPUA NEW GUINEA, Milne Bay Province: 4 ♂♂, Goodenough I., attracted to cue lure, 4–10.viii.1980, P. Spradbury. SOLOMON IS: 3 ♂♂, Honiara, Guadalcanal I., iii.1986, N.L.H. Krauss; 1 ♂, Point Cruz, Guadalcanal I., attracted to cue lure, 2.iii.1983; 1 ♂, Maloai, Shortland Is, attracted to cue lure, iii.1985, R. Macfarlane. TORRES STRAIT: 16 ♀♀ and 15 ♂♂, Murray I., attracted to bacteria lure, 28.iv.1986, J. Turner; 1 ♂, Stephens I., attracted to bacteria lure, 25.iv.1986, J. Turner.

LOCATION OF TYPES: Holotype (T.10537) and 2 paratypes (T.10538–T.10539) in QM; 10 paratypes in ANIC; 5 paratypes in BMNH; 1 paratype in DPI(PNG); 23 paratypes in DPI.

DISTRIBUTION

Known from Goodenough I., Milne Bay Province (Papua New Guinea), Shortland Is (Solomon Islands) and the Torres Strait islands: Murray and Stephens.

DIAGNOSIS

Medium sized species; medium sized oval facial spots present; humeral and notopleural calli yellow; mesonotum fuscous with lateral and medial longitudinal dark patterns, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous, microtrichia covering outer ⅓ of second costal cell only; abdominal terga III–V orange-brown except for a broad medial and 2 moderately broad lateral longitudinal dark bands connected by a narrow transverse black band across anterior margin of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.65 mm. Frons narrowing slightly posteriorly, length 1.56 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.48 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 2–7 weak dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fuscous; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.35 mm; 0.75 mm.

Thorax mesonotum red-brown with or without mottled dark patterns. Pleural areas black except red-brown below humeral calli and fuscous above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder including ventral margin black); 2 broad lateral postsutural vittae ending at or behind upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa.1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid coxae fuscous, hind coxae dark fuscous; all other segments fulvous except basal ½ of fore tibiae pale fuscous and hind tibiae fuscous; mid tibiae each with an apical black spur; rows of long dark setae on dorsal surfaces of fore femora.

Wings length 6.4 mm; costal cells fulvous (second costal cell slightly paler); microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for anterolateral corners fuscous and a broad fuscous transverse band across anterior margin but ending before lateral margins; terga III–V orange-brown except for a narrow transverse black band across anterior margin of tergum III, 2 lateral longitudinal dark fuscous bands and a broad medial longitudinal black band over all 3 terga. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2;

supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, conical in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.37:1. Apex of piercer needle shaped with 4 pairs of short subapical bristles (Fig. 183). Spicules at distal end of middle segment of medium width with 6–8 small dentations of approximately equal size (Fig. 184).

ATTRACTANT: Cue lure.

COMMENTS

B. turneri is similar to *B. abscondita* (Drew and Hancock) and *B. abundans* in possessing fulvous costal cells in addition to the characters defining the *silvicola* complex. It differs from these species in having the lateral postsutural vittae broad and ending at the upper pa. bristles and the mesonotum with a pair of broad lateral longitudinal black bands. *B. turneri* is also similar to *B. moluccensis* (Perkins) and *B. rutila* (Hering) in general body colour patterns and size. It differs from both species in the shape of the apex of the piercer and from *B. moluccensis* in the shape of the scales of the middle segment of the ovipositor. This species is named after Mr J. Turner, Department of Primary Industries, Brisbane who has undertaken extensive collections of Dacinae throughout Indonesia and the Torres Strait islands.

tryoni complex

DEFINITION OF COMPLEX: *Bactrocera* species with clear wing membrane except for narrow costal band (not confluent with R_{4+5}) and anal streak, costal cells fulvous or fuscous and generally covered with microtrichia, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with narrow dark basal band, mesonotum red-brown (with or without dark colour patterns), abdominal terga generally red-brown with variable dark colour patterns, males attracted to cue lure.

Bactrocera (Bactrocera) aquilonis (May), n. comb. (Figs 185–187)

Strumeta aquilonis May, 1965: 62–4.
Dacus (Bactrocera) aquilonis: Drew, 1982: 18–20.

MATERIAL EXAMINED

Holotype ♂; a series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype (T.6311) in QM.

DISTRIBUTION

Confined to the northern region of the Northern Territory (type locality, Nightcliff) and Western Australia.

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum pale red-brown with fuscous markings, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia covering second costal cell and most of first costal cell; abdominal terga III–V pale orange-brown with pale fuscous along anterior margin of tergum III and widening over lateral margins of that tergum, a medial longitudinal pale fuscous band on terga III and IV.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.5:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (Fig. 186). Spicules at distal end of middle segment of medium width with a row of 9–13 small dentations of uneven length (Fig. 187).

ATTRACTANT: Cue lure.

COMMENTS

B. aquilonis and the very similar *B. tryoni* (Froggatt) are an excellent example of speciation between 2 geographically isolated regions in which endemic species of fruit fly occur, i.e., northeastern and northwestern Australia. Intensive comparative studies of these 2 populations involving morphology, cytology, enzyme electrophoresis, premating and postmating isolation tests have established their identity (Drew and Lambert, 1986).

B. aquilonis and *B. tryoni* are very similar in general body and wing colour patterns. *B. aquilonis* differs in being an overall paler colour with the mesonotum pale red-brown and the abdominal terga generally fulvous without distinct fuscous markings. These species can also be separated on the differences on the ovipositors: apex of aculeus rounded and spicules with 7–10 uniform dentations in *B. tryoni* (Figs 195, 196) compared with the more pointed aculeus and

uneven dentations in *B. aquilonis* (Figs 186, 187). *B. aquilonis*, although reared from commercial host fruits, falls well below *B. tryoni* in pest status. An updated host list has been prepared (Smith et al., in press).

Bactrocera (Bactrocera) melas
(Perkins and May), n. comb. (Figs 188–190)

Strumeta melas Perkins and May, 1949: 12–14; May, 1963: 50.
Dacus tryoni var. *melas*: Hardy, 1951: 168–9.
Dacus (*Bactrocera*) *melas*: Drew, 1982: 34–5.

MATERIAL EXAMINED

AUSTRALIA, Queensland: lectotype ♀ and paralectotype ♀, Gayndah, Apr. 1940, A.W.S. May, ex fruit of *Citrus paradisi*; 1 ♀ labelled holotype, Gayndah, bred from grapefruit, 10.iii.1946, A.W.S. May; a series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPES: Lectotype (T.10602) and paralectotype (T.10603) in QM.

DISTRIBUTION

Known from coastal and subcoastal areas of eastern Queensland but more prevalent in south-east Queensland (May, 1963); type locality, Gayndah.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dark red-brown with dark fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V red-brown with fuscous along anterior margin of tergum III and broad fuscous lateral longitudinal bands over all 3 terga.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment dark red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.55:1. Apex of piercer rounded with 4 pairs of subapical bristles (Fig. 189). Spicules at distal end of middle segment of medium width with 4–8 broad dentations of uneven length (Fig. 190).

ATTRACTANT: Cue lure.

COMMENTS

The status of this species was questioned by Drew (1982) as it resembles a melanic form of *B. tryoni* (Froggatt). *B. melas* is similar to *B. neohumeralis* (Hardy) (*tryoni* complex) in having mesonotum and abdominal terga with dark red-brown to fuscous patterns but differs in having yellow humeral calli and the apical ½ of mid and hind femora fuscous. *B. melas* is minor in pest status. The host record of passionfruit (Drew, 1982) is incorrect.

Originally, Perkins and May (1949) did not define type specimens, stating only that the species was described from 4 specimens bred from grapefruit at Gayndah, Nambour and Palmwoods in the autumn of 1939 and 1940. One female labelled holotype (D.5255) in QM but dated 10.iii.1946 cannot be part of the type series. Two females in DPI labelled "Gayndah, Q., Apr. 1940, A.W.S. May, ex fruit of *Citrus paradisi*" are syntypes. I designate 1 of these (labelled "LECTOTYPE, R. Drew") as lectotype, the other as paralectotype. These have been deposited in QM and the remaining 2 types have not been located.

Bactrocera (Bactrocera) neohumeralis
(Hardy), n. comb. (Figs 191–193)

Not *Dacus humeralis* Bezzi, 1915: 95.
Chaetodacus humeralis Perkins, 1934: 42–3.
Chaetodacus tryoni var. *sarcocephali* Tryon, 1927: 188 (partim, type series).
Dacus (*Strumeta*) *tryoni* var. *neohumeralis* Hardy, 1951: 169–70 (replacement name).
Strumeta humeralis: May 1963: 46.
Dacus (*Strumeta*) *neohumeralis*: Drew, 1974a: 67.
Dacus (*Bactrocera*) *neohumeralis*: Drew, 1982: 40–3.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Perkins' type series.

LOCATION OF TYPES: Lectotype ♀ (T.10604) in QM; 7 paralectotypes (both sexes) in UQ.

DISTRIBUTION

PREVIOUSLY RECORDED: Eastern coastal areas of Queensland (type locality, Cairns), northern New South Wales, Papua New Guinea. More prevalent in northern wet tropical areas than cooler southern areas of Queensland (see Drew, 1982 for map of distribution in Australia).

NEW RECORDS: Torres Strait islands: Badu, Boigu, Darnley, Dauan, Hammond, Horn, Moa (Banks), Murray, Prince of Wales, Saibai, Stephens, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral calli dark brown to fuscous; notopleural calli yellow; mesonotum dark red-brown with dark fuscous to black markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V generally dark fuscous to dull black and tending red-brown medially.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.35:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (Fig. 192). Spicules at distal end of middle segment narrow and overlapping with 6–8 small dentations of uneven length (Fig. 193).

HOST PLANTS

NEW RECORDS: 3 specimens in *Notalaea* sp. (Oleaceae), Somerset Road (23 km from Bamaga), Queensland, 19.xii.1974, D.J. Rogers, in association with *B. jarvisi* (Tryon) (2 specimens) and *B. kraussi* (Hardy) (29 specimens); in association with *B. aglaiae* (Hardy) in *Ganophyllum falcatum* (Sapindaceae), Kamerunga, north Queensland, 4.i.1977, B. McCulloch.

ATTRACTANT: Cue lure.

COMMENTS

B. neohumeralis is similar to *B. melas* (Perkins and May) (*tryoni* complex) in having the mesonotum and abdominal terga with dark red-brown to fuscous patterns but differs in possessing fuscous to dark fuscous humeral calli.

Originally, Perkins (1934) did not designate type specimens, stating only that the species was "described from 5 males and 10 females". Five females and 3 males in UQ are part of this type series as the label data conform with those published. The remaining types have not been located. I am designating the female from Cairns, Queensland, 14.vii.1933, F.A. Perkins, bred from mandarins, labelled lectotype (T.10604) as lectotype and 4 females and 3 males as paralectotypes.

Hardy (1951) and May (1953) thought *B. neohumeralis* may be a variety or colour form of *B. tryoni*. Although these 2 species are very similar morphologically, their different daily mating periods (*B. tryoni* at dusk and *B. neohumeralis* during the middle of the day) are good reason to keep them separate.

B. neohumeralis is a species of major economic importance and of equal pest status to *B. tryoni* especially in the tropical areas of Queensland.

Bactrocera (Bactrocera) tryoni (Froggatt), n. comb. (Figs 194–196)

Tephritis tryoni Froggatt, 1897: 410–2; Froggatt, 1899: 498.
Dacus tryoni: Froggatt, 1909: 79–80, 1910: 865; Malloch, 1931: 263.
Chaetodacus tryoni: Tryon, 1927: 181–3.
Chaetodacus tryoni var. *juglandis* Tryon, 1927: 188.
Chaetodacus tryoni var. *sarcocephali* Tryon, 1927: 188 (partim, type series).
Dacus (*Strumeta*) *tryoni*: Hardy, 1951: 167–8; Drew, 1974a: 85–8.
Strumeta tryoni: May, 1963: 48.
Dacus (*Bactrocera*) *tryoni*: Drew, 1982: 43–7.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Tryon's type series.

LOCATION OF TYPES: *T. tryoni*, unknown; var. *juglandis*, holotype ♀ (D.3120) in QM; var. *sarcocephali*, lectotype ♀ and 2 ♂ paralectotypes (D.3121) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Occurs in large populations throughout eastern Australia from Cape York (Queensland) to East Gippsland (Victoria). Type localities, Tenterfield and Penrith, New South Wales — not Queensland as reported by Drew (1974a). See Drew (1982) for map of distribution in Australia. It has also been recorded from New Caledonia, Austral Islands, many islands of the Society group and Easter Island (believed eradicated from this island). Since only 3 specimens have been recorded from Papua New Guinea (1 by Drew (1982); 1 male, cue lure, Goraita, Western District, 30.ix.1972, J. Stibick; 1 male, Willison's lure, 6 km east of Morehead, Western District, 30.ix.1972, J. Stibick) in spite of intensive male lure trapping, it is most doubtful that this species is established there. The 3 records are from the Western District, the closest area of Papua New Guinea to Cape York, Queensland.

NEW RECORD: Torres Strait islands: Yam (record from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V generally red-brown with a medial and 2 broad lateral longitudinal fuscous bands over all 3 terga and joined along anterior margin of tergum III; paler forms of the abdomen are often present (Fig. 194A).

DESCRIPTION

FEMALE: No dense aggregaton of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.53:1. Apex of piercer rounded with 4 pairs of subapical bristles (Fig. 195). Spicules at distal end of middle segment of medium width with a row of 7–10 small dentations of uniform size (Fig. 196).

HOST PLANTS

NEW RECORD: *Syzygium rubrimolle* (Myrtaceae), Somerset, 11.xii.1974, D.J. Rogers — 3 specimens in association with 4 specimens of *B. jarvisi* (Tryon) and 22 specimens of *B. kraussi* (Hardy).

ATTRACTANT: Cue lure.

COMMENTS

B. tryoni is similar to *B. aquilonis* (May) (*tryoni* complex) in the general colour patterns of the wing, thorax and abdomen but differs in the characters listed under the comments on *B. aquilonis*.

Tryon (1927) described 2 varieties of *B. tryoni*, i.e. *juglandis* and *sarcocephali*. The single type (holotype ♀) of *juglandis* is identical to normal *B. tryoni*. The three types of *sarcocephali* consist of a female and male *B. tryoni* on one pin (labelled "Holotype") and a male *B. neohumeralis* (Hardy) on another pin (labelled "ALLOTYPE" and bred from *Psidium*), not 2 females and 1 male as recorded by Tryon. In the description Tryon appears to be describing *B. neohumeralis* as he stated that the mesonotum was marked with black and the abdomen dark fuscous. Also he cited a single specimen "reared from *Psidium* fruit" (probably the allotype) and stated that *sarcocephali* was probably a distinct species. The most significant distinguishing feature of *B. neohumeralis* is the dark humeral callus and this was not described. While Tryon may have been describing *B. neohumeralis*, this is not certain. Consequently I am making *sarcocephali* a junior synonym of *tryoni*, rather than have it threaten the junior, but commonly used *B. neohumeralis*. Because a holotype and paratypes were not clearly designated for *sarcocephali*, I designate the female as the lectotype and the 2 males as paralectotypes.

B. tryoni is the major pest species in Australia and is responsible for major control and quarantine programmes. The spread of this species through the South Pacific islands from Australia to Easter Island during the early 1970's is a good example of dispersal of fruit fly pest species into new areas.

SPECIES NOT PLACED IN COMPLEXES

Bactrocera (Bactrocera) abdofuscata
(Drew), n. comb. (Fig. 197)

Dacus (*Strumeta*) *abdofuscatus* Drew, 1971: 48–50.

MATERIAL EXAMINED

Two ♂ paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6938) in QM.

DISTRIBUTION

Aroa River, Central District, Papua New Guinea (type locality).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregular fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga generally fuscous tending darker laterally.

ATTRACTANT: No known record.

COMMENTS

B. abdofuscata was described adequately by Drew (1971). It is similar to *B. dyscrita* (Drew) in possessing a red-brown mesonotum and abdominal

terga of uniform pale colouration. It differs from *B. dyscrita* in having the abdominal terga entirely fuscous (pale orange-brown in *B. dyscrita*) and the lateral postsutural vittae ending before the upper pa. bristle.

Bactrocera (Bactrocera) abdonigella (Drew), n. comb. (Fig. 198)

Dacus (*Strumeta*) *abdonigella* Drew, 1971: 52–4.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6940) in QM.

DISTRIBUTION

Widespread throughout Papua New Guinea (type locality, Bubia, near Lae) especially in lowland areas and on Daru and Kiwai Is. There is 1 specimen (in DPI) from Mt Hagen, Western Highlands District. It probably does not occur in large populations as only small numbers have been collected in male lure traps.

DIAGNOSIS

Large species; small black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V generally black.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. abdonigella was described adequately by Drew (1971). It is similar to *B. abdofuscata* (Drew) and *B. dyscrita* (Drew) in possessing a red-brown mesonotum, wings with a narrow costal band and costal cells with microtrichia confined to apical portion of second costal cell only. It differs from these species in having abdominal terga III-V entirely black.

Bactrocera (Bactrocera) aithogaster, n. sp. (Fig. 199)

TYPE SPECIMENS

Holotype ♂, SOLOMON IS, Guadalcanal I.: Honiara, December 1971, N.L.H. Krauss.

Paratype, SOLOMON IS, Guadalcanal I.: 1 ♂, Honiara, December 1971, N.L.H. Krauss.

LOCATION OF TYPES: Holotype (T.10540) in QM; paratype in DPI.

DISTRIBUTION

Known only from Guadalcanal I. (Solomon Islands).

DIAGNOSIS

Small species; facial spots small and irregularly circular; humeral and notopleural calli yellow; mesonotum dark orange-brown with irregular longitudinal dark patterns, lateral postsutural vittae present, medial postsutural vittae absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V pale orange-brown except for 2 broad lateral longitudinal bands which are fuscous on tergum III and pale fuscous on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.35 mm. Frons of even width, length 1.48 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles fuscous: 1 s.or., 2 i.or.; lunule fulvous. Vertex fuscous. Face fulvous with small irregularly circular black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; bristle absent. Occiput red-brown, fulvous along eye margins; occipital row with 5 well developed fuscous bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong fulvous dorsal bristle on segment 2; length of segments: 0.15 mm; 0.28 mm.

Thorax mesonotum dark orange-brown except for irregular narrow lateral longitudinal pale fuscous lines. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices pale fuscous); anterior ½ lower hypopleural calli (remainder including ventral margins red-brown); 2 parallel sided lateral postsutural vittae of medium width ending at upper pa. bristles. Postnotum dark orange-brown. Scutellum yellow except for narrow dark orange-brown basal band. Bristles: sc. 2; prsc.

2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except hind tibiae pale fuscous; rows of short pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.1 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; tergum II orange-brown tending whitish except for a broad transverse fuscous band across anterior ½ and widening to cover lateral margins; terga III–V pale orange-brown except for 2 broad lateral longitudinal bands which are fuscous on tergum III and pale fuscous on terga IV and V (there is an indication of an indefinite narrow medial longitudinal red-brown band on terga IV and V). A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. aithogaster is similar to *B. barringtoniae* (Tryon) in possessing a red-brown mesonotum and abdominal terga III–V with broad lateral longitudinal dark bands and without a medial longitudinal dark band but differs in having a narrower mesopleural stripe (ending midway between anterior margin of notopleural callus and anterior npl. bristle) and lateral postsutural vittae narrow and tapering posteriorly to end at upper pa. bristles.

Bactrocera (Bactrocera) allwoodi (Drew), n. comb. (Fig. 200)

Dacus (*Bactrocera*) *allwoodi* Drew, 1979: 79–80.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.7777) in QM.

DISTRIBUTION

Known only from coastal areas of the Northern Territory, Australia (type locality, Smith Point, Coburg Peninsula).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching just anterior to npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown except for a narrow medial longitudinal fuscous to dull black band and fuscous lateral margins over all 3 terga.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. allwoodi was described aequately by Drew (1979). It is similar to *B. obscura* (Malloch) in possessing a black mesonotum without lateral and medial postsutural vittae and abdominal terga pale with dark markings but differs in lacking a fuscous spot on apex of scutellum, in having pale fuscous costal cells and abdominal terga III–V red-brown with broad fuscous lateral margins on tergum III, narrow fuscous margins on terga IV and V and a narrow medial longitudinal fuscous to dull black band on terga III–V.

Bactrocera (Bactrocera) amplexiseta (May), n. comb. (Fig. 201)

Strumeta amplexiseta May, 1962a: 66–8; May, 1963: 50.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.5860) in QM.

DISTRIBUTION

Known only from higher altitude rainforests in north Queensland, Australia (type locality, Atherton).

DIAGNOSIS

Medium sized species; small oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with mottled fuscous patterns, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs entirely fulvous; wing with a broad fuscous costal band and anal streak, apical ½ of wing dark fuscous to fuscous, costal cells fuscous with microtrichia covering outer ⅓ of second costal cell only; abdominal terga I–IV orange-brown except

tergum IV with a transverse black band across posterior margin and a medial longitudinal dark fuscous band, tergum V black.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.7 mm. Frons of even width, length 1.7 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short dark setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small oval black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–6 strong dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.23 mm; 0.33 mm; 0.85 mm.

Thorax mesonotum red-brown with a mottled fuscous pattern. Pleural areas red-brown with pale fuscous on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅓ lower hypopleural calli (remainder red-brown); 2 broad lateral postsutural vittae widening posteriorly to end behind upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 6.5 mm; costal cells fuscous; microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5}, apical ½ of wing fuscous to dark fuscous, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–IV orange-brown except tergum IV with a black transverse band across posterior margin and a medial longitudinal dark fuscous band, tergum V black. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. amplexiseta is similar to *B. pepisalae* (Froggatt) in having a large area of the wing infuscated and in possessing lateral postsutural vittae and facial spots but differs in having a red-brown mesonotum, infuscation covering apical half of wing and abdominal terga III–V orange-brown except posterior ½ of tergum IV and all of tergum V black.

Bactrocera (Bactrocera) angustifasciata, n. sp. (Fig. 202)

TYPE SPECIMEN

Holotype ♂, LIHIR I.: Lakakot Plantation, 8–14.vii.1970, R.M. Berena.

LOCATION OF TYPE: Holotype (T.10541) in QM.

DISTRIBUTION

Known only from Lihir I.

DIAGNOSIS

Medium sized species; large rectangular black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad triangular black marking on dorsal surface which reaches to apex of scutellum; legs fulvous except fore tibiae very pale fuscous, mid tibiae pale fuscous and hind tibiae dark fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, a narrow transverse fuscous band across centre of wing enclosing both crossveins, the r–m crossvein long and oblique, costal cells fuscous with microtrichia in outer ½ of second costal cell only; abdominal terga II–V orange-brown except for a broad medial longitudinal black band over all 4 terga and 2 broad lateral longitudinal black bands over terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons of even width, length 1.69 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered with a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large rectangular black spots; length of face

0.53 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput black dorsally, fulvous ventrally and along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.40 mm; 1.0 mm.

Thorax mesonotum black without pale markings. Pleural areas black without pale markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and narrowing sharply posteriorly to end at level of lower pa. bristles. Postnotum black. Scutellum yellow except for a broad triangular black marking on dorsal surface which has its apex between the sc. bristles. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 2; all bristles well developed and black.

Legs all coxae fulvous; all other segments fulvous except fore tibiae very pale fuscous, mid tibiae pale fuscous, hind tibiae dark fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.7 mm; costal cells fuscous; microtrichia covering outer ½ and anterior margin of second costal cell and anterior margin of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a narrow fuscous transverse band across wing enclosing both crossveins, a broad fuscous anal streak ending at wing margin; the r–m crossvein is long and oblique as in B. obliqua (Malloch); dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; terga II–V orange-brown except for narrow lateral black margins on tergum II, a broad medial longitudinal black band on terga II–V, 2 broad lateral longitudinal black bands running from anterior margin of tergum III to meet along posterior margin of tergum V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. angustifasciata is similar to *B. unilineata* in possessing one narrow transverse fuscous band across wing enclosing both crossveins, a black mesonotum and a large black triangular marking on dorsal surface of scutellum but differs in having abdominal terga II–V orange-brown with a broad medial longitudinal black band over all 4 terga and 2 broad lateral longitudinal black bands on terga II–V, costal cells fuscous, costal band overlapping R_{2+3} and humeral calli entirely yellow.

Bactrocera (Bactrocera) atra (Malloch), n. comb. (Fig. 203)

Dacus atra Malloch, 1938: 113.
Dacus (*Strumeta*) *ater*: Drew, 1974a: 16–17.

MATERIAL EXAMINED

Holotype ♀, Unurau (100–200 ft.), Raivavae I., Austral Is, August 1934, E.C. Zimmerman. This holotype is female, not male as recorded in Malloch's description.
LOCATION OF TYPE: Holotype in BPBM.

DISTRIBUTION

Unurau, Raivavae I., Austral Is (type locality).

DIAGNOSIS

Medium sized species; small fuscous facial spots present; humeral calli glossy black; notopleural calli fuscous to brown; mesonotum glossy black, mesopleural stripe absent, lateral and medial postsutural vittae absent, scutellum glossy black; wing with a narrow pale fulvous costal band and a broad pale fulvous anal streak, a pale fulvous colouration along r–m crossvein, costal cells pale fulvous, microtrichia covering all of second costal cell and outer corner of first costal cell; all abdominal terga glossy black.
ATTRACTANT: No known record.

COMMENTS

B. atra was described adequately by Drew (1974a). It is similar to *B. perfusca* (Aubertin) in possessing an entirely black scutellum but differs from this species in having a pair of black facial spots. In the original description, Malloch (1938) incorrectly used the feminine form *atra* with *Dacus* which is masculine.

Bactrocera (Bactrocera) atramentata (Hering), n. comb. (Fig. 204)

Strumeta atramentata Hering, 1941c: 9–10.
Dacus (*Strumeta*) *atramentatus* Drew, 1974a: 17–19.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPES: 1 ♂ and 1 ♀ syntype in ZMB; 1 ♀ syntype in BMNH.

DISTRIBUTION

Occurs in large populations in New Britain, New Ireland and Lihir I.; type locality, Ralum, Bismarck Archipelago.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral calli dark fuscous; notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle above, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad medial longitudinal triangular black band; wing with a narrow fuscous costal band and broad fuscous anal streak, a pale infuscation along r–m crossvein, costal cells colourless with microtrichia generally covering outer ½ of second costal cell only; all abdominal terga dull black except orange-brown along anterior margin of tergum V.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. atramentata was described adequately by Drew (1974a). It is similar to *B. picea* (Drew) in possessing a black mesonotum, uniformly black abdomen and colourless costal cells but differs from this species in having humeral calli dark fuscous, lateral postsutural vittae narrow, the black band on the scutellum narrow, legs with mid femora, apical ½ of hind femora and hind tibiae fuscous and costal band present on wing.

Bactrocera (Bactrocera) barringtoniae (Tryon), n. comb. (Figs 205–207)

Chaetodacus barringtoniae Tryon, 1927: 196–7.
Dacus (Strumeta) barringtoniae: Hardy, 1951: 144–5.
Strumeta barringtoniae: May, 1963: 50.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: Lectotype ♂ and 3 paralectotypes (1 ♂ and 2 ♀ ♀ — D.3127) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Rainforest areas of Queensland, north from Cairns (type locality).

NEW RECORDS: Torres Strait islands: Darnley, Thursday, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized to large species; medium sized oval to subquadrate black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae broad and extending posteriorly to upper pa. bristles, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with broad lateral longitudinal bands which are fuscous on tergum III and pale fuscous on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with at most very pale fuscous around s.or. bristles; anteromedial hump covered by a small number of short pale setae; orbital bristles red-brown; 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle dark fuscous. Vertex very pale fuscous. Face fulvous with medium sized circular black spots; length of face 0.5 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–7 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.35 mm; 0.95 mm.

Thorax mesonotum red-brown without dark markings. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.8 mm; costal cells colourless; microtrichia in outer corner of second costal cell

only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous; tergum II red-brown tending fulvous along posterior margin each side of midline; terga III–V orange-brown with broad lateral longitudinal bands which are fuscous on tergum III and pale fuscous on terga IV and V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.6:1. Apex of piercer tapering sharply from subapical setae and rounded at tip, with 4 pairs of subapical bristles (Fig. 206). Spicules at distal end of middle segment of medium width with 7–11 very small dentations of uniform size (Fig. 207).

HOST PLANTS

NEW RECORD: In association with *B. visenda* (Hardy) and *B. musae* (Tryon) from *Garcinia warrenii* (Guttiferae), Mt Lewis, north Queensland, 19.i.1977, B. McCulloch.

ATTRACTANT: Cue lure.

COMMENTS

B. barringtoniae is similar to *B. peninsularis* (Drew and Hancock) (*quadrata* complex) and *B. aithogaster* in possessing abdominal terga III–V orange-brown without a medial longitudinal dark band and a red-brown mesonotum. It differs from *B. peninsularis* in being a larger fly with broad lateral longitudinal dark bands over abdominal terga III–V, and from *B. aithogaster* in having a broader mesopleural stripe reaching almost to anterior npl. bristle and broad parallel sided lateral postsutural vittae ending behind upper pa. bristles.

Originally, Tryon (1927) designated types "Reg. No. Q.M. D.3127. Holo-, Allo- and 2 Paratypes". However, 2 female specimens are on 1 pin and 2 males on another (side by side on micropins) and it is impossible to determine the holotype. On each pin is a white label with "TYPE D/3127". I designate 1 male (closest to the main pin) as lectotype and the remaining specimens paralectotypes.

Bactrocera (Bactrocera) biarcuata (Walker), n. comb. (Fig. 208)

Dacus biarcuatus Walker, 1865: 122.

Strumeta biarcuatus: Perkins, 1939: 12 (lectotype designation).

Dacus (*Strumeta*) *biarcuatus*: Hardy, 1959: 164–5; Drew, 1974a: 19–21.

MATERIAL EXAMINED

Lectotype ♂; a series of specimens in DPI (see DISTRIBUTION); 2 ♂♂ in BMNH labelled "Korovou, Western Province, Solomon Is, 11.x.1984, E. Holoie".

LOCATION OF TYPE: Lectotype in BMNH.

DISTRIBUTION

PREVIOUSLY RECORDED: Type ♂, labelled "New Guinea, W.W. Saunders, B.M. 1868–4" (Hardy, 1959). In spite of intensive male lure trapping, *B. biarcuata* has been recorded only in large numbers from Bougainville I. and the Shortland Is (Solomon Islands).

NEW RECORDS: Papua New Guinea, Morobe Province: 1 ♂, Mt Missim (1450 m), 30.x.1980, A. Allison; 1 ♂, Bubia, April–May, 1971, J. Maiyel (both specimens attracted to methyl eugenol).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral calli yellow except upper anterior corner fuscous; notopleural calli yellow; mesonotum shining black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad black basal band; wing with a broad fuscous costal band and broad dark fuscous anal streak, a very broad dark fuscous pattern across centre of wing, costal cells dark fulvous, dense microtrichia covering both costal cells; all abdominal terga shining black except fuscous along posterior margin of tergum V.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. biarcuata was described adequately by Drew (1974a) with additional notes on the type by Hardy (1959). It is similar to *B. confluens* (Drew) in possessing a large transverse fuscous blotch across wing, a black mesonotum with lateral postsutural vittae and humeral calli yellow but differs in having a narrow mesopleural stripe (slightly wider than notopleural callus) and abdominal terga uniformly black. *B. retrorsa* has a very similar wing colour

pattern but differs in lacking postsutural vittae and in possessing black humeral calli and colourless costal cells.

Perkins (1939) designated the lectotype of *B. biarcuata* "by inference of holotype", according to Article 74b of the International Code of Zoological Nomenclature.

Bactrocera (Bactrocera) buinensis, n. sp. (Fig. 209)

TYPE SPECIMEN

Holotype ♂, BOUGAINVILLE I.: Buin (0–100 m), October 1971, N.L.H. Krauss.

LOCATION OF TYPE: Holotype (T.10542) in QM.

DISTRIBUTION

Known only from Buin, Bougainville I.

DIAGNOSIS

Small species; facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregular fuscous markings, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (extending midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow with a broad medial longitudinal red-brown to fuscous band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer ½ of second costal cell only; abdominal terga I–V orange-brown with a moderately broad medial longitudinal black band on terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.6 times breadth; fulvous with very pale fuscous spots around orbital bristles; anteromedial hump reduced and covered by a few short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous, medium sized oval black facial spots present; length of face 0.43 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput fulvous, tending black laterally, yellow along eye margins; occipital row with 1–2 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.28 mm; 0.75 mm.

Thorax mesonotum red-brown with irregular dark fuscous patterns between humeral and notopleural calli and inside lateral postsutural vittae. Pleural areas red-brown except fuscous before and behind mesopleural stripe and dark fuscous on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior 5/8 lower hypopleural calli (remainder red-brown); 2 narrow lateral postsutural vittae tapering posteriorly to end well before upper pa. bristles. Medial postsutural vitta absent. Postnotum black except red-brown medially. Scutellum yellow except for a broad medial longitudinal dark fuscous to red-brown band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs fore coxae fulvous, mid and hind coxae red-brown; remainder of segments fulvous except hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 5.3 mm; costal cells fuscous; microtrichia covering outer ½ of second costal cell only; remainder of wings colourless except for a fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening slightly in wing apex to end between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga red-brown except for a moderately broad medial longitudinal band which is dark fuscous on tergum III and black on terga IV and V (this band is discontinuous on the intersegmental lines). A pair of oval red-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. buinensis is similar to *B. daruensis* and *B. enochra* (Drew) in possessing a red-brown mesonotum, scutellum yellow with a medial longitudinal red-brown or fuscous band, humeral and notopleural calli not joined by a lateral yellow band, lateral postsutural vittae present, medial postsutural vitta absent, wings colourless except for costal band and anal streak. It differs from *B. enochra* in having yellow humeral calli and fuscous

costal cells and from *B. daruensis* in having irregular fuscous markings on the mesonotum and lateral postsutural vittae short and ending well before the upper pa. bristles.

Bactrocera (Bactrocera) bullata, n. sp.
(Figs 210–212)

TYPE SPECIMENS

Holotype ♀, PAPUA NEW GUINEA, East Sepik District: Abelam, 8 km SSW of Maprik, bred ex *Garcinia* sp., 19.vii.1980, J. Powell.

Paratypes, PAPUA NEW GUINEA, East Sepik District: 3 ♀♀ and 2 ♂♂, Abelam, 8 km SSW of Maprik, bred ex *Garcinia* sp., 19.vii.1980, J. Powell.

LOCATION OF TYPES: Holotype (T.10543) in QM; 1 paratype in ANIC; 4 paratypes in DPI.

DISTRIBUTION

Known only from Abelam, East Sepik District, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli yellow; mesonotum pale, notopleural calli red-brown; red-brown with a pattern of black markings, mesopleural stripe broad reaching to humeral calli, lateral and medial postsutural vittae present, scutellum yellow; legs entirely fulvous except tending pale fuscous on the basal regions of the hind tibiae; wing with a narrow fuscous costal band and broad fuscous anal streak, infuscation along r–m crossvein, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga I–V orange-brown except for a large oval to circular black spot posterocentrally on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.76 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark facial spots; length of face 0.45 mm. Genae fulvous, subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–6 well developed black bristles. Antennae with all segments fulvous; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.28 mm;0.70 mm.

Thorax mesonotum pale red-brown except glossy black across posterior margin and 2 narrow lateral longitudinal black bands. Pleural areas pale red-brown without dark markings. Yellow markings as follows: humeral calli; broad mesopleural stripe, reaching humeral calli dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli; anterior 4/5 lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae beginning anterior of mesonotal suture and ending behind upper pa. bristles; a moderately broad medial postsutural vitta beginning posterior of prsc. bristles and ending in a point posterior of mesonotal suture. Notopleural calli red-brown. Postnotum red-brown centrally, black laterally. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae fulvous; all other segments fulvous except hind tibiae tending pale fuscous basally; mid tibiae each with an apical black spur.

Wings length 5.8 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening apically between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin, infuscation around dm–cu crossvein; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; no pecten on tergum III. Tergum I and sterna I and II wider than long. All terga orange-brown except for a large circular to oval black spot posterocentrally on tergum V. A pair of oval orange-brown shining spots on tergum V. Visible portion of oviscape orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown. Ratio of length of oviscape to length of tergum V 1.27:1. Apex of piercer narrow and rounded bluntly with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 211). Spicules at distal end of middle segment wide with 11–14 dentations, some broad and elongate and some small (Fig. 212).

MALE: As for female except a small dense aggregation of microtrichia around A_1 + CuA_2; a well developed bulla around A1 + CuA_2; pecten present on abdominal tergum III; posterior lobe of surstylus short, abdominal sternum V with a moderately deep concavity on posterior margin. ATTRACTANT: No known record.

COMMENTS

B. bullata is similar to *B. cheesmanae* (Perkins) and *B. neocheesmanae* in possessing both lateral and medial postsutural vittae but differs from these

species in having a bulla in the male wing, additional infuscation on dm–cu crossvein only, costal cells colourless without microtrichia and mesonotum mostly red-brown.

Bactrocera (Bactrocera) buloloensis, n. sp.
(Fig. 213)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Morobe Province: Namo Banda logging area, Bulolo, collected on *Anthocephalus* sp. leaf, 24.iii.1980, H. Ivagai.
LOCATION OF TYPE: Holotype (T.10544) in QM.

DISTRIBUTION

Known only from Bulolo, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized irregularly oval black facial spots present; humeral and notopleural calli yellow; mesonotum black except dark fuscous on posterior region, mesopleural stripe of medium width (ending midway between anterior margin of notopleural callus and anterior npl. bristle), lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous, microtrichia covering all of second costal cell and most of first costal cell; abdominal terga III–V orange-brown except for a broad medial and 2 broad lateral longitudinal black bands.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.55 mm. Frons of even width, length 1.56 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized irregularly oval black spots; length of face 0.33 mm. Genae fulvous, pale brown subocular spot present; black bristle present. Occiput dark fuscous, yellow along eye margins; occipital row with 3–5 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a well developed fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.25 mm; 0.70 mm.

Thorax mesonotum black except dark fuscous along posterior margin, below and behind lateral postsutural vittae, between humeral and notopleural calli, inside humeral calli. Pleural areas dark fuscous except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including narrow ventral margins black); 2 narrow parallel sided lateral postsutural vittae ending before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; apical ⅓ of all femora dark fuscous, remainder fulvous; fore and hind tibiae dark fuscous, mid tibiae fulvous; apical 4 segments of tarsi fuscous, basal segment fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.9 mm; costal cells pale fuscous; microtrichia covering second costal cell and most of first costal cell; remainder of wings with a pale fuscous tint, fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; no pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad transverse dark fuscous to black band across anterior ½ and expanding to cover lateral margins; terga III–V orange-brown except for a broad medial and 2 broad lateral longitudinal black bands which join along anterior margin of tergum III. A pair of oval fuscous shining spots on tergum V. Visible portion of oviscape red-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Aculeus strongly sclerotized, red-brown, needle shaped at its tip. Ratio of length of oviscape to length of tergum V 1.52:1.

ATTRACTANT: No known record.

COMMENTS

B. buloloensis is similar to *B. congener* in possessing coloured costal cells, mesonotum mostly black and abdominal terga III–V with broad lateral and medial longitudinal black bands. It differs from this species in having dense microtrichia covering second costal cell and outer ½ of first costal cell, lateral postsutural vittae

ending at upper pa. bristles, mesopleural stripe of medium width (ending midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum with narrow basal band and apices of femora fuscous.

Bactrocera (Bactrocera) carbonaria (Hendel), n. comb.

Dacus (Chaetodacus) carbonarius Hendel, 1927b: 61–2.
Dacus (Strumeta) carbonarius: Drew, 1974a: 25.

MATERIAL EXAMINED
None available.
LOCATION OF TYPES: The 4 type specimens in the Hamburg Museum were lost when this museum was destroyed by fire in 1943.

DISTRIBUTION
Known only from New Britain (type locality).

ATTRACTANT: No known record.

COMMENTS
The original description is adequate for placing *B. carbonaria* in the key to species. It is similar to *B. phaleriae* (May) in possessing a uniformly dark coloured scutellum but differs in having the scutellum black (not brown), humeral and notopleural calli black, mesonotum and abdomen entirely black and facial spots present.

Bactrocera (Bactrocera) cheesmanae (Perkins), n. comb. (Fig. 214)

Apodacus cheesemani Perkins, 1939: 26–8.
Dacus (Apodacus) cheesemani: Hardy, 1955b: 428.
Strumeta cheesemani: May, 1963: 37.
Dacus (Strumeta) cheesemani: Drew, 1974a: 25–7.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ in BMNH.

DISTRIBUTION
PREVIOUSLY RECORDED: Widespread in Papua New Guinea (type locality, Kokodo).
NEW RECORD: Torres Strait islands: Yam (record from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; small elongate black facial spots present; humeral and notopleural calli yellow; mesonotum generally fuscous, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae present, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad fuscous transverse band across wing, costal cells fulvous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown with irregular broad fuscous markings on lateral margins of all 3 terga.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. cheesmanae was described adequately by Drew (1974a). It is similar to *B. neocheesmanae* in possessing lateral and medial postsutural vittae and a single transverse fuscous band across wing but differs in having a fuscous mesonotum and abdominal terga III–V orange-brown with broad lateral longitudinal fuscous bands.

This species was named by Perkins in honour of the collector, Lucy Evelyn Cheesman. However, in giving the name *cheesemani*, Perkins misspelt it and gave it a masculine ending. It is here corrected under Article 32(d) of the International Code of Zoological Nomenclature.

Bactrocera (Bactrocera) confluens (Drew), n. comb. (Fig. 215)

Dacus (Asiadacus) confluens Drew, 1971: 35–7.

MATERIAL EXAMINED
Two ♂ paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6931) in QM.

DISTRIBUTION
Bougainville I. (type locality, Daru Village).

DIAGNOSIS
Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, an irregularly shaped broad fuscous band across centre of wing, costal cells dark fulvous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal III–V orange-brown except for a broad medial and 2 broad lateral longitudinal black bands which join along posterior margin of tergum V.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. confluens was described adequately by Drew (1971). It is similar to *B. biarcuata* (Walker) in having the transverse band across the wing as a broad dark fuscous blotch but differs from this species in posessing a broad mesopleural stripe extending to anterior npl. bristle and abdominal

terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal black bands joined along posterior margin of tergum V.

Bactrocera (Bactrocera) congener, n. sp.
(Fig. 216)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 25.iii.1980, P. Daur.

LOCATION OF TYPE: Holotype (T.10545) in QM.

DISTRIBUTION

Known only from the Bulolo area, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; small oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow with broad black basal band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a moderately broad medial and 2 moderately broad lateral longitudinal dark bands connected along anterior marign of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.42 times breadth; fulvous with dark fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex dark fuscous. Face fulvous with small oval black spots; length of face 0.48 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with 5–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.80 mm.

Thorax mesonotum and pleural areas black. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a very small transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs coxae dark fuscous; all other segments fulvous except pale fuscous tint on apical areas of fore femora and basal ⅓ of fore tibiae, dark fuscous hind tibiae; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.1 mm; costal cells fuscous (second cell paler than first); microtrichia in outer corner of second costal cell only; remainder of wings with a pale fuscous tint, fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; ter . free; pecten present on tergum III. Tergum ' nd sterna I and II wider than long. Tergum I black except a very narrow transverse orange-brown band posterocentrally; tergum II orange-brown except dark fuscous anterolateral corners and a broad transverse black band across anterior margin; terga III–V orange-brown except for a broad transverse black band across anterior margin of tergum III, 2 moderately broad lateral longitudinal bands which are black on terga III and IV and dark fuscous on tergum V, a moderately broad medial longitudinal black band over all 3 terga. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. congener is similar to *B. buloloensis* in possessing coloured costal cells, costal band confluent with R_{2+3}, mesonotum mostly black and abdominal terga III–V with medial and lateral longitudinal broad black bands. It differs from this species in having microtrichia in outer corner of second costal cells only, lateral postsutural vittae ending before upper pa. bristles, mesopleural stripe narrow (equal in width to notopleural calli), basal

band on scutellum broad and femora entirely fulvous.

Bactrocera (Bactrocera) curvifera (Walker), n. comb. (Fig. 217)

Dacus curvifer Walker, 1864: 229.
Neodacus curvifer: Perkins, 1939: 21–2.
Dacus (Neodacus) curvifer: Hardy, 1954: 8–10.
Dacus speculifer Walker, 1865: 122; Hardy, 1959: 168, 182 (syn. and lectotype designation).
Dacus (Strumeta) curvifer: Drew, 1974a: 27–30.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: *D. curvifer*, 1 ♂ labelled "type", "Waigiou, A.R. Wallace, 68–4" in BNMH (not a type, see COMMENTS); *D. speculifer*, lectotype ♂ in BMNH.

DISTRIBUTION
Widespread in lowland rainforests of Papua New Guinea and the following islands: Samarai, Goodenough, New Britain, New Ireland and Lihir; type locality, Waigiou I., Irian Jaya.

DIAGNOSIS
Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a very large fuscous blotch across centre of wing and a narrow transverse band across apex of wing, costal cells fulvous with second cell tending paler towards centre, microtrichia in outer corner of second costal cell only; abdominal terga III–V generally dark brown to red-brown with a broad medial longitudinal dark band on tergum V.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. curvifera was described adequately by Drew (1974a). It is similar to *B. seguyi* (Hering) in possessing a black mesonotum with lateral postsutural vittae, 2 transverse fuscous bands across wing (the centre band as a broad irregular blotch) but differs from this species in having a mesopleural stripe that does not extend to the humeral callus, costal cells fulvous and abdominal terga III–V uniformly dark brown.

Hardy (1959) listed the BMNH specimen of *D. curvifer* as the type, but it is a male. Walker (1864) based his description on a female. Because the specimen mentioned by Hardy cannot be the one referred to in the original description, no valid lectotype designation "by inference of holotype" was made. Although the male in BMNH labelled "type" may have been part of the original series, there is no evidence that Walker had it before him when describing *D. curvifer*. Hence this male should not be considered a type. The female used for the description is presumed lost. Hardy (1959) designated the lectotype of *D. speculifer* "by inference of holotype", according to Article 74b of the International Code of Zoological Nomenclature.

Bactrocera (Bactrocera) curvipennis (Froggatt), n. comb. (Figs 218–220)

Dacus curvipennis Froggatt, 1909: 93.
Strumeta curvipennis: Perkins, 1939: 8–9.
Dacus (Strumeta) curvipennis: Drew, 1974a: 30–2.

MATERIAL EXAMINED
Lectotype ♂ and paralectotype ♂, labelled "syntype, New Caledonia, bred ex mandarins, October 1901, coll. Mr Butler"; a series of specimens in DPI (see DISTRIBUTION); 3 ♀♀ in BMNH from Vanuatu (formerly New Hebrides).
LOCATION OF TYPES: Lectotype and paralectotype in NSW.

DISTRIBUTION
PREVIOUSLY RECORDED: New Caledonia (type locality).
NEW RECORD: Vanuatu (formerly New Hebrides): 3 ♀♀ in BMNH labelled "New Hebrides, Aneityum, xi.1930, L.E. Cheesman".

DIAGNOSIS
Small species; very small pale fuscous facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad fuscous band along r–m crossvein, costal cells pale fuscous, microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga III–V orange-brown with a narrow transverse fuscous band along anterior margin of tergum III merging into broad lateral black margins and with anterolateral corners of terga IV and V fuscous.

DESCRIPTION
FEMALE: Ovipositor apex of piercer needle shaped with 2 pairs of subapical bristles (Fig. 219). Spicules at distal end of middle segment of medium width with 4–8 broad dentations of approximately equal length (Fig. 220).
ATTRACTANT: Cue lure.

COMMENTS

B. curvipennis was described adequately by Drew (1974a). It is similar to *B. phaea* (Drew) in possessing infuscation on the r–m crossvein, mesonotum black, scutellum entirely yellow, costal cells coloured and abdominal terga III–V with ground colour orange-brown. It is distinct from *B. phaea* in having the mesopleural stripe not extending to the humeral callus, microtrichia covering second costal cell and outer corner of first costal cell, and abdominal terga III–V orange-brown with a very narrow transverse fuscous band across anterior margin of tergum III which merges into broad lateral black margins and the anterolateral corners of terga IV and V fuscous.

Originally, Froggatt (1909) did not designate a holotype. There are 2 male syntypes (glued side by side together with a pupal case on a card on the same pin) in NSW and I designate the left-hand specimen as lectotype and the other paralectotype.

Bactrocera (Bactrocera) daruensis, n. sp.
(Fig. 221)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western Province: Wyborn's property, Daru I., hand collected in rainforest, 6.vi.1980, R.A.I., Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Western Province: 2 ♂♂, Wyborn's property, Daru I., hand collected in rainforest, 6.vi.1980, R.A.I., Drew and D.W. Currey. TORRES STRAIT: 1 ♂, Murray I., hand collected, 2.v.1984, N. Gough. LOCATION OF TYPES: Holotype (T.10546) in QM; 1 paratype in ANIC; 2 paratypes in DPI.

DISTRIBUTION

Known only from Daru I. (Papua New Guinea) and Murray I. (Torres Strait islands).

DIAGNOSIS

Medium sized species; small irregularly oval black facial spots present; humeral calli yellow; notopleural calli orange-brown; mesonotum red-brown, mesopleural stripe medium sized (reaching to anterior npl. bristle), lateral postsutural vittae very broad and parallel sided, scutellum yellow with a large triangular red-brown marking on dorsal surface; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga I–V orange-brown except for a moderately broad medial longitudinal black band on terga III–V or on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.65 mm. Frons of even width, length 1.52 times breadth; fulvous without dark markings; anteromedial hump covered with a large number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small irregularly oval black spots; length of face 0.45 mm. Genae fulvous, dark subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–8 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.78 mm.

Thorax mesonotum red-brown except for a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; medium sized mesopleural stripe, reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 very broad parallel sided lateral postsutural vittae ending at or just behind upper pa. bristles. Notopleural calli red-brown. Postnotum red-brown. Scutellum yellow except for a large triangular red-brown marking on dorsal surface. Bristles: sc. 2 (scutellar bristles absent in one specimen); prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae fulvous; all other segments fulvous except hind tibiae pale fuscous; rows of pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.5 mm; costal cells fulvous; microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V orange-brown except for a moderately broad medial longitudinal black band either on terga III–V or on terga IV and V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. daruensis is similar to *B. buinensis* in possessing fuscous costal cells, yellow humeral calli, red-brown mesonotum and scutellum yellow with a large dark triangle on dorsal surface but differs from this species in lacking dark markings on mesonotum and lateral postsutural vittae parallel sided and reaching upper pa. bristles.

Bactrocera (Bactrocera) diaphana (Hering), comb. nov. (Fig. 222)

Strumeta diaphana Hering, 1953: 508–9.
Dacus (Strumeta) diaphanus: Drew, 1974a: 32–4.

MATERIAL EXAMINED

Holotype ♀, October 1938, Bernhard Camp, Irian Jaya, J. Olthof.
LOCATION OF TYPE: Holotype in RNH.

DISTRIBUTION

Irian Jaya (type locality, Bernhard Camp).

DIAGNOSIS

Small species; medium sized black facial spots present; humeral calli yellow; posterior ½ of notopleural calli yellow (anterior ½ fuscous); mesonotum red-brown with dark fuscous markings, a broad yellow band running from humeral calli to anterior end of lateral postsutural vittae, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present and beginning anterior to mesonotal suture, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga III–V fulvous with narrow fuscous bands along anterolateral margins of tergum III and narrow pale fuscous lateral margins on terga IV and V and a pale fuscous medial longitudinal band on tergum V.
ATTRACTANT: No known record.

COMMENTS

B. diaphana was described adequately by Drew (1974a). It is similar to *B. ochromarginis* (Drew) in having the humeral and notopleural calli joined by a lateral yellow band, narrow costal band, red-brown mesonotum with medial postsutural vitta absent and lateral postsutural vittae present but differs in possessing the mesopleural stripe not extending to humeral callus, anterior ½ of notopleural calli fuscous and posterior ½ yellow, lateral postsutural vittae beginning anterior to mesonotal suture and microtrichia covering second costal cell and outer corner of first costal cell.

Bactrocera (Bactrocera) diospyri, n. sp. (Figs 223–225)

TYPE SPECIMENS

Holotype ♀, AUSTRALIA, Northern Territory: Smith Point, bred ex *Diospyros maritima*, 24.viii.1978, S. Collins.
Paratypes, AUSTRALIA, Northern Territory: 1 ♂, Smith Point, bred ex *Diospyros maritima*, 24.viii.1978, S. Collins. TORRES STRAIT, Yorke I.: 9 ♀♀ and 6 ♂♂, bred ex *Diospyros maritima*, December 1979, G. Sanewski; 4 ♀♀ and 4 ♂♂, attracted to bacteria lure, 24.iv.1986, J. Turner.
LOCATION OF TYPES: Holotype (T.10547) and 2 paratypes (T.10548–T.10549) in QM; 6 paratypes in ANIC; 2 paratypes in BMNH; 14 paratypes in DPI.

DISTRIBUTION

Known from coastal areas of the Northern Territory (Australia) and the Torres Strait islands: Sue and Yorke.

DIAGNOSIS

Small black species; large subquadrate facial spots present; mesonotum glossy black, humeral and notopleural calli yellow; lateral and medial postsutural vittae absent, mesopleural stripe medium sized (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless, microtrichia covering outer ⅓ of second costal cell only; abdomen generally glossy black.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.83 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with large subquadrate black spots reaching epistoma; length of face 0.5 mm. Genae fulvous, large dark fuscous subocular spot present; black bristle present. Occiput black, yellow along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.75 mm.

Thorax mesonotum and pleural areas glossy black with no brown markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron

as a transverse spot, anterior margin strongly convex dorsally; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black). Lateral postsutural vittae absent. Postnotum glossy black. Scutellum yellow except for moderately broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles weak and black.

Legs all coxae dark fuscous; femora dark fuscous to black except basal ⅔ of hind femora fulvous; fore tibiae pale fuscous, mid tibiae dark fuscous, hind tibiae dark fuscous to black; tarsi fulvous; mid tibiae each with an apical black spur; rows of long black setae on dorsal surfaces of fore femora.

Wings length 4.9 mm; costal cells colourless, microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band just overlapping R_{2+3} and expanding apically before ending between R_{4+5} and M, narrow fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$ absent; supernumerary lobe weak.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Terga I–V glossy black except 2 narrow transverse spots along posterior margin of tergum I, a narrow transverse fulvous band along posterior margin of tergum V and extending as narrow fulvous margins along either side of a medial longitudinal black band. A pair of oval fuscous shining spots on tergum V. Basal segment of ovipositor dark fuscous, dorsoventrally compressed and narrowing posteriorly in dorsal view, aculeus strongly sclerotized and red-brown. Ratio of length of oviscape to length of tergum V 0.61:1. Apex of piercer needle shaped with 3 pairs of subapical bristles (Fig. 224). Spicules at distal end of middle segment of medium width, scale-like with 3–5 very broad indistinct dentations (Fig. 225).

MALE: As for female except a dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development; pecten present on abdominal tergum III; posterior lobe of surstylus short, abdominal sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. diospyri is similar to *B. exspoliata* (Hering) in possessing a black mesonotum, uniformly black abdominal terga, scutellum entirely yellow, humeral and notopleural calli yellow but differs from this species in having costal cells colourless, femora black (except basal ⅔ of hind femora fulvous), fore tibiae fuscous, mid and hind tibiae dark fuscous.

Originally I identified this species as *B. exspoliata* and therefore it was recorded as such by Allwood and Angeles (1979).

Bactrocera (Bactrocera) dyscrita (Drew), comb. nov. (Fig. 226)

Dacus (Strumeta) dyscrita Drew, 1971: 63–5.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6947) in QM.

DISTRIBUTION

New Britain (type locality, Keravat).

DIAGNOSIS

Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with pale fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a broad pale fuscous costal band and anal streak, costal cells pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga uniformly orange-brown.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. dyscrita was described adequately by Drew (1971). It is similar to *B. abdofuscata* (Drew) in possessing colourless wings except for costal band and anal streak, mesonotum red-brown, costal cells colourless with microtrichia in outer corner of second costal cell only, abdominal terga of uniformly pale colouration. It differs from this species in having abdominal terga entirely orange-brown and lateral postsutural vittae ending behind upper pa. bristles.

Bactrocera (Bactrocera) ebenea (Drew), comb. nov. (Fig. 227)

Dacus (Strumeta) ebeneus Drew, 1971: 65–7.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6949) in QM.

DISTRIBUTION

New Caledonia (type locality, Noumea).

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli yellow except anterodorsal corners fuscous; notopleural calli yellow; mesonotum

glossy black, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, entire wing membrane with a diffuse fuscous colouration, costal cells pale fuscous with microtrichia in outer ⅓ of second costal cell only; all abdominal terga glossy black. ATTRACTANT: Methyl eugenol.

COMMENTS

B. ebenea was described adequately by Drew (1971). It is similar to *B. amplexiseta* (May) and *B. pepisalae* (Froggatt) in possessing diffuse infuscation over a large area of the wing membrane but differs from these species in having facial spots and lateral postsutural vittae absent.

Bactrocera (Bactrocera) enochra
(Drew), comb. nov. (Fig. 228)

Dacus (Strumeta) enochrus Drew, 1972b: 207–8.

MATERIAL EXAMINED

A series of paratypes in DPI; 2 ♂♂ in BMNH.
LOCATION OF TYPE: Holotype ♂ (T.6993) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Bougainville I. (type locality, Daru Village) and the Shortland Is (Solomon Islands).
NEW RECORD: Solomon Islands: 2 ♂♂ in BMNH labelled "Korovou, Western Province, Solomon Islands, 11.x.1984, E. Holoie".

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral calli brown; notopleural calli yellow; mesonotum red-brown with broad lateral longitudinal dark fuscous to black bands, mesopleural stripe ending just before anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum red-brown except for narrow lateral yellow margins; wing with a narrow pale fuscous costal band and broad pale fuscous anal streak, costal cells pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga mostly orange-brown with 2 broad lateral longitudinal black bands over terga III–V and a broad medial longitudinal black band over terga II–V which join on tergum V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. enochra was described adequately by Drew (1972b). It is similar to *B. buinensis* and *B. daruensis* in possessing a dark medial longitudinal band on the scutellum and a red-brown mesonotum with dark markings. It differs from these species in having the humeral calli brown and costal cells pale fulvous. It is similar also to *B. trifaria* (Drew) in general body colour patterns but this species has a mesonotum almost entirely black, humeral calli black, scutellum with a medial longitudinal black band, legs and abdominal colour patterns darker and occurs in New Britain.

Bactrocera (Bactrocera) eximia, n. sp.
(Fig. 229)

TYPE SPECIMENS

Holotype ♀, PAPUA NEW GUINEA, Madang Province: Baku, bred ex stem of *Terminalia brassii*, 30.v.1980, D. Skeltion.

Paratypes, PAPUA NEW GUINEA, Madang Province: 1 ♂, Baku, bred ex stem of *Terminalia brassii*, 30.v.1980, D. Skeltion. Central Province: 1 ♀, Sirinumu (500 m), hand collected on bushes, 13.vi.1983, J.W. Ismay.
LOCATION OF TYPES: Holotype (T.10550) in QM; 2 paratypes in DPI (both damaged).

DISTRIBUTION

Known from Madang and Central Provinces, Papua New Guinea.

DIAGNOSIS

Small species; facial spots absent, humeral calli yellow; notopleural calli with anterior ½ black and posterior ½ yellow; mesonotum black, mesopleural stripe very broad reaching humeral callus, lateral and medial postsutural vittae present, scutellum yellow; wing with a narrow fuscous costal band and anal streak, a well developed bulla above anal cell extension in male, costal cells pale fuscous, microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga I–V orange-brown except for narrow black margins on terga III and IV and a broad medial longitudinal black band on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.1 mm. Frons narrowing slightly posteriorly, length 1.69 times breadth; fulvous with fuscous around s.or. bristles and on anteromedial hump, latter covered with a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark facial spots; length of face 0.4 mm. Genae fulvous, without dark subocular spot; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with all segments fulvous; a strong black

dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.18 mm; 0.40 mm.

Thorax mesonotum black except red-brown behind lateral postsutural vittae. Pleural areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; posterior ½ of notopleural calli (anterior ½ black); broad mesopleural stripe, extending to humeral callus dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅓ lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles; a broad medial postsutural vitta beginning behind prsc. bristles and narrowing to a point at line of mesonotal suture. Postnotum black. Scutellum yellow except for narrow black basal band which expands laterally into large spots. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; npl. 2; mpl. 1; scp. 4; all bristles well developed and black.

Legs all coxae fulvous; all other segments fulvous except hind tibiae dark fuscous and apical 4 segments of all tarsi fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.7 mm; costal cells pale fuscous; microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and expanding apically to end at M, a narrow pale fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; no pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V orange-brown except for narrow black margins posterolaterally on tergum III and laterally on tergum IV, a broad medial longitudinal black band on tergum V. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view, aculeus strongly sclerotized, orange-brown, needle shaped at its tip. Ratio of length of oviscape to length of tergum V 1.25:1.

MALE: As for female except a dense aggregaton of microtrichia around $A_1 + CuA_2$; a well developed bulla around $A_1 + CuA_2$; supernumerary lobe very strong; pecten present on abdominal tergum III; posterior lobe of surstylus short, abdominal sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

In *B. eximia*, the short third antennal segment and anal cell extension are similar to characters in the subfamily Trypetinae. However, chaetotaxic and other wing venation characters resemble the subfamily Dacinae.

It is distinct from all other species of the subgenus *Bactrocera* in possessing clear wing membranes, lateral and medial postsutural vittae present and in the antennal segment and wing venation characters already stated.

Bactrocera (Bactrocera) exspoliata (Hering), n. comb. (Fig. 230)

Strumeta exspoliata Hering, 1941b: 54–5.
Dacus (Strumeta) exspoliatus: Drew, 1974a: 37–9.

MATERIAL EXAMINED

Holotype ♂, Kapakapa, Central District, Papua New Guinea, June 1891, L. Loria.
LOCATION OF TYPE: Holotype in HNHM.

DISTRIBUTION

Kapakapa, Central District, Papua New Guinea (type locality).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching anterior npl. bristle, lateral and medial and postsutural vittae absent, a yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow with a black basal band of medium width; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fulvous (second costal cell paler), microtrichia in outer ½ of second costal cell only; all abdominal terga entirely black.
ATTRACTANT: No known record.

COMMENTS

B. exspoliata was described adequately by Drew (1974a). It is similar to *B. diospyri* in possessing a black mesonotum without lateral and medial postsutural vittae, scutellum yellow, humeral and notopleural calli yellow and abdominal terga uniformly black but differs in having coloured costal cells (pale fulvous) and legs fuscous except fore tibiae fulvous.

Bactrocera (Bactrocera) facialis (Coquillett), n. comb. (Figs 231–233)

Dacus facialis Coquillett, 1910: 12–13.

Dacus tongensis Froggatt, 1910: 870–1; Malloch, 1931: 263; Perkins, 1939: 9–11 (syn.).
Chaetodacus facialis: Bezzi, 1928: 104.
Strumeta facialis: Perkins, 1939: 9–11 (lectotype designation, as *fascialis*, lapsus).
Dacus (*Strumeta*) *facialis*: Drew, 1974a: 39–41.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); 1 ♀ in BMNH labelled "Tonga, 11.10.67, W.A. Apt, reared from *Capsicum*"; 32 specimens in BMNH labelled "Tonga, Tongatapu, Tokomololo, 2.x.1975, T. Langi, reared from *Citrus maxima*".

LOCATION OF TYPES: *D. facialis*, lectotype ♂ (No. 12737), 2 ♂ and 3 ♀ paralectotypes in NMNH; *D. tongensis*, unknown.

DISTRIBUTION

Known from Tongatapu I. and the Ha'apai Group, Tonga (type locality).

DIAGNOSIS

Small species; facial spots absent; humeral and notopleural calli yellow; mesonotum dark fuscous to black, meseopleural stripe reaching almost to humeral callus, narrow short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and narrow pale fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a moderately broad medial longitudinal fuscous to black band over all 3 terga, broad lateral fuscous to black margins on tergum III and anterolateral corners of terga IV and V.

DESCRIPTION

FEMALE: Ovipositor apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 232). Spicules at distal end of middle segment of medium width with 6–9 dentations of approximately even size (Fig. 233). ATTRACTANT: Cue lure.

COMMENTS

B. facialis was described adequately by Drew (1974a). It is similar to *B. mucronis* (Drew) in possessing colourless wings except for costal band and anal streak, black mesonotum, abdomen orange-brown with dark markings and very short lateral postsutural vittae. It differs from this species in having broad black lateral margins on abdominal tergum III and anterolaterally on terga IV and V, a moderately broad medial longitudinal black band on terga III–V and lateral postsutural vittae very short and narrow and ending at level of sa. bristles.

Originally, Coquillett listed the material studied as "Two male and four female specimens, bred from guavas. Type No.12737, U.S. National Museum". I have examined 3 including that labelled type by Coquillett. The remaining 3 types are in NMNH. Dr Allen Norrbom (NMNH, pers. comm.) advised that some confusion surrounds the Coquillett types as to whether or not holotypes were designated in the cases where more than 1 specimen was involved. The specimen labelled type was later labelled lectotype by G. Steyskal because of the description of this specimen by Greene, personally communicated to and published by Perkins (1939). I am treating this specimen as the lectotype (designated by Perkins, "by inference of holotype" according to Article 74b of the International Code of Zoological Nomenclature) and the remaining specimens as paralectotypes. According to Norrbom (pers. comm.) there are 3 male and 3 female types.

Bactrocera (Bactrocera) froggatti (Bezzi), n. comb. (Fig. 234)

Chaetodacus froggatti Bezzi, 1919: 413. New scientific name (see International Code of Zoological Nomenclature page 259) for *Dacus zonatus* of Froggatt, 1910: 868–9, nec *zonatus* Saunders (1841).
Dacus zonatus: Froggatt (nec. Saunders), 1910: 868–9 (misidentification).
Dacus froggatti: Malloch, 1939a: 241–2.
Strumeta froggatti: Perkins, 1939: 15–16 (lectotype designation).
Dacus (*Strumeta*) *froggatti*: Hardy and Adachi, 1954: 169–71; Drew, 1974a: 45–7.

MATERIAL EXAMINED

A large series of specimens (including paralectotypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Lectotype ♂ in ANIC (Drew, 1974a).

DISTRIBUTION

Known from the following islands: Banika (type locality), Guadalcanal, Gizo, Russell, Shortland (Solomon Islands) and Bougainville.

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural callus yellow; mesonotum dull black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, costal cells fulvous (outer costal cell paler), microtrichia in outer corner of second costal cell only; abdominal terga III–V

fulvous with a broad medial and 2 broad lateral longitudinal black bands over all 3 terga.
ATTRACTANT: Methyl eugenol.

COMMENTS

B. froggatti was described adequately by Drew (1974a). It is similar to the species in the *bryoniae* complex in possessing colourless wings except for costal band and anal streak, costal band broad (confluent with R), mesonotum black with lateral postsutural vittae present and medial postsutural vitta absent but differs in having abdominal terga III–V fulvous with distinct broad medial and lateral longitudinal black bands not meeting along anterior margin of tergum III and males attracted to methyl eugenol.

Froggatt (1910) misidentified specimens from Solomon Islands as *Dacus zonatus* Saunders when publishing a description. Bezzi (1919) recognised Froggatt's misidentification and renamed the specimens *Chaetodacus froggatti*. The name *froggatti* is here accepted as a new scientific name under the definition of this term in the Glossary of the International Code of Zoological Nomenclature. The specimens used by Froggatt are regarded as valid types of this species.

Bactrocera (Bactrocera) furvescens, n. sp.
(Fig. 235)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 15.iv.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, 18.ii.1980 and 1 ♂, 22.ii.1980, Upper Stony logging area, Bulolo, P. Daur; 1 ♂, Mt Missim (1250 m), 9.iv.1981, A. Allison. Western Highlands District: 1 ♂, 23.vi.1978; 1 ♂, 5.x.1978; 1 ♂, 6.xi.1978; 1 ♂ ,8.ix.1980; 1 ♂, 22.ix.1980; 1 ♂, 23.ix.1980; 1 ♂, 28.x.1980; 2 ♂♂, 17.iii.1981; Kuk Agricultural Research Institute, Mt Hagen, B. Thistleton. All above paratypes collected at cue lure. SOLOMON IS, Guadalcanal I.: 1 ♂, Honiara, December 1971, N.L.H. Krauss.

LOCATION OF TYPES: Holotype (T.10551) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 9 paratypes in DPI.

DISTRIBUTION

Known from the Morobe Province and Western Highlands District, Papua New Guinea and Honiara (Solomon Islands).

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral calli fuscous; notopleural calli yellow; mesonotum black tending dark fuscous posteriorly, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), scutellum yellow with a narrow black basal band; wing with a narrow fuscous costal band and a broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V generally dark fuscous to black tending dark fulvous posterocentrally on tergum IV and centrally on tergum V, either side of a medial longitudinal fuscous band.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized oval black spots; length of face 0.4 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput pale fuscous, yellow along eye margins; occipital row with 6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.78 mm.

Thorax mesonotum black tending dark fuscous posterocentrally and brown below and behind lateral postsutural vittae. Pleural areas dark fuscous except dark red-brown below humeral calli. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including ventral margins black); 2 lateral postsutural vittae of medium width and narrowing posteriorly to end at upper pa. bristles. Humeral calli fuscous. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl.1; npl. 2; scp. 4; all bristles well developed and dark fuscous to black.

Legs all segments fulvous except fore tibiae pale fuscous and hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.3 mm; costal cells colourless; microtrichia in outer corner of second costal cell

only; remainder of wings colourless except for a fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5}, and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous except for a narrow fulvous line along posterior margin but not reaching lateral margins; tergum II fulvous except for a transverse fuscous band across anterior ½ and widening to reach lateral margins; terga III–V dark fuscous to black except dark fulvous posterocentrally on tergum IV, fulvous centrally on tergum V each side of a short medial longitudinal fuscous band on posterior area of tergum IV and anterior ½ of tergum V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. furvescens is similar to *B. neohumeralis* (Hardy) in possessing dark fuscous to black mesonotum and abdominal terga, wings colourless except for costal band and anal streak, notopleural calli yellow, medial postsutural vitta absent and lateral postsutural vittae present but differs in having the mesonotum black (not dark fuscous) and colourless costal cells without dense microtrichia.

Bactrocera (Bactrocera) hispidula (May), n. comb. (Fig. 236)

Strumeta hispidula May, 1957b: 301–3; May, 1963: 50.

MATERIAL EXAMINED

Holotype ♀, Atherton, north Queensland, 23.iv.1956, A.W.S. May; 1 ♂ labelled allotype, Atherton, north Queensland, 10.iv.1959, A.W.S. May.

LOCATION OF TYPE: Holotype (T.5595) in QM.

DISTRIBUTION

Atherton, Queensland (type locality).

DIAGNOSIS

Small species; facial spots absent; humeral calli yellow; notopleural calli fuscous; mesonotum orange-brown with dark fuscous to fuscous markings, mesopleural stripe broad reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak and narrow infuscation enclosing dm–cu crossvein, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga I–V uniformly orange-brown without dark markings.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.2 mm. Frons of even width, length 1.75 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous without dark spots; length of face 0.43 mm. Genae fulvous, pale brown subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 1–3 dark bristles. Antennae with all segments fulvous; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.25 mm; 0.58 mm.

Thorax mesonotum orange-brown except with a dark fuscous pattern on posterior margin, fuscous between humeral and notopleural calli and inside humeral calli. Pleural areas orange-brown except fuscous on sternopleuron and behind mesopleural stripe. Yellow markings as follows: humeral calli; broad mesopleural stripe, reaching humeral callus dorsally, not continuing to sternopleuron, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior ¾ lower hypopleural calli (remainder fuscous); 2 parallel sided lateral postsutural vittae ending at upper pa. bristles. Notopleural calli fuscous. Postnotum red-brown to fuscous. Scutellum yellow except for narrow dark fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae fulvous; femora fuscous to dark fuscous except basal ⅓ of hind femora fulvous; fore tibiae fulvous, mid tibiae fulvous except basal ⅓ fuscous, hind tibiae fuscous; tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.7 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening slightly beyond extremitiy of this vein to end between extremities of R_{4+5} and M, narrow infuscation enclosing dm–cu crossvein, broad fuscous anal streak ending before wing margin; dense aggregation of

microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V uniformly orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Apex of piercer with 3 pairs of subapical lobes (Fig. 236A). Ratio of length of oviscape to length of tergum V 0.91:1.

ATTRACTANT: No known record.

COMMENTS

Originally, May (1957b) designated a female holotype. A male in QM labelled allotype was designated by May (1962a) but this cannot be considered a type as it was not part of the original series.

B. hispidula is similar to *B. laticaudus* (Hardy) in possessing infuscation on wing on 1 crossvein, scutellum entirely yellow and mesonotum pale coloured but differs in having the mesonotum and abdominal terga generally orange-brown, notopleural calli fuscous, infuscation on dm–cu crossvein and costal cells colourless.

Bactrocera (Bactrocera) honiarae, n. sp. (Fig. 237)

TYPE SPECIMEN

Holotype ♂, SOLOMON IS: Honiara, Guadalcanal I., March 1986, N.L.H. Krauss.

LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Known only from Honiara, Solomon Islands.

DIAGNOSIS

Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with fuscous colouration over most of membrane, a broad fuscous costal band and anal streak, costal cells fuscous, microtrichia covering second and most of first costal cell; abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal black bands joining on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 2.3 mm. Frons of even width, length 1.53 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter prominent and covered with a large number of short black setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large circular black spots; length of face 0.68 mm. Genae fulvous, dark fuscous subocular spot present; black bristle present. Occiput fulvous, pale fuscous dorsally, yellow along eye margins; occipital row with 9–10 strong dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.34 mm; 0.55 mm; 1.1 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae and around mesonotal suture. Pleural areas black except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/8 lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae narrowing posteriorly to end before upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl.1; npl.2; scp.3; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae dark fuscous; all other segments fulvous except hind tibiae pale fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 8.6 mm; costal cells fuscous; dense microtrichia covering second costal cell and most of first costal cell; remainder of wings with fuscous over most of membrane (darker across centre region) and with a broad fuscous costal band and anal streak; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black except orange-brown across posterior margin; tergum II orange-brown except for a small black spot anterocentrally and fuscous on anterolateral corners; terga III–V orange-brown

except for a broad medial and 2 broad lateral longitudinal black bands joining across most of tergum V. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS
B. honiarae is similar to *B. pepisalae* (Froggatt) in being a large species and having most of the wing infuscated, a black mesonotum, broad lateral postsutural vittae, yellow humeral and notopleural calli and scutellum. It differs from *B. pepisalae* in possessing microtrichia over both costal cells, different fuscous patterns on the wings and abdominal terga III–V with a unique pattern of medial and lateral longitudinal black bands joined across most of tergum V.

Bactrocera (Bactrocera) humilis
(Drew and Hancock), n. comb. (Fig. 238)

Dacus (Bactrocera) humilis Drew and Hancock, 1981: 68–70.

MATERIAL EXAMINED
Holotype ♂, 4 km E of Lockerbie, Cape York Peninsula, Queensland, 30.i-4.ii.1975, G.B. Monteith.
LOCATION OF TYPE: Holotype (T.8262) in QM.

DISTRIBUTION
Lockerbie, Queensland (type locality).

DIAGNOSIS
Small species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, first costal cell pale fulvous, second costal cell fulvous, microtrichia covering second costal cell and around margins of first costal cell; abdominal terga III–V fulvous with broad lateral longitudinal fuscous to red-brown bands over all 3 terga and a narrow indefinite medial longitudinal pale red-brown band on terga III and IV.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. humilis was described adequately by Drew and Hancock (1981). It is similar to species in the *tryoni* complex in possessing a red-brown mesonotum, dense microtrichia covering costal cells, facial spots present, abdominal terga pale coloured with darker markings. It differs from these species in being a very small species and in having costal cells fulvous and abdominal terga III–V with broad lateral longitudinal fuscous to red-brown bands.

Bactrocera (Bactrocera) ismayi, n. sp.
(Fig. 239)

TYPE SPECIMENS
Holotype ♂, NEW IRELAND: Lelet Plateau, 3–5.xi.1981, J.W. Ismay.
Paratype, NEW IRELAND: Lelet Plateau, 3–5.xi.1981, J.W. Ismay.
LOCATION OF TYPES: Holotype (T.10552) in QM; paratype in DPI.

DISTRIBUTION
Known only from New Ireland.

DIAGNOSIS
Medium sized dark coloured species; large oval black facial spots present; humeral calli yellow (dorsal and anterior margins black); notopleural calli black; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae very narrow and ending at level of lower pa. bristles, medial postsutural vitta absent, scutellum yellow with a broad medial longitudinal black band; wing with a narrow dark fuscous costal band and broad dark fuscous anal streak, a broad wedge shaped dark fuscous band across centre of wing from costal band and enclosing r–m crossvein, a broad Z-shaped dark fuscous band across wing; abdominal terga I–V black without pale markings.

DESCRIPTION
MALE: Head generally dark fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.65 times breadth; dark fulvous with black extending from the vertex down to the s.or. bristles; anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fulvous. Ocellar triangle black. Vertex black. Face dark fulvous with large oval black spots; length of face 0.5 mm. Genae dark fulvous, black subocular spot present; black bristle present. Occiput black, dark fulvous along eye margins; occipital row with 6 well developed black bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 dark fulvous with black on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (dark fulvous basally); length of segments: 0.20 mm; 0.38 mm; 0.90 mm.

Thorax mesonotum and pleural areas black without pale markings. Yellow markings as follows: humeral calli (except anterior and dorsal margins black); medium sized mesopleural stripe, ending midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 very narrow lateral postsutural vittae beginning posterior to mesonotal suture and ending at level of lower pa. bristles. Notopleural calli black. Medial postsutural vitta absent. Postnotum black. Scutellum yellow except for a broad medial longitudinal black band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae dark fuscous, mid and hind coxae black; fore femora with basal ½ fulvous, apical ½ and lateral and ventral margins dark fuscous to black; mid femora black; hind femora with basal ½ fulvous, apical ½ black; fore and mid tibiae fuscous, hind tibiae dark fuscous; fore tarsi with basal segment fulvous, apical 4 segments fuscous, mid and hind tarsi with basal segments fulvous, apical 4 segments dark fulvous; mid tibiae each with an apical black spur.

Wings length 6.2 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except dark fuscous subcostal cell, narrow dark fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad wedge shaped dark fuscous band running from costal band to enclose r–m crossvein, a broad Z-shaped dark fuscous band across wing, a broad dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V black without pale markings. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. ismayi is similar to *B. reclinata* in possessing a large black marking on dorsal surface of scutellum, a black mesonotum and dark fuscous patterns across wing but differs in having a large wedge shaped band covering r–m crossvein and a broad Z-shaped band across the wing.

This species is named after Dr John W. Ismay who has made an outstanding contribution in collecting Diptera in Papua New Guinea.

Bactrocera (Bactrocera) kirki
(Froggatt), n. comb. (Figs 240–242)

Dacus kirki Froggatt, 1910: 871.
Strumeta kirki: Perkins, 1939: 20–1.
Dacus (*Strumeta*) *kirki*: Drew, 1974a: 50–3.

MATERIAL EXAMINED

Lectotype ♀, paralectotype ♀; large series of specimens in DPI (see DISTRIBUTION); 12 specimens in BMNH labelled "Tonga, Tongatapu, Veitonga, 28.v.1976, T. Langi, bred from *Terminalia catappa*"; 4 ♂♂ in BMNH from Austral Is.

LOCATION OF TYPES: Lectotype in NSW, paralectotype in BMNH.

DISTRIBUTION

PREVIOUSLY RECORDED: Widespread in the South Pacific islands: Western Samoa, American Samoa, Tonga, Niue and Tahiti; type locality unknown.

NEW RECORD: Austral Is: 4 ♂♂ in BMNH labelled "Austral Is, Tubuai, Mahu, 0-60 m, iii.1977, N.L.H. Krauss".

DIAGNOSIS

Medium sized species; large black facial spots present; humeral calli yellow (anterodorsal margins black); notopleural calli yellow; mesonotum glossy black, mesopleural stripe slightly wider than notopleural callus, lateral and medial postsutural vittae absent, scutellum glossy black with extreme lateral margins yellow; wing with a narrow pale fuscous costal band and narrow fuscous anal streak, a narrow pale fuscous tinge around r–m and dm–cu crossveins, costal cells with extremely pale fuscous tinge and microtrichia in outer ½ of second costal cell only; abdominal terga glossy black except for 2 longitudinal orange-brown bands over terga II–V either side of a broad medial longitudinal glossy black band.

DESCRIPTION

FEMALE: Ovipositor apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 241). Spicules at distal end of middle segment of medium width with 4–5 broad triangular dentations of uneven length (Fig. 242).

HOST PLANTS

NEW RECORD: *Terminalia catappa* (Combretaceae).

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. kirki was described adequately by Drew

(1974a). It is similar to *B. setinervis* (Malloch) in having lateral and medial postsutural vittae absent, scutellum yellow with a black triangle on dorsal surface and humeral calli yellow but differs in possessing facial spots and yellow notopleural calli.

There is one female in NSW labelled "*Dacus kirki* Froggatt, New Zealand, CO-TYPE" and one female in BMNH labelled "Cotype, *D. kirki*, 1910", "Peaches, Kirk 1904, New Zealand". No holotype was designated by Froggatt (1910) and I designate the female in NSW as lectotype and the female in BMNH paralectotype.

Bactrocera (Bactrocera) lampabilis (Drew), n. comb. (Fig. 243)

Dacus (Strumeta) lampabilis Drew, 1971: 67–9.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6950) in QM.

DISTRIBUTION

New Britain (type locality, Salelubu) and Lihir I.

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching humeral callus, short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a triangular shaped glossy black marking on dorsal surface; wing with a broad fuscous costal band and anal streak, a broad transverse fuscous band across centre of wing and a narrower transverse fuscous band across apex, costal cells colourless (second costal cell with outer ⅓ fuscous), microtrichia covering outer ⅓ of second costal cell only; all abdominal terga entirely glossy black except for a small dark fulvous area across posterior margin of tergum V.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. lampabilis was described adequately by Drew (1971). It is similar to *B. longicornis* Macquart in possessing 2 distinct transverse fuscous bands across wing, black mesonotum and scutellum yellow with a black triangle on dorsal surface. It differs from this species in having a broad mesopleural stripe extending to humeral callus, neither of the transverse fuscous bands across wing recurved back from the hind margin and lateral postsutural vittae broad and ending at level of sa. bristles.

Bactrocera (Bactrocera) laticaudus (Hardy), n. comb. (Figs 244–246)

Not *Dacus fuscatus* Wiedemann, 1819: 28.

Strumeta fuscatus Perkins and May, 1949: 5–7; May, 1963:50.

Dacus (Strumeta) laticaudus Hardy, 1950: 87–9, 1951: 159, 1952: 365.

MATERIAL EXAMINED

Two specimens of *S. fuscatus* both labelled holotype: lectotype ♀ (T.5248), Cairns, Queensland, 12.ix.1937, F.A.Perkins, bred from *Sideroxylon obovatum*; paralectotype ♂ (T.5247), Cairns, Queensland, 12.ix.1937, F.A. Perkins, bred from *Sideroxylon obovatum*; remainder of type series of *S. fuscatus* in UQ; a series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPES: *D. laticaudus*, holotype ♂ in NMNH; *S. fuscatus*, lectotype (T.5248) and 1 paralectotype (T.5247) in QM, 72 paralectotypes in UQ.

DISTRIBUTION

Restricted to coastal rainforests of north Queensland; type locality, near Deeral, Queensland (see Hardy, 1952).

DIAGNOSIS

Small to medium sized species; large oval black facial spots present; humeral and notopleural calli yellow; mesonotum uniformly dark fuscous, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band (almost confluent with R_{4+5}) and a broad fuscous anal streak, costal cells very pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V dark fuscous to dull black tending fuscous along posterior margin of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.67 times breadth; fulvous with, at most, pale fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with very large oval black spots; length of face 0.5 mm. Genae fulvous, dark fuscous subocular spot present; red-brown bristle present. Occiput dark fuscous, fulvous along eye margins; occiptial row with 4–7 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum and pleural areas uniformly dark fuscous. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing posteriorly to end at or just before upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow dark fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all coxae dark fuscous; fore femora fulvous with apical ⅓ pale fuscous, mid femora fulvous with apical ½ fuscous, hind femora fulvous with apical ⅓ fuscous; fore tibiae pale fuscous tending fulvous apically, mid tibiae fulvous, hind tibiae fuscous; all tarsal segments fulvous except apical 4 segments of fore tarsi pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.1 mm; costal cells very pale fuscous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, narrow fuscous band enclosing r–m crossvein, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown except for a broad transverse dark fuscous band along anterior margin and widening to cover lateral margins; terga III–V dark fuscous to dull black except fuscous along posterior margin of tergum V. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment fuscous, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.58:1. Apex of piercer tapering sharply to a point from line of subapical bristle and with 3 pairs of subapical bristles (Fig. 245). Spicules at distal end of middle segment of medium width with a range from 2 large dentations up to 6 dentations of variable size (Fig. 246).
ATTRACTANT: Methyl eugenol.

COMMENTS

B. laticaudus is similar to *B. hispidula* (May) in possessing a pale coloured mesonotum, yellow scutellum and infuscation on 1 crossvein but differs from this species in having notopleural calli yellow, mesonotum and abdominal terga mostly dark fuscous, r–m crossvein infuscated and costal cells pale fuscous.

Although *Dacus laticaudus* Hardy is a synonym of *Strumeta fuscatus* Perkins and May, Hardy (1951) noted that the name *fuscatus* was preoccupied in *Dacus* by *D. fuscatus* Wiedemann (1819) and therefore proposed *D. laticaudus* as the available name. A name rejected before 1961 as a secondary homonym cannot be restored and so *laticaudus* is here retained under *Bactrocera* even though *fuscatus* has seniority (see Article 59b of the International Code of Zoological Nomenclature).

Originally, Perkins and May (1949) did not define type specimens, only stating that the species was described from a series of over sixty specimens, bred from fruits of *Sideroxylon obovatum* collected at Cairns in August and September, 1937. The 2 specimens labelled holotype in QM (1 male and 1 female) and 72 in UQ are part of the type series. I designate the female specimen (T.5248 in QM) as lectotype and the remaining 73 specimens paralectotypes.

Bactrocera (Bactrocera) lineata (Perkins), n. comb. (Fig. 247)

Strumeta lineata Perkins, 1939: 16–17.
Dacus (Strumeta) lineatus: Drew, 1974a: 53–5.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); Perkins' type specimens.
LOCATION OF TYPES: Lectotype ♀ and paralectotype ♂ in BMNH.

DISTRIBUTION

Widespread in lowland rainforests of Papua New Guinea (type locality, Kokodo) but does not occur in nearby islands.

DIAGNOSIS

Medium sized species; large black facial spots present; humeral calli fuscous to dark fuscous; notopleural calli yellow; mesonotum shining black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, short narrow lateral postsutural vittae

present, medial postsutural vitta absent, scutellum yellow with a broad black basal band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless, microtrichia covering most of second costal cell and outer corner of first costal cell; abdominal terga mostly black except tending red-brown along posterior margin of tergum V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. lineata was described adequately by Drew (1974a). It is similar to species in the *anthracina* and *nigella* complexes in possessing a black mesonotum with lateral postsutural vittae, abdominal terga mostly black, wings colourless with costal band and anal streak but differs in having black humeral calli.

Originally, Perkins (1939) did not designate a holotype. The species was described from one male and one female and both have printed holotype labels. I have studied these specimens and designate the female as lectotype and the male paralectotype.

Bactrocera (Bactrocera) longicornis Macquart (Fig. 248)

Bactrocera longicornis Macquart, 1835: 452–3.
Dacus (Bactrocera) longicornis: Hardy, 1976: 245–9.
Dacus (Strumeta) denigratus Drew, 1971: 61–3; Hardy, 1976: 246 (syn.).

MATERIAL EXAMINED
A large series of specimens (including 1 paratype of *D. denigratus*) in DPI (see DISTRIBUTION).
LOCATION OF TYPES: *B. longicornis*, holotype ♂ in MNHN; *D. denigratus*, holotype ♂ (T.6946) in QM.

DISTRIBUTION
Known from New Ireland, Lihir I. and Bougainville I.; type locality, Gagi I. (Solomon Islands).

DIAGNOSIS
Medium sized species; large oval facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a black triangular marking on dorsal surface; wing with a broad fuscous costal band and anal streak, a broad fuscous recurved band across centre of wing and a narrow fuscous band across apex, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga mostly black except orange-brown across posterior margin of tergum V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. longicornis was described adequately by Drew (1971) as *Dacus denigratus*. This species is similar to *B. lampabilis* (Drew) in possessing 2 transverse fuscous bands across the wing, black mesonotum and a large black triangle on dorsal surface of scutellum but differs in having the mesopleural stripe not extending to humeral callus, the transverse fuscous band across centre of wing recurved back along M_{3+4} and the lateral postsutural vittae narrow and ending before the upper pa. bristles.

Bactrocera (Bactrocera) luteola (Malloch), n. comb. (Fig. 249)

Dacus luteola Malloch, 1931: 262.
Dacus incertus Malloch, 1938: 113–5; Drew, 1974a: 55 (syn.).
Dacus (Strumeta) luteolus: Drew, 1974a: 55–7.

MATERIAL EXAMINED
Holotype ♂ of *D. luteolus* and paratype ♂ of *D. incertus*.
LOCATION OF TYPES: *D. luteolus*, holotype ♂ in BMNH; *D. incertus*, holotype ♂, 4 ♀ and 3 ♂ paratypes in BPBM; 4 paratypes in NMNH.

DISTRIBUTION
Known from Bora Bora I., Society Is (type locality) and Hao I. (Tuamotu Archipelago).

DIAGNOSIS
Medium sized species; facial spots absent; humeral calli yellow; notopleural calli shining orange-brown; mesonotum shining orange-brown without dark markings, mesopleural stripe reaching to humeral callus, lateral and medial postsutural vittae absent, scutellum yellow with a broad orange-brown basal band; wing with a narrow fuscous costal band, anal streak absent, pale infuscation around r–m and dm–cu crossveins, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V shining orange-brown with oval fuscous spots on anterolateral corners of tergum III and small circular fuscous spots centrally on anterior margins of terga IV and V.
ATTRACTANT: No known record.

COMMENTS
B. luteola was described adequately by Drew (1974a). It is similar to *B. mendosa* in possessing a red-brown mesonotum, yellow humeral calli, lateral and medial postsutural vittae absent but

differs from this species in having costal cells colourless, notopleural calli shining orange-brown, mesopleural stripe reaching humeral callus, scutellum entirely yellow, triangular yellow marking along mesonotal suture absent.

Bactrocera (Bactrocera) melanogaster, n. sp. (Fig. 250)

TYPE SPECIMENS

Holotype ♂, SOLOMON IS: Lunga, Guadalcanal I., attracted to methyl eugenol, 15.i.1970, J.H. Stapley.

Paratype, BOUGAINVILLE I.: 1 ♂, Buin, Dec. 1971, N.L.H. Krauss.

LOCATION OF TYPES: Holotype (T.10553) in QM; paratype in DPI.

DISTRIBUTION

Known from Bougainville I. and the Solomon Islands.

DIAGNOSIS

Medium sized species; very large oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, medium sized mesopleural stripe reaching just anterior to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and broad fuscous anal streak; abdominal terga I–V dark shining black except for orange-brown margins posterolaterally on tergum II.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.55 mm. Frons narrowing slightly posteriorly, length 1.67 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered with a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with very large oval black facial spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with 5–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a strong black dorsal bristle on segment 2; length of segments: 0.23 mm; 0.29 mm.

Thorax mesonotum and pleural areas shining black without pale markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, extending just anterior to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing sharply posteriorly to end just behind sa. bristles. Postnotum black. Scutellum yellow except for a broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae black; apical ½ of fore and hind femora and apical ⅔ of mid femora black (remainder fulvous); fore tibiae pale fuscous, mid tibiae fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.1 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, pale fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous band enclosing r–m crossvein, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V shining black except for 2 broad transverse dark orange-brown bands posterolaterally on tergum II. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. melanogaster is similar to *B. neonigrita* in possessing colourless costal cells, abdominal terga III–V mostly black, mesonotum black, scutellum entirely yellow and infuscation on 1 crossvein but differs from this species in having short lateral postsutural vittae narrowing to end well before upper pa. bristles.

Bactrocera (Bactrocera) melanotus (Coquillett), n. comb. (Figs 251–253)

Dacus melanotus Coquillett, 1910: 13.

Dacus rarotongae Froggatt, 1910: 872; Perkins, 1939: 11 (syn.).

Chaetodacus melanotus: Bezzi, 1928: 104–5.

Strumeta melanotus: Perkins, 1939: 11.

Dacus (*Strumeta*) *melanotus*: Drew, 1974a: 57–9.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); 2 of Coquillett's types.

LOCATION OF TYPES: *D. melanotus*, lectotype ♂, 1 ♂ and 1 ♀ paralectotype in NMNH; *D. rarotongae*, unknown.

DISTRIBUTION

Restricted to the Cook Is (type locality).

DIAGNOSIS

Medium sized species; facial spots absent or small and pale; humeral calli yellow (anterolateral corners black); notopleural calli glossy black; mesonotum glossy black, mesopleural stripe reaching to humeral callus, lateral and medial postsutural vittae absent, scutellum glossy black; wing with a narrow pale fuscous costal band and narrow fuscous tint in anal cell, narrow pale fuscous markings along r–m and dm–cu crossveins, costal cells colourless or with a very pale fuscous tint, microtrichia in outer corner of second costal cell only; all abdominal terga entirely glossy black.

DESCRIPTION

FEMALE: Ovipositor apex of piercer needle shaped with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 252). Spicules at distal end of middle segment of medium width with 6–10 triangular dentations of uneven length (Fig. 253). ATTRACTANT: Cue lure. Earlier records of attraction to methyl eugenol (Drew 1974a, 1974b) are incorrect (Bateman 1985).

COMMENTS

B. melanotus was described adequately by Drew (1974a). It is similar to *B. atra* (Malloch) and *B. perfusca* (Aubertin) in possessing an entirely black scutellum, mesonotum black with medial and lateral postsutural vittae absent, abdominal terga black but differs from these species in having infuscation around r–m and dm–cu crossveins. In addition, it can be separated from *B. atra* in having humeral calli mostly yellow, yellow mesopleural stripe and black femora.

In the original description, Coquillett listed the material studied as follows. "Two males and one female bred from oranges. Type No. 12739, U.S. National Museum". Confusion surrounds the Coquillett types with regard to holotype designation (see note under *B. facialis*). I have received 2 specimens for study and designate the male labelled "Type No. 12739 USNM" by Coquillett as lectotype and the remaining specimens as paralectotypes.

Bactrocera (Bactrocera) mendosa (May), n. comb. (Figs 254–256)

Strumeta mendosa May, 1957b: 303–4; May, 1963: 50.

MATERIAL EXAMINED

Holotype ♀, Atherton, Queensland, 18.vi.1956, A.W.S. May; a series of specimens bred from *Pouteria sericea*, 30 km N of Mataranka, Northern Territory, 26.v.1976, A. Allwood.

LOCATION OF TYPE: Holotype (T.5594) in QM.

DISTRIBUTION

Known only from Mataranka (Northern Territory) and Atherton, Queensland (type locality), associated with endemic forest areas.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow with a fuscous spot on apex; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous with microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown except for a broad transverse red-brown band across anterior ⅓ of tergum III which widens on lateral margins of that tergum.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.74 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by large number of short dark setae; orbital bristles black: 1 s.or., 2–3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.55 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–7 well developed black bristles. Antennae with all segments fulvous; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.16 mm; 0.30 mm; 0.85 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a very small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); a small triangular marking above notopleural calli and extending approximately halfway along mesonotal suture. Lateral and medial postsutural vittae absent. Postnotum red-brown. Scutellum yellow with

narrow red-brown basal band and pale fuscous spot on apex. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 5.2 mm; costal cells fuscous; microtrichia covering second costal cell and outer ½ of first costal cell; remainder of wings with a pale fuscous tint except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I red-brown; tergum II fulvous except for a broad transverse red-brown band across anterior ⅔ and widening to cover lateral margins; terga III–V orange-brown except for a broad transverse red-brown band across anterior ⅓ of tergum III and widening on lateral margins of that tergum. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.75:1. Apex of piercer dorsoventrally flattened, needle shaped with a row of minute serrations along each side; 3 pairs of small subapical bristles present (Fig. 255). Spicules at distal end of middle segment of medium width with 5–9 triangular dentations of uneven length (Fig. 256).

ATTRACTANT: No known record.

COMMENTS

Originally, May (1957b) placed *B. mendosa* provisionally in *Strumeta* (= *Bactrocera*) because of the absence of postsutural vittae and, as a male specimen was unavailable, it was not known if the third abdominal tergum was ciliated. However, there is a large number of *Bactrocera* that lack postsutural vittae. *B. mendosa* is similar to *B. luteola* (Malloch) in possessing a red-brown mesonotum, yellow humeral calli and scutellum mostly yellow. It differs from this species in having fuscous costal cells, yellow notopleural calli, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow with a fuscous spot on apex and a yellow triangle along anterior margin of mesonotal suture above notopleural callus.

Bactrocera (Bactrocera) moluccensis (Perkins), n. comb. (Figs 257–259)

Strumeta moluccensis Perkins, 1939: 17–18.
Dacus (Strumeta) moluccensis: Hardy, 1970: 120–2; Drew, 1974a: 60–3.

MATERIAL EXAMINED

Holotype ♀, Buru I., Moluccas, Indonesia, 1904, H. Rolle; a large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Widespread throughout Papua New Guinea and from the following islands: Buru (type locality), New Britain, New Ireland, Lihir and Bougainville.

DIAGNOSIS

Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V fulvous with a narrow black transverse band along anterior margin of tergum III and a narrow medial longitudinal fuscous to black band over all 3 terga.

DESCRIPTION

FEMALE: Ovipositor apex of piercer with a pair of small subapical keels, 4 pairs of subapical bristles (2 large and 2 small) (Fig. 258). Spicules at distal end of middle segment wide with 13–19 dentations of markedly uneven length (Fig. 259).
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. moluccensis was described adequately by Drew (1974a). It is similar to species in the *bidentata* complex and *B. robiginosa* (May) in possessing pale fulvous costal cells without dense microtrichia, abdominal terga III–V pale and lacking lateral dark colour patterns, a medial longitudinal dark band on some abdominal terga and mesonotum pale (red-brown or orange-brown).

It differs from these species in having abdominal terga III–V with a narrow transverse black band across base of tergum III and a medial longitudinal fuscous to black band on all 3 terga. *B. turneri* is a very similar species in general size and body colour patterns but differs in the shape of the apex of the piercer and spicules of the ovipositor.

Hardy (1983) disagreed with Drew (1974a) synonymising *Strumeta rutila* Hering and *B. moluccensis*. I have received on loan the female paratype of *S. rutila* and agree with Hardy that this is a smaller specimen than the average for *B. moluccensis*. It also differs from *B. moluccensis* in possessing 2 pairs of strong subapical keels on the apex of the piercer of the ovipositor. The holotype of *S. rutila*, also examined, has the ovipositor concealed.

Bactrocera (Bactrocera) morula, n. sp.
(Fig. 260)

TYPE SPECIMEN
Holotype ♂, SOLOMON IS: Guadalcanal I., Honiara, December 1971, N.L.H. Krauss.
LOCATION OF TYPE: Holoytpe (T.10554) in QM.

DISTRIBUTION
Known only from Honiara (Solomon Islands).

DIAGNOSIS
Medium sized species; face black; humeral calli glossy black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe of medium width reaching almost to anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow except for a broad medial longitudinal glossy black band enclosing sc. bristles; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga I–V glossy black except for a narrow transverse dark fuscous band across posterior margin of tergum V and extending anteriorly along either side of a medial longitudinal black band.

DESCRIPTION
MALE: Head generally dark. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.67 times breadth; fulvous with dark fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex dark fuscous. Face glossy black, length of face 0.45 mm. Genae fuscous, black subocular spot present; black bristle present. Occiput black, fulvous along eye margins; occipital row with 4–6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segment: 0.18 mm; 0.28 mm; 0.80 mm.

Thorax mesonotum and pleural areas glossy black. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin straight; upper hypopleural calli (posterior apices glossy black); a small triangle on dorsomedial section of lower hypopleural calli (remainder glossy black). Humeral calli glossy black. Lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow except for a broad medial longitudinal glossy black band enclosing sc. bristles. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae black; all femora glossy black except hind femora tending paler basally; fore and mid tibiae dark fuscous, hind tibiae black; all tarsal segments fulvous; rows of long black setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.8 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga glossy black except for a narrow transverse dark fuscous band across posterior margin of tergum V and extending anteriorly along either side of a medial longitudinal black band. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS
B. morula is similar to *B. kirki* (Froggatt) and *B. setinervis* (Malloch) in possessing a broad black triangular marking on dorsal surface of scutellum, mesonotum black with lateral and medial postsutural vittae absent and wings colourless except for costal band and anal streak but differs

in having humeral calli black and abdominal terga uniformly black without paler markings.

Bactrocera (Bactrocera) mucronis (Drew), n. comb. (Fig. 261)

Dacus (*Strumeta*) *mucronis* Drew, 1971: 70–1.

MATERIAL EXAMINED
A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6951) in QM.

DISTRIBUTION
Known from Noumea (type locality) and Sarramea in New Caledonia.

DIAGNOSIS
Small species; facial spots absent; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for broad lateral longitudinal fuscous to black bands over all 3 terga.
ATTRACTANT: Cue lure.

COMMENTS
B. mucronis was described adequately by Drew (1971). It is similar to *B. facialis* (Coquillett) in possessing short lateral postsutural vittae, black mesonotum with medial postsutural vitta absent, scutellum yellow and wings colourless except for costal band and anal streak. It differs from this species in having 2 broad lateral longitudinal black bands on abdominal terga III–V and lateral postsutural vittae ending behind level of sa. bristles.

Bactrocera (Bactrocera) mutabilis (May), n. comb. (Figs 262–264)

Strumeta mutabilis May, 1951: 6–8.
Dacus (*Bactrocera*) *mutabilis*: Drew, 1982: 38–40.

MATERIAL EXAMINED
A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.5265) in QM.

DISTRIBUTION
Known from south-east and northern Queensland and appears to be confined to higher altitudes; type locality, Toowoomba.

DIAGNOSIS
Medium sized species; facial spots absent; humeral and notopleural calli yellow; mesonotum red-brown with oval black spots on anterior margin, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia covering second costal cell and most of first costal cell; all abdominal terga entirely orange-brown.

DESCRIPTION
FEMALE: Ovipositor apex of piercer needle shaped with 3 pairs of subapical bristles (Fig. 263). Spicules at distal end of middle segment of medium width with 9–15 small dentations of approximately even length (Fig. 264).
ATTRACTANT: No known record.

COMMENTS
B. mutabilis was described adequately by Drew (1982). It is similar to species in the *tryoni* complex, *B. humilis* (Drew and Hancock) and *B. unipunctata* (Malloch) in possessing dense microtrichia covering most of the costal cells, pale mesonotum (orange-brown or red-brown), scutellum yellow and wings colourless except for costal band and anal streak but differs in having facial spots absent and abdominal terga uniformly yellow-brown.

Bactrocera (Bactrocera) neocheesmanae, n. sp. (Fig. 265)

TYPE SPECIMENS
Holotype ♂, PAPUA NEW GUINEA, Western Highlands Province: Mt Hagen, attracted to methyl eugenol, 24.ii.1981, B. Thistleton.
Paratypes, PAPUA NEW GUINEA, Western Highlands Province: Mt Hagen, 1 ♂ 2.xii.1980, 1 ♂ 10.xii.1980, 1 ♂ 13.i.1980, B. Thistleton. Central District: 4 ♂♂, Bakoiudu (500 m), 21.i.1969, T.L. Fenner; 1 ♂, Bisianumu, Sogeri, 25.vi.1980, R.A.I. Drew and D.W. Currey; 5 ♂♂, Ningerum Garden, 28.vi.1984–10.vii.1984, K. Hortle. All paratypes attracted to methyl eugenol.
LOCATION OF TYPES: Holotype (T.10555) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 9 paratypes in DPI.

DISTRIBUTION
Known from the Western Highlands Province and Central District, Papua New Guinea.

DIAGNOSIS
Medium sized species; medium sized elongate

oval black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe broad extending to humeral callus, lateral and medial postsutural vittae present, scutellum yellow; legs fulvous except hind tibiae pale fuscous basally; wing with a broad fuscous costal band and anal streak, a broad transverse fuscous band across wing enclosing both crossveins, costal cells pale fuscous, microtrichia covering second costal cell and most of first costal cell; abdominal terga III–V orange-brown except for anterolateral corners of tergum III pale fuscous to fuscous and very narrow pale fuscous to fuscous margins laterally on all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.42 times breadth; fulvous with or without pale fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of small pale setae; orbital bristles black: 1 s.or., 3 i.or; lunule fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized elongate-oval black spots; length of face 0.48 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occiptal row with 6–8 well developed pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.73 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae and between humeral and notopleural calli. Pleural areas dark fuscous to black except red-brown above mid coxae and below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and narrowing slightly posteriorly to end before upper pa. bristles; a broad medial longitudinal vitta beginning posterior to prsc. bristles and narrowing to a point at level of mesonotal suture. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except hind tibiae pale fuscous basally; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.2 mm; costal cells pale fuscous; microtrichia covering second costal cell and most of first costal cell; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with but slightly paler above R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin, a broad transverse fuscous band across centre of wing and enclosing both crossveins; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I wider than long. Sterna I and II slightly wider than long. Tergum I dark fuscous; tergum II orange-brown except for a broad transverse dark fuscous band across anterior ½ but not reaching lateral margins; terga III–V orange-brown except for pale fuscous to fuscous anterolateral corners on tergum III and very narrow pale fuscous margins on terga III–V. A pair of orange-brown shining spots of unusual shape, in the form of narrow transverse lines. Posterior lobe of surstylus short, sternum V with a moderately deep concavity on posterior margin. ATTRACTANT: Methyl eugenol.

COMMENTS

B. neocheesmanae is similar to *B. cheesmanae* (Perkins) in possessing lateral and medial postsutural vittae, a single transverse fuscous band across the wing, costal cells pale fuscous with microtrichia covering first costal cell and mesonotum mostly fuscous or black. It differs from this species in having mesonotum mostly black and abdominal terga III–V orange-brown with at most narrow fuscous lateral margins.

Bactrocera (Bactrocera) neonigrita, n. nom.
(Fig. 266)

Not *Dacus* (*Afrodacus*) *aberrans nigritus* Hardy, 1955a: 5.
Dacus (*Strumeta*) *nigritus* Drew, 1971: 75–7.

MATERIAL EXAMINED

A large series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6955) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Widespread throughout New Britain (type locality, Keravat), New Ireland and Bougainville I.
NEW RECORD: Solomon Islands: 2 ♂♂, Korovou, attracted to methyl eugenol, 12.x.1984, E. Holoie.

DIAGNOSIS

Small species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent; scutellum yellow; wing with a narrow fulvous costal band and broad pale fuscous anal streak, broad infuscation along r–m crossvein which continues as a pale diffuse pattern across remainder of wing, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III and IV black and tergum V fuscous except dark fulvous along posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. neonigrita was described adequately by Drew (1971). It is similar to *B. melanogaster* in possessing abdominal terga III–V mostly black, costal cells colourless, mesonotum black, scutellum entirely yellow and infuscation on r–m crossvein but differs in having broad lateral postsutural vittae reaching upper pa. bristles. The name *Dacus nigritus* Drew is preoccupied in *Dacus* by *D. aberrans nigritus* Hardy and must be treated as a primary homonym even though it is now transferred to *Bactrocera* (see Articles 57(a) and 57(b) of the International Code of Zoological Nomenclature).

Bactrocera (Bactrocera) obliqua (Malloch), n. comb. (Figs 267–269)

Dacus obliquus Malloch, 1939a: 238–40.
Dacus (*Strumeta*) *obliquus*: Drew, 1974a: 67–9.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♀ in BMNH.

DISTRIBUTION

Known from New Britain, Bougainville I. and Admiralty Is (type locality).

DIAGNOSIS

Medium sized species; face black; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad medial longitudinal black band; wing with a narrow fuscous costal band and anal streak, r–m crossvein very oblique, a pale infuscation along r–m crossvein which becomes diffuse as it continues across wing, costal cells colourless with microtrichia in outer corner of second costal cell only; all abdominal terga entirely black.

DESCRIPTION

FEMALE: Ovipositor apex of piercer tapering sharply to a point from line of subapical bristles, with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 268). Spicules at distal end of middle segment of medium width with 5–9 small dentations of approximately even length (Fig. 269).
ATTRACTANT: No known record.

COMMENTS

B. obliqua was described adequately by Drew (1974a). It is similar to *B. psidii* (Froggatt) in possessing a broad black triangular marking on dorsal surface of scutellum, infuscation on crossveins and mesonotum black with medial postsutural vitta absent but differs in having a black face, r–m crossvein longer than dm–cu crossvein, lateral postsutural vittae very short and narrow ending just behind sa. bristles, legs with all tibiae and apices of femora and apical 4 segments of tarsi fuscous.

Bactrocera (Bactrocera) obscura (Malloch), n. comb. (Fig. 270)

Dacus obscurus Malloch, 1931: 264.
Strumeta obscurus: Perkins, 1939: 6.
Dacus (*Strumeta*) *obscurus*: Drew, 1974a: 69–71.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); 5 ♂♂ in DPI, Niuatoputapu I., Tonga, 25.ix.1973, O. Fakalata; 1 ♂ paratype (No. 43667), Samoa, R.W.Doane.
LOCATION OF TYPES: Holotype ♂ in BMNH, paratype ♂ in NMNH.

DISTRIBUTION

Known from Western Samoa (type locality, Upolu), Eastern Samoa and Tonga.

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow with pale fuscous on apex; wing with a narrow fuscous costal band and broad fuscous anal streak, a very pale fuscous tint across central area of wing membrane, costal cells extremely pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a medial longitudinal dark band and a pair of

anterolateral dark spots on each tergum, the dark patterns on the abdomen vary from fuscous to black.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. obscura was described adequately by Drew (1974a). It is similar to *B. allwoodi* (Drew) in possessing abdominal terga orange-brown with dark markings, mesonotum black and lacking lateral and medial postsutural vittae, humeral calli yellow and wings colourless except for costal band and anal streak. It differs from this species in having a fuscous spot on apex of scutellum, costal cells extremely pale fulvous and abdominal terga III–V orange-brown with a pair of transverse dark fuscous spots on each tergum and a narrow medial longitudinal band which is fuscous to dark fuscous on terga III and IV and black on tergum V.

Bactrocera (Bactrocera) ochromarginis
(Drew), n. comb. (Fig. 271)

Dacus (Asiadacus) ochromarginis Drew, 1971: 40–2.
Dacus (Strumeta) ochromarginis: Drew, 1972a: 21.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6933) in QM.

DISTRIBUTION

New Britain (type locality, Vudal, near Keravat).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, a broad yellow band connecting humeral and notopleural calli, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless to extremely pale fulvous with microtrichia in outer corner of second costal cell only; all abdominal terga orange-brown except for a medial elongate black spot on tergum V.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. ochromarginis was described adequately by Drew (1971). It is similar to *B. diaphana* (Hering) in possessing humeral and notopleural calli joined by a lateral yellow band, a narrow costal band not extending to R_{4+5}, mesonotum red-brown with lateral postsutural vittae present and medial postsutural vitta absent. It differs from this species in having the mesopleural stripe extending to humeral callus above, notopleural calli entirely yellow, lateral postsutural vittae beginning at mesonotal suture and microtrichia in outer corner of second costal cell only.

Bactrocera (Bactrocera) passiflorae
(Froggatt), n. comb. (Figs 272–274)

Dacus passiflorae Froggatt, 1910: 870.
Chaetodacus passiflorae: Bezzi, 1928: 106–7.
Strumeta passiflorae: Perkins, 1939: 8.
Dacus (Strumeta) passiflorae: Drew, 1974a: 71–4.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); lectotype ♂ and 2 ♂ paralectotypes.

LOCATION OF TYPES: Lectotype and 2 paralectotypes in NSW.

DISTRIBUTION

Known from Fiji (type locality) and Niue I.

DIAGNOSIS

Small species; facial spots absent; humeral calli glossy black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to or beyond anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band and narrow pale fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga I–IV glossy black and tergum V either glossy black with posterior margin dark fuscous or fuscous with a medial longitudinal black band.

DESCRIPTION

FEMALE: Ovipositor apex of piercer rounded at tip with 4 pairs of subapical bristles (Fig. 273). Spicules at distal end of middle segment of medium width with 7–12 dentations of uneven length (Fig. 274).

ATTRACTANT: Cue lure.

COMMENTS

B. passiflorae was described adequately by Drew (1974a). It is similar to *B. thistletoni* in possessing black humeral calli, scutellum entirely yellow, mesonotum black with lateral and medial postsutural vittae absent but differs in having facial spots absent and legs entirely fulvous.

In NSW there is one male labelled "Fruit Fly, Granadila, Fiji, Butler, Bred 15/6/99" and "*D. passiflorae*, Cotype, WWF, 1910", the latter label being in Froggatt's handwriting; two males on 1

pin labelled "On Guava, Fiji, 11.12.99, Mr Koeboele" and "CO-TYPE SPECIES". Froggatt did not designate types and the label data do not match exactly the collector/host information given in the original description. However, these specimens are probably part of the type series and I designate the single male as lectotype and the two males on 1 pin paralectotypes.

Bactrocera (Bactrocera) penefurva, n. sp.
(Fig. 275)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central Province: 20 km SE Port Moresby, hand collected on bushes, 26.i.1985, J.W. Ismay.

Paratype, SOLOMON IS: 1 ♂, Tenaru, Guadalcanal I., in Malaise trap, April 1984, R. MacFarlane.

LOCATION OF TYPES: Holotype (T.10556) in QM; 1 paratype in BMNH.

DISTRIBUTION

Known from the Central Province, Papua New Guinea and Tenaru, Guadalcanal I. (Solomon Islands).

DIAGNOSIS

Very small species; facial spots absent; humeral calli yellow; notopleural calli with anterior ½ black, posterior ½ fulvous; mesonotum black, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae present, scutellum yellow with anterolateral corners black; legs entirely fulvous; wing without a distinct costal band and anal streak but with a large fuscous spot in apex, a large bulla on anal cell extension, costal cells fuscous with dense microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga mostly orange-brown except for small irregular black spots on lateral margins of terga III, IV and V and a broad medial longitudinal black band on posterior ¾ of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.1 mm. Frons widening slightly posteriorly, length 1.5 times breadth; dark fulvous except dark fuscous anteriorly and fuscous around s.or. bristles; anteromedial hump absent; orbital bristles black: 1 s.or., 1 i.or.; lunule fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous without facial spots and with a small area of pale fuscous dorsally; length of face 0.4 mm. Genae fulvous, subocular spot absent; large red-brown bristle present. Occiput black dorsally, fulvous ventrally, yellow along eye margins; no distinct occipital row present. Antennae with segment 1 fulvous, segments 2 and 3 entirely dark fuscous; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.08 mm; 0.15 mm; 0.45 mm.

Thorax mesonotum and pleural areas black. Yellow markings as follows: humeral calli; broad mesopleural stripe reaching humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 5/9 lower hypopleural calli (remainder black); 2 moderately broad parallel sided lateral postsutural vittae ending behind upper pa. bristles; a very broad medial postsutural vitta rounded posteriorly and beginning at posterior margin of mesonotum and narrowing to a point anteriorly to end at level of mesonotal suture. Notopleural calli black on anterior ½ and fulvous on posterior ½. Postnotum black. Scutellum yellow except for anterolateral corners black. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 3; all bristles well developed and fuscous.

Legs all segments entirely fulvous except for a narrow black line along ventral surface of mid femora; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.2 mm; costal cells fuscous; dense microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except for a large fuscous spot covering apex of wing; there is no distinct costal band and the anal streak is absent; a large bulla covering anal cell extension; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe very strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga uniformly orange-brown except anterolateral corners of tergum I black, irregular black spots on lateral margins of terga III, IV and V and a broad medial longitudinal black stripe on posterior ¾ of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. penefurva is similar to *B. tigrina* (May) from north Queensland and is a good example of speciation between 2 geographically close land masses. The 2 species are similar in the unique male wing and body colour patterns. *B. penefurva* differs in having sa. bristles, the medial postsutural vitta longer and narrower and in lacking black

posterodorsal corners on the humeral calli of males.

Bactrocera (Bactrocera) pepisalae (Froggatt), n. comb. (Fig. 276)

Dacus pepisalae Froggatt, 1910: 869–70; Malloch, 1939a: 242–3.
Dacus (Neodacus) pepisalae: Hardy, 1954: 11–12.
Dacus (Strumeta) pepisalae: Drew, 1974a: 74–5.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Unknown.

DISTRIBUTION
Known from the following islands: Florida, Guadalcanal, San Cristobal (Solomon Islands) and Bougainville; type locality, Russell I. (Solomon Islands).

DIAGNOSIS
Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing membrane generally fuscous, costal cells dark fulvous with microtrichia in outer ½ of second costal cell only; abdominal terga III–V black.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. pepisalae was described adequately by Drew (1974a). It is similar to *B. amplexiseta* (May) and *B. ebenea* (Drew) in having a large area of the wing membrane covered with diffuse fuscous colouration, and similar to *B. amplexiseta* in possessing facial spots and lateral postsutural vittae. It differs from *B. amplexiseta* in having a black mesonotum, infuscation covering the entire wing membrane and abdominal terga III–V uniformly black and differs from *B. ebenea* in having facial spots and lateral postsutural vittae.

Bactrocera (Bactrocera) perfusca (Aubertin), n. comb. (Fig. 277)

Chaetodacus perfuscus Aubertin, 1929: 173–4.
Dacus (Marquesadacus) perfuscus: Malloch, 1932: 145–6.
Strumeta perfuscus: Perkins, 1939: 6.
Dacus (Strumeta) perfuscus: Drew, 1974a: 75–6.

MATERIAL EXAMINED
One ♀ labelled "Type", "Marquesas Is., Nuka Hiva, L.E. Cheesman" and 1 ♂ labelled "Type", "Marquesas Is., Hiva-oa, L.E. Cheesman"; 1 ♀ labelled "Paratype", "Marquesas Is., Hiva-oa, L.E. Cheesman" and 1 ♂ labelled "Paratype", "Marquesas Is., Tahuata, L.E. Cheesman".
LOCATION OF TYPES: Holotype ♂ and 16 paratypes in BMNH.

DISTRIBUTION
Hiva-oa, Marquesas Is (type locality).

DIAGNOSIS
Medium sized species; facial spots absent; humeral and notopleural calli glossy black; mesonotum entirely glossy black, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae absent, scutellum glossy black; wing with a narrow fuscous costal band and very pale anal streak, costal cells colourless with microtrichia in outer corner of second cell only; abdominal terga entirely glossy black.

DESCRIPTION
FEMALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.95 times breadth, fulvous without dark markings; anteromedial hump covered by a small number of pale setae; orbital bristles black: 1 s.or., 1 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark spots; length of face 0.48 mm. Genae fulvous, subocular spot absent; black bristle present. Occiput glossy black dorsally, fulvous ventrally; occipital row with 4–6 strong black bristles. Antennae with all segments fuscous; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.33 mm; 0.80 mm.

Thorax mesonotum and pleural areas glossy black without pale markings. Yellow markings as follows: broad mesopleural stripe reaching humeral callus dorsally, not continuing to sternopleuron, anterior margin straight; anterior 5/8 lower hypopleural calli (remainder glossy black). Humeral and notopleural calli glossy black. Upper hypopleural calli glossy black. Lateral and medial postsutural vittae absent. Postnotum glossy black. Scutellum glossy black. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae dark fuscous; fore femora fulvous, mid and hind femora glossy black; all tibiae and tarsi dark fuscous; mid tibiae each with an apical black spur.

Wings length 7.0 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening slightly in apex

of wing to end at extremity of M, anal streak reduced to a very pale fuscous tint in cell cup; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. All terga glossy black. A pair of oval glossy black shining spots on tergum V. Basal segment of ovipositor glossy black, conical in transverse cross section and tapering posteriorly in dorsal view. Apex of piercer needle shaped.

MALE: As for female except a dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development; pecten present on abdominal tergum III; posterior lobe of surstylus short; abdominal sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS

Previously, types or other specimens of this species could not be located for study (Drew 1974a). *B. perfusca* is similar to *B. melanotus* (Coquillett) in general body and wing colour patterns but differs in possessing the humeral and upper hypopleural calli entirely glossy black, fore femora fulvous and in lacking fuscous colouration around the wing crossveins.

In BMNH there are 17 specimens that are part of the type series. Two specimens, a male and female, are each labelled type and the remainder paratype. Originally, Aubertin (1929) designated the male from Hiva-oa as the holotype and the female from Nuka-Hiva as the allotype. The label data of all 17 specimens conform with that in the description and the male type can be regarded as the holotype and the remaining specimens paratypes.

Bactrocera (Bactrocera) perkinsi
(Drew and Hancock), n. comb. (Fig. 278)

Dacus (Bactrocera) perkinsi Drew and Hancock, 1981: 72–5.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.8284) in QM.

DISTRIBUTION

Restricted to the northern area of Cape York Peninsula, Queensland (type locality, Lockerbie) and the Torres Strait islands: Horn and Moa (Banks).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with or without fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown with a narrow dark band along base of tergum III and a medial longitudinal dark band over all 3 terga and lateral longitudinal dark bands running from posterior area of tergum III to tergum V.
ATTRACTANT: Cue lure.

COMMENTS

B. perkinsi was described adequately by Drew and Hancock (1981). It is similar to species in the *quadrata* complex in possessing colourless wings except for costal band and anal streak, red-brown mesonotum, microtrichia confined to outer corner of second costal cell only, abdominal terga III–V with a medial longitudinal band and narrow lateral dark colour patterns on at least some terga but differs in having a pair of fuscous to black shining spots on tergum V.

Bactrocera (Bactrocera) phaea
(Drew), n. comb. (Fig. 279)

Dacus (Strumeta) phaea Drew, 1971: 77–9.

MATERIAL EXAMINED

A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6956) in QM.

DISTRIBUTION

New Britain (type locality, Keravat) and Lihir I.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, broad infuscation along r–m crossvein, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a black transverse band across base of tergum III, a medial longitudinal black band over all 3 terga and lateral margins of tergum III and anterolateral corners of tergum IV black.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. phaea was described adequately by Drew (1971). It is similar to *B. curvipennis* (Froggatt) in possessing infuscation on one crossvein, scutellum entirely yellow, mesonotum black, costal cells coloured, legs mostly fulvous and abdominal terga III–V with ground colour orange-brown. It differs from this species in having the mesopleural stripe reaching the humeral callus, microtrichia in outer corner of second costal cell only, legs entirely fulvous, abdominal terga III–V with a broad black medial longitudial band, a black band across anterior margin of tergum III expanding to cover lateral margins of this tergum and anterolateral corners of tergum IV.

Bactrocera (Bactrocera) phaleriae
(May), n. comb. (Fig. 280)

Strumeta phaleriae May, 1955: 158–60; May, 1963: 50.

MATERIAL EXAMINED

Seven paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.5315) in QM.

DISTRIBUTION

Port Douglas, Queensland (type locality).

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli yellow; notopleural calli red-brown; mesonotum red-brown, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum red-brown with anterolateral corners yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia covering second costal cell and outer corner of first costal cell; abdominal terga I–V orange-brown except for a medial longitudinal fuscous to dark fuscous spot on posterior ½ of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons narrowing slightly posteriorly, length 1.52 times breadth, fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous without dark spots; length of face 0.45 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 3–6 red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.23 mm; 0.65 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 narrow parallel sided lateral postsutural vittae ending before upper pa. bristles. Notopleural calli red-brown. Postnotum red-brown. Scutellum red-brown except anterolateral corners yellow. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 2 or 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 5.5 mm; costal cells fulvous; microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V orange-brown except for a fuscous to dark fuscous medial longitudinal spot on posterior ½ of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.59:1. Apex of piercer unique in shape having 1 pair of reduced subapical lobes (Fig. 280A).

ATTRACTANT: No known record.

COMMENTS

B. phaleriae is similar to *B. carbonaria* (Hendel) in possessing the scutellum almost entirely

darkened but differs in having humeral calli yellow (with anterior ⅓ brown), notopleural calli red-brown, scutellum almost entirely red-brown, facial spots absent, mesonotum and abdomen uniformly dark orange-brown. There is a large number of other species that have colourless wings and colouration on the scutellum in varying shapes and intensities, i.e. *B. atramentata* (Hering), *B. buinensis*, *B. daruensis*, *B. enochra* (Drew), *B. picea* (Drew), *B. trifaria* (Drew) and species in the *fagraea* complex. *B. phaleriae* differs from these species in having the scutellum entirely darkened except for a small yellow area on each anterolateral corner.

Originally, May (1955) described the mesopleural stripe as "almost attaining humeral callus". However it is narrower, ending at the anterior npl. bristle.

Bactrocera (Bactrocera) picea (Drew), n. comb. (Fig. 281)

Dacus (*Strumeta*) *piceus* Drew, 1972b: 208–10.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6992) in QM.

DISTRIBUTION

Recorded from Russell I. and the Shortland Is (Solomon Islands), also Bougainville I. (type locality, Buin).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral calli glossy black with an irregular longitudinal fulvous band through centre; notopleural calli yellow; mesonotum glossy black, mesopleural stripe slightly wider than notopleural callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow except for a broad medial longitudinal glossy black band; wing with a pale fuscous tint around costal margin and a broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga glossy black except posterior margin of tergum V tending dark fuscous.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. picea was described adequately by Drew (1972b). It is similar to *B. atramentata* (Hering) in possessing colourless wings except for costal band and anal streak, mesonotum black with lateral postsutural vittae present and medial postsutural vitta absent, scutellum yellow with a broad medial longitudinal black band, abdominal terga uniformly black and costal cells colourless. It differs from this species in being a small species and having humeral calli glossy black with a fulvous band in centre, lateral postsutural vittae broad, a broader black band on scutellum, costal band absent, mid and hind femora and hind tibiae black.

Bactrocera (Bactrocera) pisinna, n. sp. (Fig. 282)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Kaindi (1400 m), attracted to cue lure, 16.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: Mt Kaindi (between 1200 m and 1550 m), 1 ♂ 2.iii.1981, 1 ♂ 29.iii.1981, 1 ♂ 4.v.1981, 1 ♂ 23.xi.1981, 1 ♂ 14.xii.1981, A. Allison, all paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10557) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 3 paratypes in DPI.

DISTRIBUTION

Known only from Mt Kaindi, Morobe Province, Papua New Guinea.

DIAGNOSIS

Very small species; facial spots absent; humeral and notopleural calli yellow; mesonotum glossy black, postsutural vittae absent, mesopleural stripe of medium width, scutellum yellow; wing with a narrow costal band and a narrow transverse band across centre which encloses both crossveins, costal cells dark fuscous, microtrichia covering both costal cells; abdomen with a glossy appearance and with broad lateral dark fuscous to black margins on terga III and IV and with the centre portions of terga III–V fuscous.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 0.83 mm. Frons of even width, length 1.38 times breadth; dark fulvous with no dark markings, anteromedial hump reduced and covered by a few short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous, facial spots absent; length of face 0.28 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput dark fuscous, yellow along eye margins; occipital row with 6–8 small pale bristles. Antennae with segments 1 and 2 red-brown; segment 3 red-brown with fuscous on apex and outer surface; a weak red-brown dorsal bristle on segment 2; arista black (red-brown basally); length of segments: 0.05 mm; 0.15 mm; 0.38 mm.

Thorax mesonotum glossy black. Pleural areas glossy black except red-brown above fore coxae. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black). Lateral and medial postsutural vittae absent. Postnotum glossy black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. (reduced); mpl. 1; npl. 2; scp. 4; all bristles (except sa.) well developed and black.

Legs fore coxae fulvous, mid and hind coxae dark fuscous; remaining segments fulvous except mid and hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 3.5 mm; costal cells dark fuscous; microtrichia covering both costal cells; remainder of wings colourless except for a dark fuscous subcostal cell, narrow dark fuscous costal band confluent with R_{2+3} and ending at extremity of M, a narrow transverse dark fuscous band across wing and enclosing both crossveins, a narrow dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen rounded with a glossy appearance; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous centrally, black laterally, with a narrow transverse red-brown band along posterior margin and ending before lateral margins; tergum II dark fuscous to black with a narrow transverse red-brown band along posterior margin but not reaching lateral margins; terga III–V fuscous except for broad lateral dark fuscous to black margins on terga III and IV. A pair of oval shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. pisinna is similar to *B. retrorsa* in possessing infuscation on wing in addition to costal band and anal streak, mesonotum black with lateral and medial postsutural vittae absent and scutellum entirely yellow. It differs from this species in having costal cells fuscous, a narrow transverse fuscous band across wing enclosing both crossveins, humeral calli yellow, abdominal terga dark fuscous and all femora entirely fulvous.

Bactrocera (Bactrocera) psidii (Froggatt), n. comb. (Figs 283–285)

Tephritis psidii Froggatt, 1899: 500–1.
Dacus psidii: Froggatt, 1909: 86; Malloch, 1931: 263, 1938: 115.
Dacus virgatus Coquillett, 1910: 13; Malloch, 1931: 264 (syn.).
Strumeta psidii: Perkins, 1939: 18–19.
Dacus ornatissimus Froggatt, 1909: 93 (partim, lectotype only); Drew, 1974a: 76 (syn.).
Dacus (Strumeta) psidii: Drew, 1974a: 76–8.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: *T. psidii*, unknown (no type material was mentioned in the original description by Froggatt); *D. virgatus*, holotype ♀ (No. 12738) in NMNH; *D. ornatissimus*, lectotype ♂ in NSW.

DISTRIBUTION

Restricted to New Caledonia (type locality).

DIAGNOSIS

Medium sized species; generally small fuscous to dark fuscous facial spots present; humeral calli yellow except anterodorsal corner black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe equal in width to notopleural callus, short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad triangular black marking on dorsal surface; wing with a narrow tint of extremely pale fuscous colouration around costal margin and a narrow fulvous anal streak, a narrow tint of fuscous colouration around r–m and dm–cu crossveins, costal cells colourless to extremely pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga entirely glossy black.

DESCRIPTION

FEMALE: Ovipositor apex of piercer needle shaped with 2 pairs of subapical bristles (Fig. 284). Spicules at distal end of middle segment of medium width with 8–11 small dentations of approximately even length (Fig. 285).
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. psidii was described adequately by Drew (1974a). It is similar to *B. obliqua* (Malloch) in possessing infuscation on crossveins and scutellum yellow with a broad black triangular marking on dorsal surface. It differs from this species in having the face fulvous with small pale spots in 75 per cent of specimens, costal band narrow and not overlapping R_{2+3}, r–m crossvein shorter than

dm–cu crossvein, infuscation around crossveins very narrow and pale, legs entirely fulvous, lateral postsutural vittae elongate and ending before upper pa. bristles.

As discussed by Drew (1974a), the type series of *D. ornatissimus* Froggatt consists of 2 species, *B. psidii* and *B. musae*. Despite the labelling of the specimens (type or cotype), Froggatt (1909) did not designate a type in his original description. In order to prevent future nomenclatural problems I designate the male labelled "New Caledonia, 4.4.97, bred guava, type WWF" as the lectotype. This is a specimen of *B. psidii* whereas the paralectotypes are all specimens of *B. musae*.

Bactrocera (Bactrocera) reclinata, n. sp. (Fig. 286)

TYPE SPECIMENS

Holotype ♂, BOUGAINVILLE I.: Daru Village, attracted to methyl eugenol, 30.v.1970, R.M. Berena.

Paratype, BOUGAINVILLE I.: 1 ♂, Daru Village, attracted to methyl eugenol, May 1970, R.M. Berena.

LOCATION OF TYPES: Holotype (T.10558) in QM; 1 paratype in DPI.

DISTRIBUTION

Known only from Bougainville I.

DIAGNOSIS

Medium sized species; very large oval black facial spots present; humeral calli yellow; notopleural calli black; mesonotum black, mesopleural stripe of medium width ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae narrow and very short, medial postsutural vitta absent, scutellum yellow with a very broad medial longitudinal shining black band; legs generally dark fuscous to black except basal areas of femora fulvous and basal segment of tarsi fulvous; wing with a narrow fuscous costal band and broad fuscous anal streak, a narrow U-shaped fuscous band across centre costal cells colourless, microtrichia in outer ⅓ of second costal cell only; abdominal terga I–V generally shining black.

DESCRIPTION

MALE: Head generally dark in colour. Vertical length 1.7 mm. Frons narrowing slighlty posteriorly, length 1.67 times breadth; uniformly fuscous, anteromedial hump covered with a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex dark fuscous. Face dark fulvous with large irregularly oval black spots; length of face 0.55 mm. Genae dark fulvous, fuscous subocular spot present; black bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with 7 strong black bristles. Antennae with segments 1 and 2 dark fulvous with fuscous markings, segment 3 fuscous; a strong black dorsal bristle on segment 2; arista black (dark fulvous basally); length of segments: 0.28 mm; 0.40 mm; 1.03 mm.

Thorax mesonotum and pleural areas shining black without pale markings. Yellow markings as follows: humeral calli (anterior ⅓ and broad ventral margin fuscous); medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 4/7 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing sharply posteriorly to end midway between sa. and lower pa. bristles. Notopleural calli black. Postnotum black. Scutellum yellow except for a broad medial longitudindal shining black band which encloses the apical sc. bristles. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; npl.2; mpl. 1; scp. 4; all bristles well developed and black.

Legs all coxae dark fuscous; fore femora with apical ½ dark fuscous to black (basal ½ fulvous), mid femora black except for a fulvous tint basally, apical ½ hind femora black (basal ½ fulvous); fore tibiae fuscous, mid tibiae dark fuscous, hind tibiae black; all tarsal segments fuscous except basal segment fulvous; rows of long black bristles on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.5 mm; costal cells colourless; microtrichia in outer ⅓ second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a U-shaped fuscous band across wing enclosing both crossveins and recurving back along CuA_1 towards base of wing, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V shining black except for 2 narrow transverse orange-brown markings on lateral margins of tergum II either side of midline. A pair of oval black shining spots on tergum V. Posterior

lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Methyl eugenol.

COMMENTS

B. reclinata is similar to *B. anfracta* in possessing a distinct fuscous marking across wing, mesonotum black with lateral postsutural vittae present and medial postsutural vitta absent and scutellum with a large black triangular marking on dorsal surface but differs in having a unique fuscous band across wing enclosing both crossveins and recurving back to enclose CuA_1.

Bactrocera (Bactrocera) retrorsa, n. sp.
(Fig. 287)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Stony logging area, Bulolo, attracted to methyl eugenol, 4.iii.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 2 ♂♂, Upper Manki logging area, Bulolo, 15.iv.1980, P. Daur; 1 ♂, Upper Stony logging area, Bulolo, 7.iii.1980, P.Daur; 1 ♂, Bubia, Lae, 4.i.1960, J.H. Ardley. Northern District: 1 ♂, Lejo plantation, 13.ii.1975, E.S.C. Smith. All paratypes attracted to methyl eugenol.
LOCATION OF TYPES: Holotype (T.10559) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 3 paratypes in DPI.

DISTRIBUTION

Known from the Morobe Province and Northern District, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized subquadrate black facial spots present; humeral calli black dorsally and dark fuscous ventrally; notopleural calli yellow; mesonotum black, mesopleural stripe of medium width (just wider than notopleural callus), lateral and medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, a large irregularly shaped fuscous pattern across centre; abdominal terga I–V black except for dark fuscous along either side of a medial longitudinal black band on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.46 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered with a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized subquadrate black spots; length of face 0.55 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput fuscous, yellow along eye margins; occipital row with 7–10 well developed black bristles. Antennae with segments 1 and 2 fulvous; segment 3 fuscous except fulvous along ventral margin; a strong fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.40 mm; 1.0 mm.

Thorax mesonotum and pleural areas black without pale markings. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, slightly wider than notopleural callus dorsally, continuing to sternopleuron as a very small fuscous marking, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder including broad ventral margins black). Humeral calli black dorsally, dark fuscous ventrally. Lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow except for broad black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; npl. 2; mpl. 1; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; apical ⅓ of all femora dark fuscous (remainder fulvous); fore and mid tibiae pale fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; middle tibiae each with an apical black spur.

Wings length 7.0 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a fuscous pattern across wing beginning as a narrow band enclosing r–m crossvein then expanding into a large oval pattern and recurving back along underside of CuA_1, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V black except for dark fuscous either side of a medial longitudinal black band on tergum V. A pair of oval shining spots on tergum V which are black on lateral ½ and dark fuscous on inner ½. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Methyl eugenol.

COMMENTS

B. retrorsa is similar to *B. pisinna* in possessing a black mesonotum with lateral and medial postsutural vittae absent and wings with distinct fuscous markings in addition to costal band and anal streak. It differs from this species in having colourless costal cell, a broad dark fuscous blotch across wings which encloses both crossveins and most of discoidal cell, humeral calli black, abdomen uniformly black and femora fulvous with apices dark fuscous. It is similar to *B. biarcuata* (Walker) in general wing and body colouration, but this species is geographically restricted to Bougainville I. and possesses lateral postsutural vittae.

Bactrocera (Bactrocera) robiginosa
(May), n. comb. (Fig. 288)

Strumeta robiginosa May, 1957b: 305–6; May, 1963: 50.

MATERIAL EXAMINED

Holotype ♀, Stoney Creek, Cairns District, Queensland, 8.xi.1955, A.W.S. May. In the original description, May (1957b) noted the collector as W. Pont, however the specimen label states A.W.S. May.

LOCATION OF TYPE: Holotype (T.5592) in QM.

DISTRIBUTION

Stoney Creek, Cairns, Queensland (type locality).

DIAGNOSIS

Medium sized species; small oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs entirely fulvous; wing with a narrow fuscous costal band and anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; all abdominal terga pale orange-brown except for very narrow medial longitudinal bands on terga III, IV and V which are very pale fuscous on tergum III, fuscous on tergum IV and black on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.7 mm. Frons of even width, length 1.6 times breadth; fulvous without dark markings; anteromedial hump covered by a large number of short dark setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small circular black spots; length of face 0.5 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 3–6 red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.33 mm; 0.83 mm.

Thorax mesonotum red-brown with very narrow pale fuscous lateral longitudinal bands. Pleural areas red-brown except pale fuscous on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 broad lateral postsutural vittae ending at upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 6.6 mm; costal cells fulvous (second cell slightly paler); microtrichia in outer corner of second costal cells only; remainder of wings with a pale fuscous tint except fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; no pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V pale orange-brown except for narrow medial longitudinal bands on tergum III, IV and V which are very pale fuscous on tergum III, fuscous on tergum IV and black tergum V. A pair of oval fuscous shining spots on tergum V. Basal segment of ovipositor red-brown, conical in transverse cross section and tapering posteriorly in dorsal view; aculeus needle shaped at its tip. Ratio of length of oviscape to length of tergum V 0.63:1.

ATTRACTANT: No known record. Earlier record of attraction to cue lure (Drew and Hooper, 1981) is doubtful.

COMMENTS

B. robiginosa is similar to *B. moluccensis*

(Perkins) and species in the *bidentata* complex in possessing a red-brown mesonotum, costal cells coloured with microtrichia in outer corner of second costal cell only, abdominal terga III–V pale without distinct lateral dark colour patterns. It differs from these species in having a narrow medial longitudinal indistinct band on tergum III becoming pale fuscous on tergum IV and fuscous on tergum V and with fuscous to black shining spots on tergum V.

Bactrocera (Bactrocera) rutila (Hering), n. comb. (Fig. 289)

Strumeta rutila Hering, 1941a: 45–6.
Dacus (Bactrocera) rutilus: Hardy, 1983: 15.

MATERIAL EXAMINED

PAPUA NEW GUINEA: holotype ♀, 1896, Biro; paratype ♀ in BMNH with the following labels - "N. Guinea, Biro, 96", "Lenien Berlinhafen", "*Strumeta rutila* det. Hering 1940". INDONESIA, Irian Jaya: 1 ♂ in BMNH with 2 labels, "Neth. Ind.— American New Guinea Expedit, Bernhard Camp 50 m, 6.x.1938, J. Olthof" and "*Strumeta rutila* Hering", the latter in Hering's handwriting.
LOCATION OF TYPES: Holotype in HNHM, paratype ♀ in BMNH.

DISTRIBUTION

Known from Papua New Guinea (type locality, Berlinhafen) and Irian Jaya. The label data on the specimens studied is vague, exact locality being unavailable.

DIAGNOSIS

Small species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with a pair of fine pale fuscous lines inside lateral postsutural vittae, mesopleural stripes reaching midway between anterior margin of notopleural callus and anterior npl. bristles, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous (second cell slightly paler), microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown except for a fuscous to dark fuscous band across anterior margin of tergum III and a similar elongate spot posterocentrally on tergum V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.48 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized subquadrate black spots; length of face 0.43 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput red-brown, fulvous along eye margins; occipital row with 5–6 strong dark bristles. Antennae with segments 1 and 2 fulvous; segment 3 absent in paratype; a red-brown dorsal bristle on segment 2; length of segments: 0.15 mm; 0.28 mm.

Thorax mesonotum red-brown except for a pair of narrow pale fuscous longitudinal lines inside lateral postsutural vittae. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 lateral postsutural vittae of even width and ending just before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1 (absent in paratype); mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells pale fulvous (second cell slightly paler); microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark red-brown; tergum II dark red-brown across anterior ⅔ and widening to cover lateral margins (remainder fulvous); terga III–V red-brown except for a narrow fuscous to dark fuscous band along anterior margin of tergum III and a narrow medial longitudinal fuscous spot on posterior ½ of tergum V. A pair of oval red-brown shining spots on tergum V. Basal segment of ovipositor red-brown, oval in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V

0.74:1. Apex of piercer with 2 pairs of strong subapical keels.
ATTRACTANT: No known record.

COMMENTS

Drew (1974a) made *B. rutila* a synonym of *B. moluccensis* (Perkins). These species, together with *B. turneri* are identical on the standard characters used for identification. The study of females however, reveals that these are good species; the apex of the piercer is needle shaped in *B. turneri*, possessing a pair of weak subapical keels in *B. moluccensis* and having 2 pairs of strong subapical keels in *B. rutila*. There are no other characters on which these species can be confidently separated.

Bactrocera (Bactrocera) samoae, n. sp.
(Fig. 290)

TYPE SPECIMEN

Holotype ♀, WESTERN SAMOA: Utumapu, 14.xii.1968, B. Hocking.
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Known only from Western Samoa.

DIAGNOSIS

Small species; facial spots absent; humeral calli glossy black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. callus, lateral and medial postsutural vittae absent, scutellum yellow; wing with a narrow fuscous costal band, anal streak absent, costal cells colourless with microtrichia in outer ⅓ of second costal cell only; abdominal terga II–V orange-brown with a medial longitudinal dark fuscous band on terga III–V and 2 lateral longitudinal glossy black bands on terga II–V.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.1 mm. Frons of even width, length 1.85 times breadth; fulvous with fuscous laterally from s.or. bristles to vertex; orbital bristles dark fuscous: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous without dark spots; length of face 0.3 mm. Genae fulvous, brown subocular spot present. Occiput black, fulvous along eye margins; occipital row with 4 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a weak pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.08 mm; 0.23 mm; 0.50 mm.

Thorax mesonotum and pleural areas glossy black. Yellow markings as follows: notopleural calli; mesopleural stripe reaching anterior npl. bristle dorsally, continuing to sternopleuron as a small pale spot, anterior margin convex; upper hypopleural calli (posterior apices glossy black); anterior 3/5 lower hypopleural calli (remainder glossy black). Humeral calli glossy black. Lateral and medial postsutural vittae absent. Postnotum glossy black. Scutellum yellow except narrow black basal band. Bristles; sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 4.1 mm; costal cells colourless; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, a narrow fuscous costal band confluent with R_{2+3} and widening slightly at wing apex. Anal streak reduced to a pale fuscous tint in posterior cubital cell; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; terga II–V orange-brown with a moderately broad medial longitudinal dark fuscous to black band on terga III–V and 2 broad lateral longitudinal glossy black bands over terga II–V. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor glossy black, conical in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.17:1. Apex of piercer needle shaped.
ATTRACTANT: No known record.

COMMENTS

B. samoae is similar to *B. passiflorae* (Froggatt) in having a glossy black mesonotum, black humeral calli, yellow notopleural calli, yellow scutellum, lateral and medial postsutural vittae absent, facial spots absent and wings with a narrow fuscous costal band. It differs from *B. passiflorae* in possessing a unique abdominal colour with tergum I black, terga II–V orange-brown with a medial dark fuscous band on terga III–V and broad lateral longitudinal glossy black bands over terga II–V.

Bactrocera (Bactrocera) seguyi
(Hering), n. comb. (Fig. 291)

Strumeta (Bactrocera) seguyi Hering, 1939: 165–6.
Dacus peculiaris Malloch, 1939a: 235; Hering, 1941a: 53 (syn.).

Dacus (Neodacus) seguyi: Hardy, 1954: 12.
Dacus (Strumeta) seguyi: Drew, 1974a: 79–81.

MATERIAL EXAMINED
A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: *S. seguyi*, holotype ♀ in MNHN; *D. peculiaris*, holotype ♂ in NMNH.

DISTRIBUTION
Widespread over Papua New Guinea, Irian Jaya (type locality, either Humboldt Bay or Dorey [= Manokwari]) and New Britian, where it is common in lowland rainforest areas.

DIAGNOSIS
Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a broad recurved fuscous band across centre of wing and a narrow fuscous transverse band across apex of wing, first costal cell fuscous, second costal cell colourless in centre with fuscous around margins, microtrichia covering second costal cell and outer ⅔ of first costal cell; abdominal terga II–IV fulvous and tergum V red-brown except for a black transverse band across anterior margin of tergum II, a broad medial longitudinal black band over all 4 terga and 2 lateral longitudinal black bands on terga III–V.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. seguyi was described adequately by Drew (1974a). It is similar to *B. curvifera* (Walker) in possessing a broad fuscous blotch across centre of wing enclosing both crossveins and most of discoidal cell, mesonotum black with lateral postsutural vittae present, medial postsutural vitta absent and scutellum entirely yellow. It differs from this species in having the mesopleural stripe extending to humeral callus, costal cells fuscous, abdominal terga II–V fulvous with a broad medial longitudinal black band over all 4 terga and 2 broad lateral longitudinal black bands on terga III–V.

Bactrocera (Bactrocera) setinervis
(Malloch), n. comb. (Fig. 292)

Dacus setinervis Malloch, 1938: 112–3.
Strumeta setinervis: Perkins, 1938: 6.
Dacus (Strumeta) setinervis: Drew, 1974a: 81–3.

MATERIAL EXAMINED
Holotype ♂, (No.1182), north-west side of Henderson I. at 100 ft., June 1934, E.C. Zimmerman.
LOCATION OF TYPE: Holotype in BPBM.

DISTRIBUTION
Henderson I. (type locality).

DIAGNOSIS
Medium sized species; facial spots absent; humeral calli yellow; notopleural calli fuscous; mesonotum glossy black, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae absent, scutellum glossy black except lateral margins yellow; wing with a narrow fuscous costal band (discontinuous in centre of wing) and a pale fulvous colouration in anal cell, costal cells colourless with microtrichia in outer corner of second costal only; abdominal terga II–V glossy black except for irregularly shaped fulvous spots towards centre of each tergum either side of a broad medial longitudinal fuscous band.
ATTRACTANT: No known record.

COMMENTS
B. setinervis was described adequately by Drew (1974a). It is similar to *B. kirki* in possessing colourless wings except for costal band and anal streak, lateral and medial postsutural vittae absent, scutellum with a broad black band on dorsal surface and humeral calli yellow but differs in having facial spots absent and notopleural calli black.

Bactrocera (Bactrocera) strigata
(Perkins), n. comb. (Figs 293–295)

Chaetodacus strigatus Perkins, 1934: 43–4.
Strumeta strigatus: May, 1963: 50.

MATERIAL EXAMINED
A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: Perkins (1934) did not designate types and no specimens to which the original description can be attributed have been found.

DISTRIBUTION
Known from Stanthorpe (type locality), Gatton and Gayndah in south-east Queensland and Bairnsdale, Victoria.

DIAGNOSIS
Medium sized species; facial spots absent; humeral calli yellow; notopleural calli dark orange-brown; mesonotum red-brown, mesopleural stripe reaching anterior npl. bristle, very short lateral postsutural vittae present, medial postsutural vitta

absent, scutellum fuscous except anterolateral corners yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak and a narrow transverse fuscous band across centre of wing which encloses both crossveins, first costal cell pale fulvous, second costal cell very pale fulvous, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for fuscous on lateral margins of tergum III, pale fuscous to very pale fuscous on lateral margins of terga IV and V, a narrow medial longitudinal band which is very pale fuscous on posterior of tergum III, fuscous on tergum IV and black on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.55 times breadth; fulvous with at most, pale fuscous around orbital bristles and on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with dark facial spots absent; length of face 0.45 mm. Genae fulvous, subocular spots absent; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–6 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a very strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.53 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margins straight; upper hypopleural calli (posterior apices red-brown); anterior ½ lower hypopleural calli (remainder red-brown); 2 very short lateral postsutural vittae tapering posteriorly to end just behind sa. bristles. Notopleural calli dark orange-brown. Postnotum red-brown. Scutellum fuscous except for anterolateral corners yellow. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with a apical black spur.

Wings length 5.3 mm; first costal cell pale fulvous, second costal cell very pale fulvous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening in apex of wing to end between extremities of R_{4+5} and M, narrow transverse fuscous band across wing and enclosing both crossveins, broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I orange-brown except for narrow fuscous lateral margins; tergum II orange-brown; terga III–V orange-brown except for broad fuscous lateral margins on tergum III, narrow pale fuscous to very pale fuscous lateral margins on terga IV and V and a medial longitudinal band which is very pale fuscous on posterior area of tergum III, fuscous on tergum IV and black on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1:1. Apex of piercer broad, narrowing sharply with 1 pair of subapical keels, 2 pairs of small subapical bristles (Fig. 294). Spicules at distal end of middle segment of medium width with a large number of small (sometimes indistinct) dentations (Fig. 295).

ATTRACTANT: No known record.

COMMENTS

B. strigata is similar to *B. angustifasciata*, *B. ismayi*, *B. lampabilis* (Drew), *B. longicornis* Macquart, *B. reclinata*, *B. unilineata* and species in the *frauenfeldi* complex in possessing infuscation across wing as one or more transverse bands and scutellum with a large fuscous or black triangular marking on dorsal surface. It differs from these species in having a red-brown mesonotum and a broad fuscous longitudinal band on the dorsal surface of the scutellum.

Bactrocera (Bactrocera) thistletoni, n. sp.
(Fig. 296)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western Highlands

District: Mt Hagen, 31.iii.1981, attracted to cue lure, B. Thistleton.

Paratypes, PAPUA NEW GUINEA, Western Highlands District: 1 ♂, Mt Hagen, 31.iii.1981, B. Thistleton. Central Province: 1 ♂, Bisianumu, Sogeri Plateau, 25.vi.1980, R.A.I. Drew and D.W. Currey. Western District: 1 ♂, Nomad, 17.xi.1980, P. Senat. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10560) in QM; 1 paratype in ANIC; 2 paratypes in DPI.

DISTRIBUTION

Known from the Western Highlands District, Central Province and Western District, Papua New Guinea.

DIAGNOSIS

Medium sized species; face dark fuscous with large oval black facial spots filling the antennal furrows; humeral calli dark fuscous to black; notopleural calli yellow; mesonotum black, mesopleural stripe of medium width (extending almost to anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow with a broad black basal band; wing with a narrow fuscous costal band and a broad fuscous anal streak, costal cells colourless with microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V black except for a narrow transverse orange-brown band across posterior margin of tergum V and extending as a narrow margin either side of a narrow medial longitudinal dark fuscous band on this tergum.

DESCRIPTION

MALE: Head generally dark coloured. Vertical length 1.5 mm. Frons of even width, length 1.48 times breadth; dark fulvous except dark fuscous centrally on lower ½; anteromedial hump covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fulvous. Ocellar triangle black. Vertex fuscous. Face dark fuscous with 2 large oval black spots filling antennal furrows; length of face 0.45 mm. Genae dark fulvous, dark brown subocular spot present; black bristle present. Occiput black, fulvous along eye margins; occipital row with 6–8 well developed black bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 fuscous; a strong dark fulvous bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.80 mm.

Thorax mesonotum uniformly black. Pleural areas black without pale markings. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin straight; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including broad ventral margins black). Postnotum black. Scutellum yellow except for a broad black basal band. Humeral calli black dorsally, dark fuscous ventrally. Lateral and medial postsutural vittae absent. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and fuscous to black.

Legs fore coxae dark fuscous, mid and hind coxae dark fuscous to black; fore and mid femora black, hind femora with apical ½ black and basal ½ fulvous; fore and mid tibiae fuscous, hind tibiae dark fuscous, all tarsal segments fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells colourless; microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with or just overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak, ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I and II black except for 2 transverse orange-brown bands posterolaterally on tergum II; terga III–V black except for a narrow transverse orange-brown band across posterior margin of tergum V and extending as a narrow margin either side of a narrow medial longitudinal dark fuscous band on this tergum. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. thistletoni is similar to *B. passiflorae* (Froggatt) in possessing wings colourless except for costal band and anal streak, lateral and medial postsutural vittae absent, scutellum entirely yellow and humeral calli black but differs from this species in having large oval black facial spots, legs with fore and mid femora and apical ½ of hind femora black, fore and mid tibiae fuscous and hind tibiae dark fuscous. It is similar to *B. lineata* (Perkins) in general body colour patterns but differs in having microtrichia in outer ½ of second costal cell only, face dark fuscous with large black spots, lateral postsutural vittae absent and mesopleural

stripes extending almost to anterior npl. bristles.

This species is named after Dr B. Thistelton, Mt Hagen, who made extensive collections of Dacinae in Papua New Guinea.

Bactrocera (Bactrocera) trifaria (Drew), n. comb. (Fig. 297)

Dacus (Strumeta) trifarius Drew, 1971: 87–9.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6962) in QM.

DISTRIBUTION

New Britain (type locality, Keravat).

DIAGNOSIS

Medium sized species; large black facial spots present; humeral calli fuscous to black; notopleural calli yellow; mesonotum fuscous to black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a broad medial dark fuscous to black band; wing with a narrow pale fuscous costal band and broad pale fuscous anal streak, costal cells pale fulvous with microtrichia in outer corner of second costal cell only; abdominal terga fulvous except for a broad medial and 2 broad lateral longitudinal black bands over all terga and joined along anterior margin of tergum I.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. trifaria was described adequately by Drew (1971). It is similar to *B. enochra* (Drew) from Bougainville I. in general wing and body colour patterns, but differs in having the mesonotum generally black, humeral calli fuscous to black, scutellum mostly fuscous to black and abdomen with broad lateral and medial longitudinal black bands over terga I–V. *B. trifaria* is similar to *B. atramentata* (Hering) and *B. picea* (Drew) in possessing the mesonotum black (or almost black), scutellum yellow with a medial longitudinal fuscous or black band and wings colourless except for costal band and anal streak. It differs from these species in having abdominal terga not entirely black and costal cells pale fulvous (not colourless).

Bactrocera (Bactrocera) umbrosa (Fabricius), n. comb. (Fig. 298)

Dacus umbrosus Fabricius, 1805: 274.

Dacus fascipennis Wiedemann, 1819: 28; Bezzi, 1913: 72 (syn.); Hardy, 1968: 146 (syn.).

Bactrocera fasciatipennis Doleschall, 1856: 412; Osten-Sacken, 1881 (fide Bezzi, 1913: 69) (syn.).

Dacus conformis Walker, 1857: 34; Osten-Sacken, 1881 (fide Bezzi, 1913: 69) (syn.).

Dacus diffusus Walker, 1860: 153; Hardy, 1959: 169–70 (syn. and lectotype designation), not Hardy and Adachi (1954) as referenced by Drew (1974a).

Dacus frenchi Froggatt, 1909: 92–3; Bezzi, 1919: 417 (syn.).

Dacus (Bactrocera) umbrosus: Malloch, 1939b: 412; Drew 1982: 75–8.

Strumeta umbrosa: Perkins, 1939: 12.

Strumeta frenchi: Perkins, 1939: 13.

Dacus (Strumeta) umbrosus: Hardy and Adachi, 1954: 184; Drew, 1974a: 88–92.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPES: *D. umbrosus*, holotype (sex ?) in ZMC; *D. fascipennis*, holotype ♂ in NHMV; *B. fasciatipennis*, unknown; *D. conformis*, holotype ♀ in BMNH; *D. diffusus*, lectotype ♂ in BMNH; *D. frenchi*, holotype ♀ unknown.

DISTRIBUTION

Widespread throughout South East Asia (type locality, Sumatra), Papua New Guinea, islands of the Bismarck Archipelago, Bougainville I., Solomon Islands, Vanuatu (formerly New Hebrides) and New Caledonia where it occurs in very large populations in lowland areas, particularly in disturbed situations.

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, 3 transverse fuscous bands across wing with the basal 1 joining with the anal streak, costal cells fulvous with microtrichia in outer ½ of second costal cell only; abdominal terga varying from orange-brown with a medial longitudinal black stripe on terga IV and V to orange-brown with a broad medial and 2 broad lateral longitudinal black bands over terga III–V.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. umbrosa bears no close resemblance to other species. It is easily recognised by 3 broad transverse bands across the wings which are red-brown, not the usual fuscous colour.

To conform with the decision made for specimens previously considered types of other

Walker species (see COMMENTS under *B. curvifera*), the male designated as lectotype of *D. diffusus* by Hardy (1959) should not be regarded as a type. The female of this species noted by Hardy (1959) may be regarded as a syntype.

Bactrocera (Bactrocera) unilineata, n. sp.
(Fig. 299)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, 6.iv.1980, attracted to cue lure, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Upper Manki logging area, Bulolo, 15.iv.1980, P. Daur; 1 ♂, Upper Stony logging area, Bulolo, 15.ii.1980, P.Daur; 2 ♂♂, Mt Missim (1500 m and 1600 m), near Wau, 30.x.1980, A. Allison; 2 ♂♂, Mt Missim (1525 m), 20.xi.1980, A. Allison; 7 ♂♂, Mt Missim (1350 m, 1500 m, 1525 m, 1550 m, 1600 m), 18.xii.1980, A. Allison; 1 ♂, Mt Kaindi (1230 m), 19.i.1981, A. Allison. Western Highlands District: 1 ♂, Highlands Agricultural Experiment Station, Mt Hagen, 21.x.1980, B. Thistleton. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10561) and 1 paratype (T.10562) in QM; 3 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 9 paratypes in DPI.

DISTRIBUTION

Known from Morobe Province and Western Highlands District, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral and notopleural calli yellow; mesonotum shining black, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow with a medial longitudinal triangular black band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a very pale fulvous tint, microtrichia in outer ½ of second costal cell only; abdominal terga I–V black except for orange-brown either side of a medial longitudinal black band on tergum II, a medial longitudinal black band on tergum V and a narrow dark fuscous band along posterior margin of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.52 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous without dark markings; length of face 0.48 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fuscous, fulvous along eye margins; occipital row with 4–7 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong dark fuscous to black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum and pleural areas shining black without pale markings. Yellow markings as follows: humeral calli (narrow anterolateral margins black); notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, not continuing to sternopleuron (or if it does it is very small), anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder including ventral margins black); 2 lateral postsutural vittae of medium width, narrowing sharply posteriorly to end approximately midway between sa. and lower pa. bristles. Postnotum black. Scutellum yellow except for a narrow triangular marking on dorsal surface with apex between the sc. bristles. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; femora fulvous tending darker apically; fore tibiae pale fuscous, mid tibiae fulvous except fuscous basally, hind tibiae dark fuscous; all tarsal segments fulvous; mid tibiae each with an apical black spur; rows of short dark setae on dorsal surfaces of fore femora.

Wings length 6.0 mm; costal cells with a very pale fulvous tint; microtrichia in outer ½ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin, a narrow fuscous transverse band across wing enclosing both crossveins; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V black except for orange-brown either side of a broad medial longitudinal black band on tergum II and a narrow dark fuscous band along posterior margin of tergum V. A pair of oval orange-brown to fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. unilineata is similar to *B. angustifasciata*, *B. ismayi*, *B. lampabilis* (Drew), *B. longicornis* Macquart and *B. reclinata* in having infuscation on the wing as a transverse band in addition to costal band and anal streak, mesonotum black with medial postsutural vitta absent and scutellum yellow with a large black triangular marking on dorsal surface. It differs from *B. ismayi*, *B. lampabilis*, *B. longicornis* and *B. reclinata* in having 1 narrow transverse fuscous band across the wing enclosing both crossveins, and from *B. angustifasciata* in having abdominal terga black, costal cells with a pale fuscous tint, costal band confluent with R_{2+3} and humeral calli black around anterior and dorsal margins.

Bactrocera (Bactrocera) unipunctata (Malloch), n. comb. (Fig. 300)

Dacus unipunctatus Malloch, 1939a: 245–6.
Dacus (Strumeta) unipunctatus: Drew, 1974a: 94–6.

MATERIAL EXAMINED

Holotype ♂, Tulagi, Florida I., Solomon Islands, R.A. Lever (no date).
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Tulagi, Florida I., Solomon Islands (type locality).

DIAGNOSIS

Small species; small black facial spots present; humeral and notopleural calli yellow; mesonotum shining red-brown without dark markings, mesopleural stripe reaching to humeral callus, short lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and an extremely pale fulvous anal streak, costal cells colourless, microtrichia covering both costal cells; all abdominal terga shining orange-brown with a large circular black spot on anterocentral margin of tergum V.
ATTRACTANT: No known record.

COMMENTS

B. unipunctata was described adequately by Drew (1974a). Known only from the holotype, it is provisionally placed in *Bactrocera* as the presence or absence of the pecten on abdominal tergum III cannot be confirmed on this damaged teneral specimen. It is similar to *B. humilis* (Drew and Hancock), *B. mutabilis* (May) and species in the *tryoni* complex in possessing wings colourless except for costal band and anal streak, mesonotum red-brown and dense microtrichia covering most of both costal cells. It differs from *B. mutabilis* in having facial spots present and from the other species in having all abdominal terga shining orange-brown with a large circular black spot on anterocentral margin of tergum V and without other dark colour patterns.

Subgenus **Gymnodacus** Munro

Bactrocera (Gymnodacus) calophylli (Perkins and May), n. comb. (Figs 301–303)

Asiadacus calophylli Perkins and May, 1949: 16–18.
Dacus (Gymnodacus) calophylli: Hardy, 1951: 130–1.
Gymnodacus calophylli: May, 1963: 42, 49.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); 8 specimens of the type series.
LOCATION OF TYPES: Lectotype ♀ (T.5259) and paralectotype ♂ (T.5258) in QM; 6 paralectotypes in UQ.

DISTRIBUTION

Known only from coastal rainforests in the Cairns district, Queensland (type locality).

DIAGNOSIS

Small to medium sized species; facial spots small and elongate; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe of medium width reaching anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs generally fulvous with fore tibiae very pale fuscous and hind tibiae pale fuscous; wing with a broad fuscous costal band, anal cell pale fuscous and anal streak absent, costal cells with a very pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad transverse black band across anterior margin of tergum III and a broad medial longitudinal black band over all 3 terga and narrow lateral fuscous margins on terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.67 times breadth; fulvous with fuscous on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small elongate fuscous spots; length of face 0.38 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput red-brown, fulvous along eye margins; occipital row with a large number of small

dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.25 mm; 0.58 mm.

Thorax mesonotum black except brown markings as follows: below and behind lateral postsutural vittae, inside lateral postsutural vittae, around mesonotal suture, inside humeral calli. Pleural areas black except pale below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width and narrowing posteriorly to end well before upper pa. bristles. Postnotum black. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except fore tibiae very pale fuscous and hind tibiae pale fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.2 mm; costal cells with a very pale fuscous tint; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and overlapping this vein at extremity (there is a very narrow pale fuscous area above R_{4+5} beyond r–m crossvein), pale fuscous in anal cell (anal streak absent); no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; tergum II orange-brown with a narrow transverse black band across anterior area but not reaching lateral margins; terga III–V orange-brown except for a broad transverse black band across anterior margin of tergum III (anterolateral corners of tergum III dark fuscous), a broad medial longitudinal black band over all 3 terga, narrow lateral fuscous margins on terga IV and V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.52:1. Apex of piercer elongate, narrow and rounded at tip with 3 pairs of very small subapical bristles (Fig.302). Spicules at distal end of middle segment indistinct, of medium width, with 7–12 very small dentations of even size (Fig. 303).

ATTRACTANT: No known record.

COMMENTS

B. calophylli, *B. hastigerina* (Hardy) and *B. petila* are the only species of subgenus *Gymnodacus* known in the South Pacific region. *B. calophylli* is distinct in having a black mesonotum, broad costal band confluent with R_{4+5}, abdominal terga III–V orange-brown with a broad medial longitudinal black band and 2 narrow lateral longitudindal dark bands which are joined along base of tergum III by a broad black band. Originally, Perkins and May (1949) did not define type specimens. The authors stated that the species was "described from two males and six females bred from fruits of *Calophyllum inophyllum* Linn. collected at Cairns in February, 1938". Two of these specimens (T.5258 and T.5259 in QM), a male and a female, each have a holotype label while the other 6 specimens in UQ bear paratype labels. I designate the female (T.5259) as lectotype and the remaining specimens paralectotypes.

Bactrocera (Gymnodacus) hastigerina (Hardy), n. comb.

Dacus (*Gymnodacus*) *hastigerinus* Hardy, 1954: 19–21; Drew, 1974a: 10.

MATERIAL EXAMINED

NEW BRITAIN: 1 ♂ paratype, Keravat, bred ex *Spondias* sp., October 1949, N.L.H. Krauss.

LOCATION OF TYPE: Holotype ♂ in NMNH.

DISTRIBUTION

Keravat, New Britain (type locality).

DIAGNOSIS

Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and very narrow pale fuscous anal streak, costal cells pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V red-brown with a narrow medial longitudinal pale fuscous band over all 3 terga.

ATTRACTANT: No known record.

COMMENTS

B. hastigerina was described adequately by Hardy (1954) and Drew (1974a). It differs from *B. calophylli* (Perkins and May) in having the mesonotum red-brown with a pattern of fuscous markings, costal band narrow (overlapping R_{2+3} but not reaching R_{4+5}) and abdominal terga III–V red-brown with a narrow medial longitudinal pale fuscous band.

Bactrocera (Gymnodacus) petila, n. sp.
(Fig. 304)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Nami Creek, Mt Kaindi (1650 m), attracted to cue lure, 4.v.1981, A. Allison.

LOCATION OF TYPE: Holotype (T.10563) in QM.

DISTRIBUTION

Known only from Nami Creek, Mt Kaindi, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized irregularly oval black facial spots present; humeral and notopleural calli yellow; mesonotum black with a broad medial longitudinal dark fuscous pattern, mesopleural stripe narrow and equal in width to notopleural callus, lateral postsutural vittae of medium width and ending at or just before upper pa. bristles, medial postsutural vitta absent, scutellum yellow; wing with a fuscous tint and with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous, microtrichia in outer corner of second costal cell only; abdominal tergum III black, abdominal terga IV and V fuscous except for a broad medial longitudinal black band and 2 broad lateral longitudinal black bands joining along anterior margin of tergum IV.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.5 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered with a small number of short dark setae; orbital bristles dark fuscous: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with medium sized irregularly oval black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; fuscous bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with 3–5 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.19 mm; 0.26 mm; 0.78 mm.

Thorax mesonotum black except for a medial longitudinal dark fuscous pattern. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder including broad ventral margins black); 2 lateral postsutural vittae of medium width, narrowing slightly posteriorly to end at or just before upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs all coxae dark fuscous; all other segments fulvous except fore tibiae fuscous and hind tibiae dark fuscous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.6 mm; costal cells fuscous (second cell slightly paler); microtrichia in outer corner of second costal cell only; remainder of wings with a pale fuscous tint, a fuscous subcostal cell, a narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen elongate-oval; terga free; no pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II red-brown except for a broad transverse black band across anterior ⅔ and widening to cover lateral margins; tergum III black; terga IV and V fuscous except for a broad medial longitudinal black band and 2 broad lateral longitudinal black bands which join along anterior margin of tergum IV and a narrow transverse red-brown band across posterior margin of tergum V. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. petila is similar to *B. buloloensis* and *B. congener* (subgenus *Bactrocera*) in possessing colourless wings except for costal band and anal streak, mesonotum mostly black, abdominal terga

not entirely black, lateral postsutural vittae ending posterior to sa. bristles and costal cells pale fuscous to fuscous. It differs from these species in having the mesonotum with a very broad dark fuscous band anteromedially, abdominal terga fuscous to black with red-brown posterocentrally on tergum IV and centrally on tergum V and pecten on tergum III absent. It differs from the other species of subgenus *Gymnodacus*, *B. calophylli* (Perkins & May) and *B. hastigerina* (Hardy), in having the mesonotum and abdomen almost all black.

Subgenus **Notodacus** Perkins

Bactrocera (Notodacus) xanthodes (Broun), n. comb. (Figs 305–307)

Tephrites (*Dacus*) *xanthodes* Broun, 1905: 3–4.
Dacus (*Tephrites*) *xanthodes*: Froggatt, 1909: 91.
Chaetodacus xanthodes: Bezzi, 1928: 105–6.
Dacus xanthodes: Malloch, 1931: 260–61.
Notodacus xanthodes: Perkins, 1937: 56–7; Perkins, 1939: 24–5.
Dacus (*Notodacus*) *xanthodes*: Hardy, 1955b: 434; Drew, 1974a: 11–14.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: No types were designated by Broun (1905) and no specimens to which the original description can be attributed are known to exist. In the original description, *B. xanthodes* was recorded as being bred from fruits imported into New Zealand from Suva, Tonga and Rarotonga in the Cook Is.

DISTRIBUTION
Known from Fiji, Western Samoa, Tonga, Cook Is and Vanuatu (formerly New Hebrides). Drew's statement (1974a) that this species probably does not occur in the Cook Is is incorrect (Bateman 1985).

DIAGNOSIS
Medium sized species; small black facial spots present; humeral calli fulvous except for a broad yellow band on posterior ⅔; notopleural calli orange-brown; mesonotum transparent with a shining orange-brown colouration and with irregular dark markings, broad lateral yellow band running from humeral calli to end just before lateral postsutural vittae, large yellow spot on pleural region in place of the normal mesopleural stripe, lateral postsutural vitta present and beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum orange-brown with lateral yellow margins; wing with a narrow fuscous costal band and a broad fulvous anal streak, costal cells extremely pale fulvous with microtrichia in outer corner of second costal cell only; all abdominal terga transparent and shining orange-brown with no dark markings.

DESCRIPTION
FEMALE: Ovipositor apex of piercer rounded at tip with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 306). Spicules at distal end of middle segment of medium width with 7–12 dentations of markedly uneven length (Fig. 307).

HOST PLANTS
NEW RECORDS: 1 commercial host, watermelon, *Citrullus lanatus* (Cucurbitaceae), December 1985, in Tonga (pers. comm. Plant Quarantine and Health Branch, Canberra, Australia); 1 wild host, *Barringtonia edulis* (Barringtoniaceae), Efate, Vanuatu, 4.xii.1986, E. Kanas.
ATTRACTANT: Methyl eugenol.

COMMENTS
B. xanthodes was described adequately by Drew (1974a). It is a unique species having a pair of well developed humeral bristles, the integument on the head, thorax and abdomen transparent and giving a mottled appearance due to internal tissues being visible, a soft integument particularly noticeable on the abdomen where the terga fold ventrally in dead specimens.

Subgenus **Polistomimetes** Enderlein

Bactrocera (Polistomimetes) decurtans (May), n. comb. (Figs 308–310)

Daculus decurtans May, 1965: 61–2.

MATERIAL EXAMINED
A large series of specimens (including 1 paratype) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.6310) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: Northern Territory (type locality, Berrimah), including Melville I. and northern Western Australia.
NEW RECORDS: Torres Strait islands: Badu, Moa (Banks), Yorke and Queensland: eastern coastal areas of Cape York Peninsula (records from Plant Quarantine Survey).

DIAGNOSIS
Medium sized species; large circular black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe

reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except fore tibiae pale fuscous and hind tibiae fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous with microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V orange-brown except for a narrow transverse dark fuscous band along anterior margin of tergum III, narrow pale fuscous margins on each tergum, a medial longitudinal band which is fuscous on posterior ⅓ of tergum III, dark fuscous on tergum IV and black on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.57 times breadth; fulvous with at most, pale fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large circular black spots; length of face 0.43 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 5–9 red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a red-brown dorsal bristle on segment 2; arista red-brown (fulvous basally); length of segments: 0.18 mm; 0.28 mm; 0.73 mm.

Thorax mesonotum red-brown without dark markings. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices fuscous); anterior 3/5 lower hypopleural calli (remainder fuscous); 2 broad lateral postsutural vittae narrowing slightly posteriorly to end before upper pa. bristles. Postnotum fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except fore tibiae pale fuscous and hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.7 mm; costal cells pale fuscous (second cell paler); microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I pale fuscous; tergum II orange-brown, tending fulvous along posterior margin either side of midline; terga III–V orange-brown except for a narrow transverse dark fuscous band across anterior margin of tergum III, narrow pale fuscous lateral margins on terga III, IV and V and a medial longitudinal band which is fuscous on posterior ⅓ of tergum III, dark fuscous on tergum IV and black on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.74:1. Apex of piercer broad with 3 pairs of subapical keels; 3 pairs of subapical bristles (1 large and 2 small) (Fig. 309). Spicules at distal end of middle segment of medium width with 10–16 dentations of uniform size (Fig. 310).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. decurtans is similar to *B. fuscalata* and *B. murrayi* (Perkins) in possessing yellow humeral calli, mesonotum red-brown or dark fuscous with lateral postsutural vittae present and medial postsutural vitta absent. It is similar to *B. murrayi* and differs from *B. fuscalata* in having a uniformly red-brown mesonotum, wings colourless except for costal band and anal streak and abdominal terga orange-brown with dark markings. It differs from *B. murrayi* in having the lateral postsutural vittae ending before the upper pa. bristles and the apex of the piercer of the ovipositor with 3 pairs of subapical lobes. *B. decurtans* and *B. bidentata* (May) are similar in external body colour patterns and in possessing a trilobed apex of aculeus. Although *B. decurtans* is placed in subgenus *Polistomimetes*, (lacking prsc. and sa. bristles), it may be a subgenus *Bactrocera* species. *B. decurtans*

and *B. bidentata* can be separated on the slight difference in shape of the apex of aculeus (Figs 61, 309).

Bactrocera (Polistomimetes) fuscalata, n. sp. (Fig. 311)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau, atttracted to methyl eugenol, 1.xii.1980, A. Allison.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Mt Missim (1600 m), 11.xii.1980, A. Allison. Western Highlands District: 1 ♂, Kuk Agricultural Research Institute, Mt Hagen, 28.x.1980, B. Thistleton. Paratypes attracted to methyl eugenol.

LOCATION OF TYPES: Holotype (T.10564) in QM; 2 paratypes in DPI.

DISTRIBUTION

Known from Morobe Province and Western Highlands District, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous without dark spots; humeral and notopleural calli yellow; mesonotum dark fuscous, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing generally fuscous, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V dull black.

DESCRIPTION

MALE: Head generally dark fulvous. Vertical length 1.43 mm. Frons narrowing slightly posteriorly, length 1.38 times breadth; dark fulvous without dark markings; anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or; lunule dark fulvous. Ocellar triangle black. Vertex dark fulvous. Face fulvous without dark spots; length of face 0.58 mm. Genae dark fulvous, large fuscous subocular spot present; black bristle present. Occiput fuscous, fulvous along eye margins; occipital row with 4–5 well developed black bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 fulvous except dark fuscous on apex and outer surface; a black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum dark fuscous. Pleural areas dark fuscous, tending black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, anterior margin slightly convex; upper hypopleural calli (posterior apices dark fuscous); anterior ⅓ lower hypopleural calli (remainder dark fuscous); 2 parallel sided lateral postsutural vittae ending at upper pa. bristles. Postnotum dark fuscous. Scutellum yellow except for narrow dark fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs fore coxae dark fuscous, mid and hind coxae fuscous; fore femora dark fuscous, mid and hind femora fuscous; fore and hind tibiae fuscous, mid tibiae fulvous; basal segment of tarsi fulvous, remaining segments fuscous; mid tibiae each with an apical black spur; fore femora with a row of long pale setae on dorsal surface.

Wings length 6.0 mm; costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; remainder of wings fuscous except for a dark fuscous subcostal cell, dark fuscous along costal margin to apex of R_{2+3}, a narrow dark fuscous anal streak reaching wing margin; a dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I wider than long. Abdominal sterna I and II slightly longer than wide. Tergum I dark fuscous to black; tergum II dark fuscous; terga III–V dull black. A pair of oval dull black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. fuscalata is similar to *B. decurtans* (May) and *B. murrayi* (Perkins) in possessing a pale mesonotum, yellow humeral calli, lateral postsutural vittae present and medial postsutural vitta absent but differs from these species in having the mesonotum dark fuscous, fuscous colouration over the apical ½ of wing and abdominal terga III–V dull black.

Bactrocera (Polistomimetes) mesonotochra, n. sp. (Fig. 312)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Bubia, near Lae, 28.xii.1963, D.K. McAlpine.

LOCATION OF TYPE: Holotype (T.10565) in QM.

DISTRIBUTION

Known only from Bubia, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with medium sized black spots; humeral calli yellow (pale red-brown along anterior and ventral margins); notopleural calli yellow; broad yellow band connecting humeral and notopleural calli; mesonotum pale red-brown, lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a broad fuscous costal band confluent with R_{4+5}, costal cells fuscous, dense microtrichia covering both costal cells; abdominal terga III–V orange-brown with a narrow transverse fuscous band along anterior margin of tergum III and with fuscous on lateral margins of tergum III and anterolateral margins of terga IV and V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.56 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of small dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized oval black spots, not reaching epistoma; length of face 0.6 mm. Genae fulvous, fuscous subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–7 well developed black bristles. Antennae segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.2 mm; 0.40 mm; 1.08 mm.

Thorax mesonotum pale red-brown. Pleural areas pale red-brown except fuscous along anterior margin of mesopleural stripe. Yellow markings as follows: humeral calli (pale red-brown along anterior and ventral margins); notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; a broad band connecting humeral and notopleural calli; 2 lateral postsutural vittae tapering posteriorly to end before the upper pa. bristles; a broad medial postsutural vitta rounded posteriorly at level of upper pa. bristles and tapering anteriorly to end at level of mesonotal suture; upper hypopleural calli (posterior apices pale red-brown); anterior ⅔ lower hypopleural calli (remainder pale red-brown). Postnotum pale red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except with a pale fuscous tint on basal ½ of fore tibiae and on hind tibiae; mid tibiae each with an apical black spur; fore femora with a row of long setae on dorsal and ventral surfaces.

Wings length 6.2 mm; costal cells fuscous, dense microtrichia covering both coastal cells; remainder of wings colourless except for dark fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and overlapping R_{4+5} at apex of wing where it merges into the general membrane colour, anal streak absent but with fuscous tint in anal cell; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I wider than long. Abdominal sterna I and II as long as wide. Tergum I pale fuscous; tergum II orange-brown, tending whitish posteriorly and pale fuscous on lateral margins; terga III–V covered with a dense golden pubescence, orange-brown except for a narrow transverse fuscous band along anterior margin of tergum III which widens to cover lateral margins, anterolateral margins of terga IV and V fuscous. A pair of oval fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a moderate concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. mesonotochra is similar to *B. neopagdeni*, *B. pagdeni* (Malloch) and *B. visenda* (Hardy) in possessing lateral and medial postsutural vittae. It differs from *B. neopagdeni* and *B. pagdeni* and is similar to *B. visenda* in having wings not entirely infuscated and abdominal terga orange-brown with dark patterns. It differs from *B. visenda* in lacking a transverse fuscous band across the wing and in having the humeral and notopleural calli joined by a lateral yellow band, the mesopleural stripe of medium width and not extending to the humeral callus.

Bactrocera (Polistomimetes) murrayi (Perkins), n. comb. (Figs 313–315)

Daculus murrayi Perkins, 1939: 25–6; May, 1963: 41, 49.
Dacus (Daculus) murrayi: Hardy, 1951: 125–7; Drew, 1974a: 3–6.

MATERIAL EXAMINED

A series of specimens (including paralectotypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Lectotype ♂ in SAM (see Drew 1974a).

DISTRIBUTION

PREVIOUSLY RECORDED: Eastern coastal areas of north Queensland (north from Innisfail) and the Torres Strait islands: Moa (Banks), Murray (type locality).

NEW RECORDS: Torres Strait islands: Badu, Stephens, Thursday (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized circular black facial spots present; humeral and notopleural calli yellow; mesonotum pale red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a dark fuscous to black transverse band across anterior margin of tergum III and fuscous to dark fuscous narrow lateral margins on terga III, IV and V and a medial longitudinal black band over all 3 terga which ends before posterior margin of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.7 mm. Frons narrowing slightly posteriorly, length 1.6 times breadth; fulvous with, at most, pale fuscous on anteromedial hump; latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots; length of face 0.53 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–9 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.80 mm.

Thorax mesonotum pale red-brown without dark markings. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous); 2 parallel sided lateral postsutural vittae reaching upper pa. bristles. Postnotum fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.7 mm; costal cells fulvous (second cell slightly paler); microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I red-brown; tergum II fulvous except for a broad transverse red-brown band across anterior ⅓, widening to cover lateral margins and with a narrow transverse black band across centre; terga III–V orange-brown except for a transverse dark fuscous to black band across anterior margin of tergum III, narrow fuscous to dark fuscous lateral margins on each tergum and a medial longitudinal black band over all 3 terga but ending before posterior margin of tergum V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.2:1. Apex of piercer narrow and needle shaped at tip with 4 pairs of subapical bristles (2 large and 2 small) (Fig. 314). Spicules at distal end of middle segment of medium width with 8–10 small dentations of approximately equal size (Fig. 315).

HOST PLANTS

NEW RECORD: 10 ♀♀ and 9 ♂♂ ex *Ficus* sp. (Moraceae), Etty Beach, near Innisfail, north Queensland, January 1983, A. Stocker.

ATTRACTANT: No known record.

COMMENTS

B. murrayi can be confused with *B. decurtans* (May). Both species have a uniformly red-brown mesonotum, humeral calli yellow, lateral postsutural vittae present, medial postsutural vitta absent, colourless wings except for costal band and anal streak and abdominal terga orange-brown with dark markings. *B. murrayi* differs in having the lateral postsutural vittae ending at the upper pa. bristles and the apex of the piercer of the ovipositor needle shaped.

Bactrocera (Polistomimetes) neopagdeni, n. sp. (Fig. 316)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Central Province: 20 km SE Port Moresby, hand collected on bushes, 26.i.1985, J.W.Ismay.

LOCATION OF TYPE: Holotype (T.10567) in QM.

DISTRIBUTION

Known only from the Central Province, Papua New Guinea.

DIAGNOSIS

Medium to large sized species; facial spots present; yellow humeral and notopleural calli connected by a broad yellow band; mesonotum dark red-brown, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae present, scutellum yellow; legs fulvous except basal ⅔ of fore tibiae and hind tibiae fuscous; wing with a broad fuscous costal band, anal streak reduced to very pale infuscation within anal cell, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V fulvous except for 2 broad lateral longitudinal fuscous bands over all 3 terga and connected along anterior margin of tergum III.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.8 mm. Frons of even width, length 1.5 times breadth; fulvous without dark markings, anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 3 i.or. (1 pair very small); lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with moderately large pear shaped black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fulvous; occipital row with 4–6 strong black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segment: 0.20 mm; 0.35 mm; 0.95 mm.

Thorax mesonotum red-brown without dark markings. Pleural areas red-brown except fuscous along anterior margin of mesopleural stripe. Yellow markings as follows: humeral calli; notopleural calli; a broad band connecting humeral and notopleural calli; mesopleural stripe of medium width, reaching midway between anterior marign of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly concave; upper hypopleural calli (posterior apices red-brown); anterior ⅓ lower hypopleural calli (remainder red-brown); 2 narrow parallel sided lateral postsutural vittae ending before upper pa. bristles; a moderately broad medial postsutural vitta rounded posteriorly at level of upper pa. bristles and narrowing anteriorly to end just behind level with mesonotal suture. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except basal ⅔ of fore tibiae and all of hind tibiae fuscous and apical 4 segments of fore tarsi red-brown; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.7 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings with a very pale fulvous tint except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and merging into tint across wing. The anal streak is reduced to a fulvous tint within the anal cell; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga free; no pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II red-brown except anterolateral corners fuscous and a narrow transverse fulvous band across posterior margin; terga III–V fulvous except for 2 broad lateral longitudinal fuscous to dark fuscous bands which are joined by a narrow fuscous to dark fuscous band along anterior margin of tergum III. A pair of oval red-brown shining spots on tergum V. Basal segment of ovipositor very long, red-brown and cylindrical so that it is circular in transverse cross section. Ratio of length of oviscape to length of tergum V 2.3:1. The apex of the piercer has 1 pair of subapical lobes and lateral indentations.

ATTRACTANT: No known record.

COMMENTS

B. neopagdeni is similar to *B. pagdeni* (Malloch) in the unique body shape and size and shape of the basal segment of the ovipositor but differs in possessing a red-brown mesonotum, a pale fulvous tint in wing membrane (not a general fuscous pattern), legs not entirely fulvous, abdominal terga III–V fulvous with broad lateral longitudinal fuscous bands (not entirely fuscous).

Bactrocera (Polistomimetes) pagdeni
(Malloch), n. comb. (Fig. 317)

Dacus pagdeni Malloch, 1939a: 243–5.
Dacus (Daculus) pagdeni Drew, 1974a: 6–8.

MATERIAL EXAMINED

Holotype ♀, Tulagi Ridge, Florida I., Solomon Is, March 1934, H.T. Pagden.
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Florida I., Solomon Islands (type locality).

DIAGNOSIS

Large species; medium sized black facial spots present; humeral and notopleural calli yellow and joined by a broad lateral yellow band; mesonotum dull black, mesopleural stripe reaching almost to anterior npl. bristle, narrow short lateral postsutural vittae present, medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band and anal streak, entire wing membrane with a general fuscous colouration, costal cells fuscous, microtrichia covering both costal cells; abdominal terga III–V fuscous with shining spots on tergum V black.
ATTRACTANT: No known record.

COMMENTS

B. pagdeni was described adequately by Drew (1974a). It is similar to *B. neopagdeni* in general body shape, wing colour patterns, abdominal colouration and in having lateral and medial postsutural vittae but differs in having a black mesonotum, wings with a general fuscous colouration, legs entirely fulvous and abdominal terga entirely fuscous.

Bactrocera (Polistomimetes) toxopeusi
(Hering), n. comb. (Fig. 318)

Daculus toxopeusi Hering, 1953: 510.
Dacus (Daculus) toxopeusi Drew, 1974a: 8–10.

MATERIAL EXAMINED

Holotype ♂, Hollandia, Irian Jaya, July 1938, L.J. Toxopeus.
LOCATION OF TYPE: Holotype in RNH.

DISTRIBUTION

Irian Jaya (type locality, Hollandia, now known as Jayapura).

DIAGNOSIS

Medium sized species; large oval black facial spots present; humeral calli brown; notopleural calli yellow; mesonotum dull black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a narrow pale fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia covering most of second costal cell; abdominal tergum I black, abdominal terga II–IV dark fuscous to black, abdominal tergum V dark orange-brown with anterior and anterolateral margins fuscous.
ATTRACTANT: No known record.

COMMENTS

B. toxopeusi was described adequately by Drew (1974a). It is similar to *B. decurtans* (May), *B. fuscalata* and *B. murrayi* (Perkins) in having lateral postsutural vittae present and medial postsutural vitta absent but differs from these species in having a black mesonotum and black humeral calli.

Bactrocera (Polistomimetes) visenda
(Hardy), n. comb. (Figs 319–321)

Dacus (Heterodaculus) visendus Hardy, 1951: 134–8.
Daculus visendus May, 1963: 40, 49.
Dacus (Daculus) visendus Drew, 1974a: 10.
Dacus (Polistomimetes) visendus: Drew, 1979: 76.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ in NMNH.

DISTRIBUTION

PREVIOUSLY RECORDED: Widespread in southern coastal areas of Papua New Guinea (Western and Central Provinces), eastern coastal areas of Queensland, north from latitude 17-db- S (type locality, Babinda).
NEW RECORDS: Torres Strait islands: Badu, Boigu, Darnley, Dauan, Horn, Murray, Saibai, Thursday, Yam (records from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli

yellow; mesonotum red-brown with irregular pale fuscous blotches, broad mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae present, scutellum yellow; legs fulvous except hind tarsi pale fuscous; wing with a broad fuscous costal band and anal streak, a broad fuscous band across centre of wing which encloses both crossveins, costal cells fuscous with microtrichia covering second costal cell and outer ⅓ of first costal cell; abdominal terga III–V orange-brown with 2 broad lateral longitudinal fuscous to dark fuscous bands, oval shining spots on tergum V reduced to narrow transverse dark fuscous elongate markings.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with pale fuscous on anteromedial hump, latter covered by small number of short dark setae; orbital bristles red-brown to fuscous: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.5 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 6–8 pale red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.30 mm; 0.85 mm.

Thorax mesonotum red-brown with irregular pale fuscous blotches. Pleural areas pale fuscous to dark fuscous. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin concave; upper hypopleural calli (posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous); 2 narrow lateral postsutural vittae tapering posteriorly to end well before upper pa. bristles; a broad medial longitudinal postsutural vitta broadly rounded posteriorly and tapering anteriorly to end in a point just anterior of mesonotal suture. Postnotum fuscous. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 5.6 mm; costal cells fuscous; microtrichia covering second costal cell and outer ⅓ of first costal cell; remainder of wings with a pale fuscous tint except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} (except for a pale spot just beyond r–m crossvein) and not distinctly overlapping R_{4+5} at extremity of wing, a broad fuscous band across centre of wing from costal band to hind margin and enclosing both crossveins, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous; tergum II fulvous except for a broad transverse dark fuscous band across anterior ½ and widening to cover lateral margins; terga III–V orange-brown except for 2 broad lateral longitudinal fuscous to dark fuscous bands over all 3 terga. A pair of narrow transverse dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment dark red-brown, oval in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.4:1. Apex of piercer needle shaped with 4 pairs of subapical bristles (1 pair large) (Fig. 320). Spicules at distal end of middle segment narrow with 3–5 dentations of equal size on intersegmental line and changing to large triangular scales proximally (Fig. 321).

ATTRACTANT: Methyl eugenol.

COMMENTS

B. visenda is similar to *B. mesonotochra* in possessing lateral and medial postsutural vittae, a red-brown mesonotum, wings not entirely infuscated and abdominal terga orange-brown with dark markings but differs in having a broad transverse fuscous band across wing, humeral and notopleural calli not joined by a lateral yellow band and mesopleural stripe reaching humeral callus.

Trypetidacus, n. subgen.

Bactrocera (Trypetidacus) invisitata, n. sp.
(Fig. 322)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Kaindi (1450 m), attracted to methyl eugenol, 1.vi.1981, A. Allison.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, 25.v.1981, 1 ♂, 8.vi.1981, Mt Kaindi (1650 m), A. Allison; 2 ♂♂, Nami Creek, Mt Kaindi (1650 m), 11.v.1981, A. Allison; all above paratypes attracted to methyl eugenol. Eastern Highlands Province: 1 ♂, 1 ♀, Daulo Pass (2500 m), 2.v.1959, C.D. Michener; 1 ♂, Daulo Pass, 20.v.1968, J. and M. Sedlacek.

LOCATION OF TYPES: Holotype (T.10568) in QM; 7 paratypes in DPI.

DISTRIBUTION

Known from Mt Kaindi (above 1450 m), Morobe Province and Daulo Pass (2500 m), Eastern Highlands Province, Papua New Guinea.

DIAGNOSIS

Small glossy black species; facial spots absent; humeral calli yellow (except anterior ¼ pale fuscous); notopleural calli yellow; mesonotum glossy black, mesopleural stripe broad reaching anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow; wing with a very narrow fuscous costal band, anal streak absent, anal cell extension very short, costal cells with a very pale fuscous tint, microtrichia in extreme outer corner of second costal cell only; abdominal terga III and IV glossy dark fuscous to black except for irregular orange-brown markings posterocentrally on both terga and irregular fuscous markings anterocentrally on tergum IV, tergum V orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 0.93 mm. Frons of even width, length 1.53 times breadth; fulvous with fuscous around s.or. bristles and on anteromedial hump; latter with just a few small dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous, facial spots absent; length of face 0.38 mm. Genae fulvous, pale brown subocular spot present; red-brown bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with 5–8 small pale bristles. Antennae with all segments fulvous; no well developed dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.08 mm; 0.15 mm; 0.41 mm.

Thorax mesonotum glossy black without pale markings. Pleural areas glossy black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli (except anterior ¼ pale fuscous); notopleural calli; broad mesopleural stripe, extending to anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin convex; anterior ¾ lower hypopleural calli (remainder black). Upper hypopleural calli glossy black. Lateral and medial postsutural vittae absent. Postnotum glossy black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 2; all bristles small and black.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except apices of hind femora fuscous and hind tibiae entirely fuscous; mid tibiae each with an apical black spur.

Wings length 4.5 mm; costal cells with a pale to very pale fuscous tint; microtrichia in extreme outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, very narrow costal band confluent with R_{2+3} and widening slightly in apex of wing to reach M, very narrow infuscations around r–m and dm–cu crossveins, pale fuscous in anal cell; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak. The wing is long and narrow and the anal cell extension is short as in the subfamily Trypetinae.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I glossy dark fuscous to black; tergum II glossy dark fuscous to black except orange-brown across posterior margin; terga III and IV glossy dark fuscous to black except irregular orange-brown areas posterocentrally on both terga and fuscous anterocentrally on tergum IV; tergum V orange-brown except fuscous along anterior margin. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. invisitata is a unique species with some characters not present in other species of Dacinae. It has very short antennae and anal cell extension, characteristic of the Trypetinae. Also, this species has very long narrow wings with markings consisting of an extremely narrow costal band continuing around the wing margin to CuA_1, narrow infuscation around crossveins and no distinct anal streak. The general wing venation and thoracic chaetotaxy are characteristic of Dacinae.

Melanodacus Group of Subgenera

Hemisurstylus, n. subgen.

Bactrocera (Hemisurstylus) melanoscutata, n. sp. (Fig. 323)

TYPE SPECIMENS

Holotype ♂, NEW BRITAIN: Lowlands Agricultural

Experiment Station, Keravat, bred from fruit of *Garcinia xanthochymus* in orchard, 3.ix.1970, D.F. O'Sullivan.

Paratypes, NEW BRITAIN: 2 ♂♂, bred from fruit of *G. xanthochymus*, Lowlands Agricultural Experiment Station, Keravat, 3.ix.1970, D.F. O'Sullivan.

LOCATION OF TYPES: Holotype (T.10569) in QM; 2 paratypes in DPI.

DISTRIBUTION

Known only from Keravat, New Britain.

DIAGNOSIS

Medium sized species; face fulvous with very large black facial spots; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width (ending just before anterior npl. bristle), scutellum yellow with a broad medial longitudinal black band; wing with a broad pale fuscous costal band and broad fuscous anal streak, costal cells pale fuscous, microtrichia in outer corners of both cells; abdominal terga II–V pale orange-brown except for a broad medial and 2 broad lateral longitudinal black bands over all 4 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 2.05 mm. Frons of even width, length 1.89 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump; latter covered by a large number of small pale bristles; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with very large oval black spots reaching epistoma; length of face 0.6 mm. Genae fulvous, fuscous subocular spot present; black bristle present. Occiput fuscous, yellow along eye margins; occipital row with 3–7 well developed black bristles and a large number of small paler bristles. Antennae with segments 1 and 2 fulvous, segment 3 fuscous; a black dorsal bristle on segment 2; arista black (fulvous basally); length of segment: 0.25 mm; 0.38 mm; 1.2 mm.

Thorax mesonotum black. Pleural areas black except dark fuscous below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, ending just before anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; 2 parallel sided lateral postsutural vittae ending just before upper pa. bristles; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder including ventral margin black). Postnotum black. Scutellum yellow except for a broad medial longitudinal black band. Bristles: sc. 4; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; femora fulvous except apical ⅓ of each femur dark fuscous; fore and mid tibiae fuscous, hind tibiae dark fuscous; tarsi fulvous; mid tibiae each with an apical black spur; fore femora with rows of long dark setae on dorsal surface.

Wings length 7.5 mm; costal cells pale fuscous, microtrichia in outer corners of both cells; remainder of wings with a very pale fuscous tint, a pale fuscous subcostal cell, broad pale fuscous costal band confluent with R_{4+5} (except for a paler area above this vein towards apex of wing) and ending between extremities of R_{4+5} and M, pale fuscous surrounding r–m crossvein, a broad fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III; tergum I and sterna I and II wider than long. Tergum I black. Terga II–V pale orange-brown except for a broad medial and 2 broad lateral longitudinal black bands which join at posterior end of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short and stout, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. melanoscutata is distinct in having the posterior lobe of the surstylus short and stout (as in the *Bactrocera* group of subgenera), the posterior margin of abdominal sternum V with a slight concavity (as in the *Zeugodacus* group of subgenera), a broad black band on the scutellum, broad fuscous costal band confluent with R_{4+5}, pale infuscation over entire wing membrane and darker infuscation along r–m crossvein.

Subgenus **Hemizeugodacus** Hardy

Bactrocera (Hemizeugodacus) abdomininigra, n. sp. (Fig. 324)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Naibata Banda logging area, Bulolo, hand collected on ground, 13.v.1980, H. Ivagai.

LOCATION OF TYPE: Holotype (T.10570) in QM.

DISTRIBUTION

Known only from Bulolo, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli glossy black; posterior ½ notopleural calli yellow (anterior ½ glossy black), mesonotum glossy black, medium sized mesopleural stripe extending to anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow with a broad triangular black basal band; wing with a very narrow fuscous costal band and narrow fuscous anal streak, costal cells colourless with microtichia in outer corner of second cell only; abdominal terga I–V glossy black except for 2 transverse orange-brown bands along posterior margin of tergum II either side of midline.

DESCRIPTION

MALE: Head vertical length 1.3 mm. Frons of even width, length 1.53 times breadth; fulvous with dark fuscous around orbital bristles and on anteromedial hump, latter covered with a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fuscous. Ocellar triangle black. Vertex dark fuscous. Face fulvous without dark facial spots; length of face 0.4 mm. Genae fulvous, brown subocular spot present; dark fuscous bristle present. Occiput black dorsally, fulvous ventrally, yellow along eye margins; occipital row with 6 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.23 mm; 0.60 mm.

Thorax mesonotum and pleural areas glossy black without pale markings. Yellow markings as follows: posterior ½ of notopleural calli (anterior ½ glossy black); medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ½ lower hypopleural calli (remainder including broad ventral margins black). Lateral and medial postsutural vittae absent. Humeral calli glossy black. Postnotum glossy black. Scutellum yellow except for a broad glossy black basal band which is expanded into a triangle with apex in centre of scutellum. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae pale fuscous, mid and hind coxae dark fuscous; all other segments fulvous except apical ⅓ of mid and hind femora black, mid tibiae fuscous and hind tibiae dark fuscous tending black basally; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, very narrow fuscous costal band confluent with R_{2+3} and ending at extremity of M, a narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I–V glossy black except for 2 narrow transvere orange-brown bands along posterior margin of tergum II either side of midline. A pair of oval glossy black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. abdominalnigra differs from the other species of subgenus *Hemizeugodacus* in having the mesonotum and abdominal terga uniformly glossy black and a black triangular marking on the dorsal surface of the scutellum.

Bactrocera (Hemizeugodacus) aglaiae (Hardy), n. comb. (Figs 325–327)

Dacus (Hemizeugodacus) algaiae Hardy, 1951: 131–4.
Dacus (Hemizeugodacus) aglaiae: Hardy, 1952: 365 (emendation to *aglaiae*).
Neozeugodacus aglaiae: May, 1963: 50; May, 1953: 48.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); 1 ♀ paratype in UH, Atherton Tableland, February 1950, bred from *Aglaia sapindina*, N.L.H. Krauss; 2 ♀ paratypes in UH, Atherton Tableland, November 1949, bred from *Aglaia ferruginea*, N.L.H. Krauss.

LOCATION OF TYPE: Holotype ♂ in NMNH.

DISTRIBUTION

Known from Mossman, the Cairns district and the Atherton Tableland (type locality), Queensland, where its hosts grow in the eastern coastal rainforest.

DIAGNOSIS

Medium sized species; medium sized oval black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae present, scutellum yellow; legs entirely fulvous; wing with a pale fuscous tint and with a narrow fuscous costal band and anal streak, costal cells fulvous with microtrichia in outer corner of second costal cell

only; abdominal terga III–V fulvous with a medial longitudinal red-brown to pale fuscous band and broad lateral longitudinal red-brown bands over all three terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.8 mm. Frons of even width, length 1.63 times breadth; fulvous with pale fuscous around orbital bristles; anteromedial hump covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.53 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.33 mm; 0.90 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 parallel sided lateral postsutural vittae ending at upper pa. bristles; a broad medial postsutural vitta beginning at level of prsc. bristles and ending at level of mesonotal suture. Postnotum red-brown. Scutellum yellow except for a narrow red-brown basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical red-brown spur.

Wings length 6.7 mm; costal cells fulvous (second cell slightly paler); microtrichia in outer corner of second costal cell only; remainder of wings with a pale fuscous tint, except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and narrowing to end between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I and II red-brown except fulvous along posterior margin of tergum II either side of midline; terga III–V fulvous except for a medial longitudinal band which is red-brown on tergum III and pale fuscous on terga IV and V and broad lateral longitudinal red-brown bands over all 3 terga. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.8:1. Apex of piercer broad, narrowing sharply and rounded at tip, with 4 pairs of small subapical bristles (Fig. 326). Spicules at distal end of middle segment of medium width with a large number of small dentations (Fig. 327).

HOST PLANTS

NEW RECORD: *Ganophyllum falcatum* (Sapindaceae), Kamerunga, Queensland, 4.i.1977, B. McCulloch, in association with *B. neohumeralis* (Hardy).

ATTRACTANT: No known record.

COMMENTS

B. aglaiae is similar to *B. aurea* (May) in possessing a red-brown mesonotum and abdominal terga orange-brown with dark markings but differs from this species in having a medial postsutural vitta present, mesopleural stripe of medium width and not reaching the humeral callus, scutellum entirely yellow and wing without a transverse fuscous band.

Bactrocera (Hemizeugodacus) aurea (May), n. comb. (Fig. 328)

Neozeugodacus aureus May, 1951: 10–12; May, 1963: 50.
Dacus (Hemizeugodacus) aureus: Hardy, 1955b: 430 and 1956: 70–1.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.5262) in QM.

DISTRIBUTION

Ravensbourne, south-east Queensland (type locality).

DIAGNOSIS

Medium sized species; small circular black facial

spots present; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow except apical ⅓ pale fuscous; legs fulvous except all femora pale fulvous on basal ⅔ and hind tibiae fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, a broad pale fuscous band across centre of wing from R_{4+5} to hind margin and enclosing both crossveins, costal cells fuscous with microtrichia covering second costal cell and outer ⅓ of first costal cell; abdominal terga II–V fulvous except for a broad red-brown band across base of tergum II and widening to cover lateral margins, a very broad medial longitudinal band over all 4 terga which is red-brown on terga II, III and anterior of tergum IV and dark fuscous on remainder of tergum IV and tergum V, 2 moderately broad lateral longitudinal red-brown bands over terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.65 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short dark setae; orbital bristles red-brown to black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small circular black spots; length of face 0.45 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 2–6 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a very strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segment: 0.13 mm; 0.23 mm; 0.65 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin concave; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 parallel sided lateral postsutural vittae ending before upper pa. bristles. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band and apical ⅓ pale fuscous. Bristles: sc. 4; prsc. 2; pa. 2; sa. absent; mpl.1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except basal ⅔ of all femora pale fulvous and hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 5.6 mm; costal cells fuscous; microtrichia covering second costal cell and outer corner of first costal cell; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a broad transverse pale fuscous band across wing from R_{4+5} to hind margin and enclosing both crossveins, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I red-brown; terga II–V fulvous except for a broad transverse red-brown band across anterior margin of tergum II and widening to cover lateral margins, a very broad medial longitudinal band which is red-brown on terga II, III and anterior of tergum IV and dark fuscous on remainder of tergum IV and tergum V, moderately broad lateral longitudinal red-brown bands over terga III–V; pair of oval fulvous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.86:1.

ATTRACTANT: No known record.

COMMENTS

B. aurea is similar to *B. aglaiae* (Hardy) in possessing a red-brown mesonotum and abdominal terga orange-brown with dark markings but differs in having the medial postsutural vitta absent, mesopleural stripe reaching humeral callus, scutellum yellow with a red-brown spot on apex and wing with a single transverse fuscous band.

Subgenus **Melanodacus** Perkins

Bactrocera (Melanodacus) nigra
(Tryon), n. comb. (Figs 329–331)

Dacus niger Tryon, 1927: 211–12.
Melanodacus niger: Perkins, 1937: 57.
Dacus (Melanodacus) niger: Hardy, 1951: 138–40.
Paratridacus niger: May, 1963: 42, 50.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: Lectotype ♂ (D.3136) and 3 paralectotypes (D.3136) in QM.

DISTRIBUTION

Known from the following localities in Queensland: Atherton, Cairns, Ayr, Maryborough and Nambour along the east coast and from Ravensbourne, Toowoomba in the southeastern highlands; type locality, Gympie or Cleveland (not specified on labels).

DIAGNOSIS

Small dark coloured species; medium sized oval facial spots present; humeral calli yellow (except anterodorsal corners glossy black); notopleural calli yellow; mesonotum glossy black, mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae absent, scutellum yellow with broad medial longitudinal glossy black band; wing with an indistinct very pale fulvous tint along costal margin, anal streak absent, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V glossy black except red-brown to pale along posterior margin of tergum V and extending along either side of a medial longitudinal glossy black band on tergum V.

DESCRIPTION

MALE: Head generally dark. Vertical length 1.25 mm. Frons of even width, length 2.1 times breadth; fulvous with broad pale fuscous markings along entire length, anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized oval black spots; length of face 0.38 mm. Genae fulvous, pale brown subocular spot present; black bristle present. Occiput black, fulvous along eye margins; occipital row with 4–6 well developed black bristle. Antennae with segments 1 and 2 fulvous, segment 3 fuscous; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.23 mm; 0.63 mm.

Thorax mesonotum and pleural areas glossy black without pale markings. Yellow markings as follows: humeral calli (except anterodorsal corners glossy black); notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin straight; upper hypoplerual calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black). Lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow except for broad medial longitudinal band which encloses both apical bristles. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs femora fulvous except apical ¼ of mid and hind femora dark fuscous; fore tibiae pale fuscous, mid tibiae fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long dark setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 4.6 mm; costal cells colourless; microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, a very narrow indefinite pale fuscous costal band ending between extremities of R_{4+5} and M (this band generally seems to be confluent with R_{2+3} but it is very pale and indefinite), a pale fuscous tint in anal cell (a definite anal streak is absent); no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Tergum I glossy black; tergum II glossy black except for 2 transverse fulvous spots along posterior margin either side of midline; terga III–V glossy black except red-brown to pale fuscous along posterior margin of tergum V and extending along either side of a medial longitudinal glossy black band; pair of oval glossy black shining spots on tergum V. Posterior lobe of surstylus short, sternum V with only a slight concavity on posterior margin.

FEMALE: Ovipositor basal segment glossy black, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.58:1. Apex of piercer needle shaped with 2 pairs of very small subapical bristles in a small socket (Fig. 330). Spicules at distal end of middle segment of medium width and either triangular or with 2 or 3 large dentations (Fig. 331).

HOST PLANTS

NEW RECORD: *Cryptocarya* sp. (Lauraceae), Cairns Botanical Gardens, November 1977, B. McCulloch.

ATTRACTANT: No known record.

COMMENTS

B. nigra is unique in Australia having glossy black pigmentation on the thorax and abdomen typical of many South Pacific species in countries outside Australia. The male possesses a short

posterior surstylus lobe and a slight concavity on posterior margin of sternum V. Other important characters are the glossy black medial longitudinal band on the dorsal surface of the scutellum and the absence of lateral and medial postsutural vittae. See comments for *B. satanellus* (Hering) for characters that separate these 2 species.

Originally, Tryon (1927) defined in the text a holotype, allotype and 1 paratype but the sex of these specimens was not recorded. In QM there are 4 specimens each with a white label marked "TYPE D/3136" but the specimen designated holotype cannot be determined. I designate one male (labelled "LECTOTYPE, R. Drew") as lectotype and the other 3 specimens paralectotypes (2 females and the sex of 1 cannot be determined).

Bactrocera (Melanodacus) satanellus (Hering), n. comb. (Fig. 332)

Melanodacus satanellus Hering, 1941a: 48.
Dacus (Paratridacus) satanellus: Drew, 1973: 19–21.

MATERIAL EXAMINED

Paralectotype ♀, Kapakapa, Central District, Papua New Guinea, 1891, L. Loria and the following specimens in BMNH: paralectotype ♂ and lectotype ♀ labelled "paratype", "N. Guinea Mer, Kapakapa, Mag. Giugno. 1891, L. Loria", "*Melanodacus satanellus* det. Hering 1941", "F. Bearb. erh. V, Mus Budapest 27.iii.1941", "Purch from E.M. Hering B.M. 1965-270".

LOCATION OF TYPES: Lectotype ♀, paralectotype ♂ in BMNH; 1 ♂ and 1 ♀ paralectotype in HNHM.

DISTRIBUTION

Kapakapa, Central District, Papua New Guinea (type locality).

DIAGNOSIS

Small species; face glossy black; humeral calli glossy black; notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching just anterior to npl. bristle, lateral postsutural vittae present as short elongate spots, medial postsutural vitta absent, scutellum yellow with a narrow medial longitudinal glossy black band; wing membrane colourless except subcostal cell extremely pale fulvous, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga glossy black.

ATTRACTANT: No known record.

COMMENTS

Originally, Hering (1941a) listed a male and female type and did not designate a holotype. It is now apparent that there were more than 2 specimens in the type series, one male and one female labelled syntype in HNHM (A. Dely — Draskovits, pers. comm.) and one male and one female labelled paratype in BMNH. The label data on the 4 specimens conform with Hering's description. I designate the female in BMNH as lectotype and the remaining 3 specimens paralectotypes.

Drew (1973) incorrectly stated that the male has a pecten on abdominal tergum III but it is absent; also the male has a short posterior surstylus lobe and the posterior margin of abdominal sternum V with a shallow concavity. These characters confirm the placement of this species in subgenus *Melanodacus*. The apex of the piercer of the ovipositor has an unusual apical cleft (Fig. 332A).

B. satanellus was described adequately by Drew (1973). It is similar to *B. nigra* (Tryon) in being a small glossy black species and in having wings with an indistinct costal band and anal streak. It differs from *B. nigra* in possessing a glossy black face, humeral calli glossy black, broader mesopleural stripe (reaching anterior of anterior npl. bristle) and 2 very short and narrow lateral postsutural vittae.

Queenslandacus Group of Subgenera

Queenslandacus, n. subgen.

Bactrocera (Queenslandacus) exigua (May), n. comb. (Fig. 333)

Psilodacus exiguus May, 1957b: 300–1.
Daculus exiguus: May, 1963: 41, 49.

MATERIAL EXAMINED

Holotype ♂, Atherton, north Queensland, December 1955, J. Rosser; 1 ♀, Wallaman Falls, north Queensland, attracted to light trap, 31.i.1975, B.K. Cantrell.

LOCATION OF TYPE: Holotype (T.5607) in QM.

DISTRIBUTION

Known only from the higher altitude areas of Atherton (type locality) and Wallaman Falls, north Queensland.

DIAGNOSIS

Small species; facial spots absent; humeral and notopleural calli yellow; mesonotum uniformly black, mesopleural stripe reaching humeral callus, lateral and medial postsutural vittae absent, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band and anal streak and infuscation around r–m crossvein which extends as a pale fuscous tint into discoidal cell, costal cells pale fuscous to fuscous with microtrichia in outer ⅓ of second costal cell

only; abdominal terga I–V uniformly red-brown without dark markings.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.3 mm. Frons narrowing slightly posteriorly, length 1.38 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous, dark facial spots absent; length o_1 face 0.43 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of very small pale setae. Antennae with all segments fulvous; a weak red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.65 mm.

Thorax mesonotum uniformly black except brown to dark brown around lateral margins, around mesonotal suture, inside humeral calli. Pleural areas red-brown except dark fuscous to black on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous); anterior ¾ lower hypopleural calli (remainder dark fuscous). Lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow except for narrow brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 2; all bristles well developed and black.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 4.9 mm; costal cells pale fuscous to fuscous; microtrichia covering outer ⅓ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and narrowing beyond extremity of this vein to end between extremities of R_{4+5} and M, infuscation around r–m crossvein which continues into discoidal cell as a pale fuscous tint, broad pale fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I and sterna I and II wider than long. Terga I–V uniformly red-brown without dark markings. A pair of oval red-brown shining spots on tergum V. Basal segment of ovipositor red-brown, circular in transverse cross section and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.81:1.

MALE: As for female except posterior lobe of surstylus long; posterior margin of abdominal sternum V with a deep concavity.

ATTRACTANT: No known record.

COMMENTS

B. exigua does not fit into any previously established subgenus. The posterior lobe of the surstylus is elongate and the posterior margin of abdominal sternum V has a deep concavity and for this reason it is placed in a new subgenus. It is easily identified in having a black mesonotum without lateral postsutural vittae, a distinctive wing colour pattern of a narrow costal band and infuscation along r–m crossvein and a uniformly orange-brown abdomen.

Zeugodacus Group of Subgenera

Subgenus **Austrodacus** Perkins

Bactrocera (Austrodacus) cucumis (French), n. comb. (Figs 334–336)

Dacus tryoni var. *cucumis* French, 1907: 307.
Dacus cucumis: Froggatt, 1910: 866.
Austrodacus cucumis: Perkins, 1937: 56; May, 1953: 10; May, 1963: 39, 49, 65–6.
Dacus (*Austrodacus*) *cucumis*: Hardy, 1951: 122–5; Drew, 1972a: 11; Drew, 1982: 15–18.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Unknown.

DISTRIBUTION

PREVIOUSLY RECORDED: Occurs throughout the eastern coastal areas of Australia from Cape York in the north to northern New South Wales. See Drew (1982) for distribution map of eastern Australia (type locality, Bowen, Queensland); known also from the Northern Territory, although no fruit infestations have been recorded.

NEW RECORD: Torres Strait islands: Prince of Wales (record from Plant Quarantine Survey).

DIAGNOSIS

Medium sized species; small fuscous to black facial spots present; humeral and notopleural calli yellow; mesonotum orange-brown without dark markings, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow;

wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous (second cell slightly paler than first), microtrichia in outer corner of second costal cell only; abdominal terga I and II orange-brown, terga III–V fulvous except for 2 broad lateral longitudinal orange-brown bands over all 3 terga and a narrow medial longitudinal band which is orange-brown on tergum III and orange-brown to dark fuscous on tergum IV and V (this band is broader on tergum V).

DESCRIPTION

FEMALE: Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.9:1. Apex of piercer broad with 1 pair of small subapical keels; 4 pairs of subapical bristles (2 large and 2 small) situated very close to apex (Fig. 335). Spicules at distal end of middle segment of medium width with 4–7 dentations, some broad and elongate and some small (Fig. 336).

ATTRACTANT: No known record.

COMMENTS

B. cucumis was described adequately by Hardy (1951) and Drew (1982). It is a pale orange-brown species with medial and lateral postsutural vittae present, a yellow scutellum, prsc. and sa. bristles absent, 4 sc. bristles present and a small elongate-oval black spot centrally on tergum V. It is a serious pest of a range of commercial cucurbit crops.

Subgenus **Diplodacus** May

Bactrocera (Diplodacus) signatifera (Tryon), n. comb. (Figs 337–339)

Dacus signatifer Tryon, 1927: 210–11.
Dacus (Daculus) signatifer: Hardy, 1951: 127–9.
Diplodacus signatifer: May, 1963: 42, 49.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); Tryon's type specimens.

LOCATION OF TYPES: Lectotype ♀ (D.3135) and 1 paralectotype ♀ (D.3135) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: The eastern coastal rainforests of Queensland, north from Bowen (type locality).

NEW RECORDS: Torres Strait islands: Yam I., 23.iii.1985, J. Turner; Stephens I., 26.v.1985, J. Rhodes. Northern Territory: Fogg Dam, near Darwin and Cobourg Peninsula, December 1984, A. Allwood. All attracted to bacteria bait in Plant Quarantine Survey.

DIAGNOSIS

Medium sized pale coloured species; large circular black facial spots present; humeral and notopleural calli yellow; mesonotum orange-brown, mesopleural stripe of medium width reaching almost to anterior npl. bristle, lateral and medial postsutural vittae present, scutellum yellow; legs with all segments fulvous; wing with a narrow fuscous costal band and pale fuscous anal streak, costal cells pale fuscous, microtrichia in outer corner of second costal cell only; abdomen with all terga orange-brown except fulvous along posterior margin of tergum II and a large oval black spot posterocentrally on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.53 times breadth; fulvous without dark markings; anteromedial hump covered by a large number of short pale setae; orbital bristles red-brown to black: 2 i.or., s.or. usually absent; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large circular black spots; length of face 0.45 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with all segments fulvous; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.60 mm.

Thorax mesonotum and pleural areas orange-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, ending just before anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices orange-brown); anterior 3/5 lower hypopleural calli (remainder orange-brown); 2 lateral postsutural vittae of medium width beginning anterior to mesonotal suture and narrowing posteriorly to end before upper pa. bristles; medial postsutural vitta of medium width, rounded posteriorly at a point level with lower pa. bristles and narrowing to a point anteriorly to end anterior to mesonotal suture. Postnotum orange-brown. Scutellum yellow with a broad orange-brown basal band. Bristles: sc. 2 or 4; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black (occasionally 1 pa. weak and pale red-brown).

Legs all segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells pale fuscous (second cell usually paler than first); microtrichia in outer corner of second costal cell only; remainder of wings colourless or with a pale fuscous tint except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening slightly apically to end between extremities of R_{4+5} and M, narrow pale fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga orange-brown except a broad transverse fulvous band across posterior margin of tergum II but not reaching lateral margins and a large oval black spot posterocentrally on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, conical in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.66:1. Apex of piercer rounded at tip with 4 pairs of subapical bristles (Fig. 338). Spicules at distal end of middle segment of medium width with 5–7 short broad dentations of uneven length (Fig. 339).

HOST PLANTS

NEW RECORD: In association with *B. barringtoniae* (*Tryon*) from *Barringtonia calyptrata* (Barringtoniaceae), Gordonvale rainforest, north Queensland, 24.i.1977, B. McCulloch.

ATTRACTANT: No known record.

COMMENTS

B. signatifera is similar to *B.* (*Papuodacus*) *neopallescentis* in possessing a red-brown mesonotum with lateral and medial postsutural vittae (lateral vittae beginning anterior to mesonotal suture), abdominal terga mostly orange-brown, wings colourless except for costal band and anal streak. It differs in having pale fuscous costal cells, facial spots large and circular, lateral postsutural vittae ending before upper pa. bristles and prsc. bristles always absent.

Originally, Tryon (1927) listed two females (in QM) as "types". They are in poor condition and each has a white label marked "TYPE D/3135". I designate 1 specimen (labelled "LECTOTYPE, R. Drew") as lectotype and the other paralectotype.

Heminotodacus, n. subgen.

Bactrocera (Heminotodacus) dissidens, n. sp. (Fig. 340)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Stony logging area, Bulolo, under leaf of *Musa* sp., 1.viii.1979, H. Ivagai.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♀, Upper Stony logging area, Bulolo, under leaf of *Bambusa* sp., 27.vii.1979, H. Roberts; 1 ♂, Upper Stony logging area, Bulolo, under leaf of shrub, 10.viii.1979, H. Ivagai.

LOCATION OF TYPES: Holotype (T.10571) in QM; 2 paratypes in DPI.

DISTRIBUTION

Known only from Bulolo, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous without dark facial spots; humeral and notopleural calli yellow and connected by a broad yellow band; mesonotum shining black, lateral postsutural vittae present, mesopleural stripe broad and reaching to anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, a broad fuscous band across centre of wing from R_{4+5} to hind margin and a narrow fuscous band across base of wing joining with anal streak, first costal cell pale fuscous and second costal cell with a pale fuscous tint, microtrichia in outer corner of first costal cell and along anterior ½–¾ of second costal cell; all abdominal terga orange-brown with a medial longitudinal fuscous band, apex of aculeus with 2 pairs of subapical lobes.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons of even width, length 1.55 times breadth; fulvous without dark markings; anteromedial hump with a small number of short dark setae; orbital bristles well developed and black: 1 s.or., 3–4 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with no dark spots; length of face 0.43 mm. Genae fulvous, dark subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 3–4 well developed black bristles and a large number of smaller pale bristles. Antennae with all segments fulvous; a well developed black dorsal bristle on segment 2; arista

black (fulvous basally); length of segments: 0.10 mm; 0.25 mm; 0.58 mm.

Thorax mesonotum shining black except brown along mesonotal suture, below and behind lateral postsutural vittae. Pleural areas shining black except red-brown below humeral calli and fuscous above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; a broad yellow band connecting humeral and notopleural calli; 2 broad parallel sided lateral postsutural vittae ending just behind upper pa. bristles; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black). Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; hm. 1; scp. 4; all bristles well developed and black except for the hm. bristles which are absent in the female specimen.

Legs all segments fulvous except hind tibiae with pale fuscous tint on basal ⅔; mid tibiae each with an apical black spur; fore femora with rows of long pale setae on dorsal surfaces.

Wings length 5.1 mm; first costal cell pale fuscous, second costal cell with a pale fuscous tint; microtrichia in outer corner of first costal cell and along anterior ½–¾ of second costal cell; remainder of wings colourless except for a fuscous subcostal cell, narrow pale fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous transverse band running from R_{4+5} to hind margin and enclosing both crossveins, a narrow transverse fuscous band running from junction of R_{2+3} and R_{4+5} to anal streak, a broad fuscous anal streak reaching to wing margin, a diffuse pale fuscous tint in apex of wing around M; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga orange-brown except for a medial longitudinal diffuse fuscous band over all terga but interrupted at intersegmental lines. A pair of orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Tip of piercer strongly sclerotized, orange-brown with 2 pairs of subapical lobes (Fig. 340A). Ratio of length of oviscape to length of tergum V 0.92:1.

ATTRACTANT: No known record.

COMMENTS

B. dissidens is distinct in having humeral bristles, face without dark spots, a yellow band joining humeral and notopleural calli, a broad but incomplete transverse band across wing from R_{4+5} to hind margin and a narrow pale fuscous mark across apex of wing.

Hemiparatridacus, n. subgen.

Bactrocera (Hemiparatridacus) abdoaurantiaca, n. sp. (Fig. 341)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Eastern Highlands District: Aiyura (1650 m), hand collected on maize plant, 3.iii.1958, J.H. Barrett.

Paratype, PAPUA NEW GUINEA, Eastern Highlands District: 1 ♀, collected on maize plant, Aiyura (1650 m), 3.iii.1958, J.H. Barrett.

LOCATION OF TYPES: Holotype (T.10572) in QM; paratype in DPI.

DISTRIBUTION

Known only from Aiyura, Eastern Highlands District, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous without dark spots; humeral and notopleural calli yellow; mesonotum black, lateral and medial postsutural vittae present, broad mesopleural stripe reaching to anterior npl. bristle, scutellum yellow; wing with a narrow pale fuscous costal band and broad pale fuscous anal streak, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V pale orange-brown with no dark markings, pecten absent on tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.44 times breadth; fulvous with no dark markings; anteromedial hump covered with a large number of short pale setae; orbital bristles dark fuscous: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with no dark spots; length of face 0.55 mm. Genae fulvous, pale subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a small number of well

developed pale bristles. Antennae with all segments fulvous; a well developed pale dorsal bristle on segment 2; arista fuscous (fulvous basally); length of segments: 0.15 mm; 0.28 mm; 0.75 mm.

Thorax mesonotum black except for a medial longitudinal dark red-brown pattern anterior to mesonotal suture. Pleural areas black except fuscous below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; 2 moderately broad parallel sided lateral postsutural vittae beginning as a spot anterior to mesonotal suture and ending behind upper pa. bristles; a broad medial postsutural vitta, rounded posteriorly at level of pa. bristles and narrowing to a point anteriorly at level of mesonotal suture; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black). Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles are well developed and dark fuscous.

Legs all segments fulvous; mid tibiae each with an apical black spur; fore femora with a row of long pale setae on dorsal surface.

Wings length 6.7 mm; costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only, remainder of wings colourless except for a fuscous subcostal cell, narrow pale fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, a broad pale fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten absent on tergum III. Tergum I wider than long, sterna I and II slightly longer than wide. Tergum I fuscous; tergum II pale orange-brown except dark fuscous across anterior ½ and ending before lateral margins. Terga III–V pale orange-brown with no dark markings. A pair of oval pale orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: Ovipositor basal segment red-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1:1.

ATTRACTANT: No known record.

COMMENTS

B. abdoaurantiaca is a unique species in having face without spots, black mesonotum with medial and lateral postsutural vittae (the latter beginning anterior to mesonotal suture), prsc. bristles absent, abdominal terga III–V uniformly pale orange-brown and pecten on abdominal tergum III absent.

Subgenus **Javadacus** Hardy

Bactrocera (Javadacus) aberrans (Hardy), n. comb. (Figs 342–344)

Dacus (Afrodacus) aberrans Hardy, 1951: 118–20; Hardy, 1955a: 5, 10.

Afrodacus mesoniger May, 1951: 8–10, 1963: 49, 70–1. New synonymy based on a study of a paratype of *D. aberrans* and the holotype and paratypes of *A. mesoniger*. Hardy (1956) discussed the dating of the 2 original descriptions.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION); the type series of *A. mesoniger* and a paratype of *D. aberrans*. LOCATION OF TYPES: *D. aberrans*, holotype ♂ in NMNH; *A. mesoniger*, holotype ♀ (T.5264) in QM.

DISTRIBUTION

Known from rainforests in coastal and subcoastal Queensland from Cairns and Atherton in the north to Toowoomba, Mt Glorious and Cunningham's Gap in the south; type locality, Lake Barrine, Queensland.

DIAGNOSIS

Medium sized species; face with small to medium sized black spots; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with a broad medial longitudinal black band, pale fuscous laterally on terga III and IV, black anterolaterally on tergum V and a narrow transverse black band across base of tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.52 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with small to medium sized circular black spots;

length of face 0.45 mm. Genae fulvous; red-brown to black bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–6 small bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.68 mm.

Thorax mesonotum black with brown markings as follows: below and behind lateral postsutural vittae, around mesonotal suture, between humeral and notopleural calli, inside humeral calli. Pleural areas black except red-brown above mid coxae and below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae narrowing posteriorly to end before level of lower pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae pale fuscous; all other segments fulvous except hind tibiae fuscous; mid tibiae each with an apical black spur.

Wings length 5.0 mm; costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and widening slightly in apex of wing to end between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I black; tergum II orange-brown with a narrow transverse dark fuscous band across centre of tergum and expanding to cover lateral margins; terga III–V orange-brown with dark markings as follows: a narrow transverse black band across base of tergum III, a broad medial longitudinal black band over all 3 terga, pale fuscous laterally on terga III and IV, anterolateral corners of tergum V black. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.68:1. Apex of piercer broad, narrowing sharply to a rounded tip, 4 pairs of subapical bristles (Fig. 343). Spicules at distal end of middle segment narrow, triangular, occasionally with 2 dentations (Fig. 344).

HOST PLANTS: Hardy (1951) and May (1953) recorded different species of *Litsea* as the hosts of their respective species. They are now synonymised (Queensland Herbarium Botanists, pers. comm.). *Neolitsea involucrata* does not occur in Australia (Queensland Herbarium Records) and therefore this record (May 1953) must be in error.
ATTRACTANT: No known record.

COMMENTS

B. aberrans has the posterior lobe of surstylus long, posterior margin of abdominal sternum V with a slight concavity, sa. bristles absent, mesonotum black, abdominal terga III–V orange-brown with a black "T" and darkening on lateral margins, and wings colourless with a costal band and anal streak.

Bactrocera (Javadacus) melanothoracica, n. sp.
(Fig. 345)

TYPE SPECIMENS

Holotype ♂, TORRES STRAIT: Yam I., attracted to methyl eugenol, 21.vi.1977, R. Paton.

Paratypes, TORRES STRAIT: 23 ♂♂, Yam I., 21.vi.1977, R. Paton; 5 ♂♂, Yam I., 11.ii.1980, G. Sanewski; 1 ♂, Badu I., 21.vi.1977, R. Paton. QUEENSLAND: 1 ♂, Bamaga, 19–21.vi.1977, R. Paton; 1 ♂, Iron Range, 25 km SW Lockhart, 14–21.iv.1977, R.I. Storey; 1 ♂, Gordon's Mine Area, Iron Range, 12–18.ii.1976, G.B. Monteith; 1 ♂, ABRS Area 3, Captain Billy Creek, 5–12.ii.1976, G.B. Monteith. All paratypes attracted to methyl eugenol.

LOCATION OF TYPES: Holotype (T.10573) and 4 paratypes (T.10574–T.10577) in QM; 8 paratypes in ANIC; 2 paratypes in BMNH; 19 paratypes in DPI.

DISTRIBUTION

Recorded from the Torres Strait islands: Yam and Badu; Queensland: Bamaga, Iron Range and Captain Billy Creek (near Shelburne Bay).

DIAGNOSIS

Medium sized species; medium sized circular facial spots present; humeral and notopleural calli yellow; mesonotum black, lateral postsutural vittae

present, medial postsutural vitta absent, mesopleural stripe broad reaching anterior npl. bristle, scutellum yellow with a narrow black basal band; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a pale fulvous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V mostly orange-brown except for a medial longitudinal black band of medium width over all 3 terga, pale fuscous along anterior margin of tergum III and extending around lateral margins of all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.7 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter without short setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized circular black spots; length of face 0.45 mm. Genae fulvous, large brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–5 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.20 mm; 0.30 mm; 0.80 mm.

Thorax mesonotum black except broad red-brown lateral margins which enclose lateral postsutural vittae and continue inside humeral calli. Pleural areas red-brown except fuscous behind mesopleural stripe, dark fuscous to black along anterior margin of mesopleural stripe and on sternopleuron. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching anterior npl. bristle dorsally, continuing to sternopleuron as transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder black); 2 narrow lateral postsutural vittae narrowing slightly posteriorly to end before the upper pa. bristles. Postnotum black, red-brown medially. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.3 mm; costal cells with a pale fulvous tint and microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I orange-brown except for a medial longitudinal dark fuscous spot on posterior ½ and dark fuscous patches laterally; tergum II orange-brown except for an elongate dark fuscous spot anteromedially and fulvous along posterior margin; terga III–V mostly orange-brown except for a medial longitudinal black band over all 3 terga beginning posterior to anterior margin of tergum III and ending before posterior margin of tergum V, pale fuscous along anterior margin of tergum III and continuing around lateral margins of terga III, IV and V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus elongate, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. melanothoracica is similar to *B. aberrans* (Hardy) in possessing a black mesonotum, colourless wings except for costal band and anal streak, humeral and notopleural calli yellow, scutellum yellow, medial postsutural vitta absent and lateral postsutural vittae present. It differs from this species in having the costal band overlapping R_{2+3}, broader mesopleural stripes reaching to the anterior npl. bristles, abdominal tergum III without a transverse black band across anterior margin. It is also similar to *B. endiandrae* (Perkins and May) in general wing and body colour patterns but differs in lacking the sa. bristles and in having the posterior lobe of the surstylus long and the mesopleural stripes broader.

Bactrocera (Javadacus) unirufa, n. sp.
(Fig. 346)

TYPE SPECIMEN

Holotype ♂, AUSTRALIA, Queensland: Bellenden Ker Range (100 m), attracted to methyl eugenol, 17–24.x.1981, G.B. Monteith.

LOCATION OF TYPE: Holotype (T.10578) in QM.

DISTRIBUTION

Known only from Bellenden Ker Range, Queensland.

DIAGNOSIS

Medium sized species; medium sized circular

black facial spots present; humeral and notopleural calli yellow; mesonotum basically red-brown with a pattern of fuscous markings, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous, microtrichia in outer corner of second costal cell only; abdominal terga III–V uniformly red-brown without dark markings.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons narrowing slightly posteriorly, length 1.5 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with medium sized circular black spots; length of face 0.4 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 3–4 well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.28 mm; 0.73 mm.

Thorax mesonotum red-brown except for 2 irregularly shaped broad posterolateral fuscous markings and smaller fuscous to pale fuscous markings on anterior area. Pleural areas fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices dark fuscous); anterior 3/5 lower hypopleural calli (remainder dark fuscous); 2 narrow lateral postsutural vittae narrowing posteriorly to end well before upper pa. bristles. Postnotum fuscous tending red-brown centrally. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown.

Legs all segments fulvous except fore and mid tibiae pale fuscous and hind tibiae fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells pale fuscous; microtrichia in outer corner of second costal cell only; remainder of wings colourless except for fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I red-brown except fuscous across anterior ½; tergum II red-brown except fulvous along posterior margin; terga III–V uniformly red-brown without dark markings. A pair of oval red-brown shining spots on tergum V. Posterior lobe of surstylus elongate, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. unirufa is similar to the other 2 South Pacific species of subgenus *Javadacus*, i.e. *B. aberrans* (Hardy) and *B. melanothoracica* in possessing colourless wings except for costal band and anal streak, humeral and notopleural calli yellow, medial postsutural vitta absent and lateral postsutural vittae present. It differs from these species in having the mesonotum basically red-brown and abdominal terga III–V uniformly red-brown without dark markings.

Niuginidacus, n. subgen.

Bactrocera (Niuginidacus) singularis, n. sp. (Fig. 347)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Kunai Creek, Mt Kaindi (1450 m), attracted to cue lure, 25.v.1981, A. Allison.

Paratypes, PAPUA NEW GUINEA, Morobe Province, Mt Kaindi: 1 ♂, Kunai Creek (1450 m), 29.xii.1980; 1 ♂, Pitpit Gully (1550 m), 8.vi.1981; 2 ♂♂, Lower Namie Creek (1600 m), 18.iii.1980 and 8.vi.1980; 1 ♂, Namie Creek (1650 m), 15.vi.1981; 1 ♂, Wau, 1.xii.1980; all attracted to cue lure by A. Allison.

LOCATION OF TYPES: Holotype (T.10579) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 4 paratypes in DPI.

DISTRIBUTION

Known only from Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous without facial spots; humeral and notopleural calli yellow;

mesonotum black, broad medial postsutural vitta present, lateral postsutural vittae absent, mesopleural stripe broad reaching just anterior to anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, fuscous colouration enclosing r–m crossvein and continuing into discoidal cell, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for pale fuscous to fuscous anterolaterally on terga III and IV, a medial longitudinal black vitta on tergum V and pecten absent on tergum III.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.1 mm. Frons narrowing slightly posteriorly, length 1.47 times breadth; fulvous without dark markings; anteromedial hump with a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with no dark spots; length of face 0.45 mm. Genae fulvous, subocular spot and bristle absent. Occiput red-brown, fulvous along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 fulvous; segment 3 pale fuscous; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.58 mm.

Thorax mesonotum black. Pleural areas black except dark fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe reaching just anterior to anterior npl. bristle dorsally, continuing to sternopleuron as a round spot, anterior margin convex; a very broad medial postsutural vitta broadly rounded posteriorly at level of upper pa. bristles and narrowing to end just anterior of mesonotal suture; upper hypopleural calli (except broad black margin adjacent to postnotum); anterior ⅔ lower hypopleural calli (remainder black). Lateral postsutural vittae absent. Postnotum black, tending dark fuscous centrally. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles weak and red-brown to fuscous.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except apical 4 segments of all tarsi fuscous; mid tibiae each with an apical black spur.

Wings length 4.9 mm; costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; remainder of wings colourless except for dark fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, fuscous enclosing r–m crossvein and continuing into discoidal cell as an indefinite spot of colour, a narrow fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen elongate-oval; terga free; pecten absent on tergum III. Tergum I wider than long, sterna I and II slightly longer than wide. All terga orange-brown except pale fuscous to fuscous on anterior and lateral areas of terga I and II and anterolaterally on terga III and IV, a medial longitudinal black band on tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long and stout, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. singularis is distinct in having posterior lobe of surstylus long, abdominal sternum V with a slight concavity on posterior margin, 2 sc. bristles, prsc. bristles absent, pecten on abdominal tergum III absent, mesonotum black with lateral postsutural vittae absent and medial postsutural vitta present, wing with infuscation along r–m crossvein expanding over part of discoidal cell and abdomen elongate-oval.

Subgenus **Papuodacus** Drew

Bactrocera (Papuodacus) neopallescentis, n. nom.
(Fig. 348)

Not *Dacus (Afrodacus) aberrans pallescentis* Hardy, 1955a: 5–6.
Dacus (Hemizeugodacus) pallescentis Drew, 1971: 44–6.
Dacus (Papuodacus) pallescentis: Drew, 1972a: 13.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6936) in QM.

DISTRIBUTION

Known only from Bisianumu, Ninoa Estate and Konedobu (type locality), Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots very small and pale or absent; humeral and notopleural calli yellow; mesonotum pale red-brown without dark markings, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells

colourless with microtrichia in outer corner of second costal cell only; abdominal terga pale orange-brown except for a small dark fuscous spot centrally on posterior margin of tergum V.
ATTRACTANT: Cue lure.

COMMENTS

B. neopallescentis is similar to *B. atrisetosa* (Perkins) and *B. trichota* (May) in possessing a red-brown mesonotum, lateral and medial postsutural vittae present, legs fulvous and abdominal terga orange-brown but differs in lacking sa. bristles and fuscous markings on mesonotum and in having colourless costal cells. *Dacus pallescentis* Drew is preoccupied in *Dacus* by *Dacus aberrans pallescentis* Hardy and must be treated as a primary homonym even though it is transferred to *Bactrocera* (see Articles 57(a) and 57(b) of the International Code of Zoological Nomenclature).

Subgenus **Paradacus** Perkins

Bactrocera (Paradacus) aurantiventer, n. sp. (Fig. 349)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Missim (1200 m), attracted to cue lure, 16.iv.1981, A. Allison.
LOCATION OF TYPE: Holotype (T.10580) in QM.

DISTRIBUTION

Known only from Mt Missim, Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral and notopleural calli yellow; mesonotum black, lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a very pale fulvous tint and microtrichia absent; abdominal terga II–V orange-brown without dark markings.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.3 mm. Frons narrowing slightly posteriorly, length 1.3 times breadth; fulvous without dark markings, anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous without dark markings; length of face 0.45 mm. Genae fulvous, subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 4–5 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a weak fulvous dorsal bristle on segment 2; length of segments: 0.13 mm; 0.23 mm.

Thorax mesonotum black except brown below and behind lateral postsutural vittae, above mesopleural suture and inside humeral calli. Pleural areas black except red-brown below humeral calli and above mid coxae. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe reaching anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ¾ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width beginning anterior to mesonotal suture and narrowing slightly posteriorly to end before upper pa. bristles; a very broad medial postsutural vitta rounded posteriorly at level of upper pa. bristles and narrowing to a point anterior to mesonotal suture. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous; rows of long black setae on dorsal surfaces of fore femora.

Wings length 5.6 mm; costal cells with a very pale fulvous tint, microtrichia absent; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I fuscous; terga II–V orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus very long, sternum V with a slight concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

B. aurantiventer is similar to *B. citroides* in having clear wings except for costal band and anal streak, lateral and medial postsutural vittae present and abdominal terga uniformly orange-brown but differs in having a black mesonotum and the humeral and notopleural calli not joined by a lateral yellow band.

Bactrocera (Paradacus) citroides, n. sp.
(Fig. 350)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central Province: 51 km NW of Port Moresby on Moresby–Bereina road, attracted to cue lure, 26.vi.1980, R.A.I. Drew and D.W. Currey. LOCATION OF TYPE: Holotype (T.10581) in QM.

DISTRIBUTION

Known only from the Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with large oval black spots; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum orange-brown; lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga orange-brown with no dark markings.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.48 mm. Frons narrowing slightly posteriorly, length 1.42 times breadth; fulvous without dark markings; anteromedial hump with a large number of short pale setae; orbital bristles black: 1 s.or., 3 i.or; all well developed except 1 i.or. reduced and pale on one side; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large oval black spots not reaching epistoma; length of face 0.5 mm. Genae fulvous, small dark subocular spot present; dark fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 2–3 well developed dark bristles. Antennae with all segments fulvous; arista black (fulvous basally); length of segments 0.10 mm; 0.23 mm; 0.75 mm.

Thorax mesonotum and pleural areas orange-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; broad band connecting humeral and notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin convex; 2 lateral postsutural vittae beginning anterior to mesonotal suture and narrowing slightly posteriorly to end at upper pa. bristles; a broad medial postsutural vitta rounded posteriorly at level of upper pa. bristles and narrowing to a point anteriorly at level of mesonotal suture; upper hypopleural calli (posterior apices orange-brown); anterior ⅔ lower hypopleural calli (remainder orange-brown). Postnotum orange-brown. Scutellum yellow except for narrow orange-brown basal band. Bristles: sc. 4; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp 4; all bristles well developed and black.

Legs all segments fulvous; mid tibiae each with an apical black spur; fore femora with a row of long pale setae on dorsal surface.

Wings length 5.9 mm; costal cells with a pale fuscous tint; microtrichia in outer corner of second costal cell only; remainder of wings colourless except for a fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending just beyond extremity of R_{4+5}, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II slightly wider than long. All terga orange-brown with no dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. citroides is similar to *B. aurantiventer* in possessing clear wings except for costal band and anal streak, lateral and medial postsutural vittae present and abdominal terga uniformly orange-brown but differs in having the mesonotum uniformly orange-brown and the humeral and notopleural calli joined by a lateral yellow band.

Bactrocera (Paradacus) decipiens
(Drew), n. comb. (Figs 351–353)

Dacus (*Paradacus*) *decipiens* Drew, 1972a: 13–15.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♀ (T.6987) in QM.

DISTRIBUTION

Keravat, New Britain (type locality).

DIAGNOSIS

Large species; medium sized fuscous to black facial spots present; humeral and notopleural calli

yellow; mesonotum red-brown with 2 broad lateral longitudinal fuscous bands, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a broad pale fuscous costal band and anal streak, an irregular recurved pale fuscous marking across wing, costal cells extremely pale fuscous (second cell paler in centre), microtrichia in outer ⅓ of second costal cell only; abdominal terga I–V fulvous except for broad lateral fuscous margins on tergum I and a narrow medial longitudinal fuscous band on tergum V.

DESCRIPTION

FEMALE: Ovipositor apex of piercer with a large pair of subapical keels and with 4 pairs of subapical bristles (Fig. 352). Spicules at distal end of middle segment of medium width with 7–11 narrow, elongate dentations of uneven length (Fig. 353).

ATTRACTANT: No known record.

COMMENTS

B. decipiens was described adequately by Drew (1972a). It is similar to *B. perplexa* (Walker) in possessing infuscation on wings in addition to costal band and anal streak but differs in having an irregular S-shaped pale fuscous marking across wing, microtrichia in outer ⅓ of second costal cell only, mesopleural stripe not extending to humeral callus, abdominal terga mostly orange-brown with broad lateral fuscous margins on tergum I, a narrow medial longitudinal fuscous band on tergum V and apex of piercer of ovipositor with 1 pair of subapical lobes.

Bactrocera (Paradacus) perplexa (Walker), n. comb. (Fig. 354)

Dacus perplexus Walker, 1862: 14.
Paradacus perplexus: Perkins, 1939: 33–4.
Dacus (Paradacus) perplexus: Hardy and Adachi, 1954: 156–7; Hardy, 1959: 180; Drew, 1973: 13–15.

MATERIAL EXAMINED

Syntype ♀, Gilolo, Moluccas, labelled "*Dacus implexus*" in Walker's handwriting and listed as probably Walker's type by Hardy (1959).

LOCATION OF TYPES: Syntype ♀ in NMV; 1 ♂ labelled "type","East Indies, Gilolo, W.W. Saunders, B.M. 1868-4" in BMNH (not a type, see COMMENTS under *B. curvifera*).

DISTRIBUTION

Gilolo, Indonesia (type locality).

DIAGNOSIS

Large species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with a pattern of fuscous markings, mesopleural stripe reaching to humeral callus, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band and moderately broad fuscous anal streak, infuscation along r–m crossvein and a V-shaped fuscous band across wing, costal cells pale fuscous, microtrichia covering most of second costal cell only; abdominal terga orange-brown except fuscous lateral margins on tergum I and a narrow transverse fuscous band along anterior margin of tergum II which ends before fuscous anterolateral margins and a narrow medial longitudinal fuscous band on terga III–V.

ATTRACTANT: No known record.

COMMENTS

B. perplexa was described adequately by Drew (1973). It is similar to *B. decipiens* (Drew) in possessing infuscation across wings in addition to costal band and anal streak but differs in having a broad U-shaped fuscous band across wing, microtrichia covering most of second costal cell, mesopleural stripe extending to humeral callus, abdominal terga orange-brown with a narrow transverse fuscous band across anterior margin of tergum II and on anterolateral corners of this tergum and apex of piercer of ovipositor needle shaped.

Subgenus **Paratridacus** Shiraki

Bactrocera (Paratridacus) alampeta, n. sp. (Fig. 355)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Western Highlands District: Kuk Agriculture Research Station, Mt Hagen, attracted to methyl eugenol, 30.xii.1980, B. Thistleton.

LOCATION OF TYPE: Holotype (T.10582) in QM.

DISTRIBUTION

Known only from Mt Hagen, Western Highlands District, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral and notopleural calli yellow; mesonotum black with pale markings, lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous

costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for fuscous areas on lateral margins of tergum III and an irregular very narrow medial longitudinal pale fuscous band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.41 times breadth; fulvous with pale fuscous around orbital bristles, anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 3 i.or; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous without dark markings; length of face 0.48 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of weak pale bristles. Antennae with all segments fulvous; a weak pale dorsal bristle on dorsal segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.73 mm.

Thorax mesonotum black except dark fuscous below and behind lateral postsutural vittae and a narrow medial longitudinal fuscous band running from anterior end of medial postsutural vitta to anterior margin of mesonotum. Pleural areas dark fuscous except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a large transvere spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ¾ lower hypopleural calli (remainder black); 2 broad parallel sided lateral postsutural vittae beginning anterior to mesonotal suture and ending at upper pa. bristles; a medial postsutural vitta broadly rounded at prsc. bristles and narrowing to a point at level of mesonotal suture. Postnotum dark fuscous to black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black (scp. bristles particularly long).

Legs all segments fulvous except femora darker fulvous apically and hind tibiae pale fuscous basally; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.3 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings with a very pale fulvous tint, fuscous subcostal cell, narrow fuscous costal band slightly overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten on tergum III absent. Tergum I and sterna I and II wider than long. Tergum I dark fuscous except for an irregular transverse orange-brown band across posterior margin; tergum II orange-brown except for a transverse dark fuscous band across anterior ½ and ending before lateral margins; terga III–V orange-brown except for broad fuscous areas on lateral margins of tergum III, an irregular very narrow medial longitudinal pale fuscous band over terga III–V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. alampeta is similar to *B. atrisetosa* (Perkins) and *B. mesonotaitha* in possessing colourless wings except for costal band and anal streak, humeral calli and scutellum entirely yellow, lateral and medial postsutural vittae present but differs in having a black mesonotum.

Bactrocera (Paratridacus) atrisetosa (Perkins), n. comb. (Figs 356–358)

Zeugodacus atrisetosus Perkins, 1939: 29–30.
Dacus (Zeugodacus) papuaensis Malloch, 1939b: 412–3; May, 1962a: 64 (syn.).
Melanodacus rubidus May, 1957b: 297–8; May, 1962a: 65 (syn.).
Melanodacus atrisetosus: May, 1962a: 64.
Dacus (Paratridacus) atrisetosus: Drew, 1973: 15–18.

MATERIAL EXAMINED

A large series of specimens in DPI and WEI (see DISTRIBUTION).

LOCATION OF TYPES: *Z. atrisetosus*, syntype ♀ in BMNH; *D. papuaensis*, holotype ♂ in NMNH; *M. rubidus*, holotype ♂ in QM.

DISTRIBUTION

Known only from Papua New Guinea (type localities Mafula, Mondo and Mt. Lamington) where it occurs at higher altitudes (1200 m–1650 m). Malloch (1939b) recorded a female of *D. cucumis* French from Mondo (1524 m), Papua, but

this was most likely an incorrect identification of a specimen of *B. atrisetosa*.

DIAGNOSIS

Medium sized species; small fuscous facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with irregularly shaped fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells pale fulvous with microtrichia in outer ½ of second costal cell only; abdominal terga III–V orange-brown occasionally with fuscous on lateral margins of tergum III and generally with a narrow medial fuscous band on tergum V.

DESCRIPTION

FEMALE: Ovipositor basal segment red-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.2:1. Apex of piercer with 1 pair of small subapical keels; 5 pairs of subapical bristles (2 large and 3 small) close to apex (Fig. 357). Spicules at distal end of middle segment of medium width with 6–9 dentations, some broad and elongate and some small (Fig. 358).
ATTRACTANT: No known record.

COMMENTS

B. atrisetosa was described adequately by Drew (1973). It is similar to *B. mesonotaitha* in possessing a red-brown mesonotum, lateral and medial postsutural vittae, humeral calli and scutellum yellow and wings colourless or with pale fuscous tint except for costal band and anal streak. It differs from this species in having the costal band narrow (just overlapping R_{2+3}), mesonotum red-brown with fuscous patterns, wings colourless, costal cells pale fulvous, abdominal terga III–V orange-brown except for a narrow medial longitudinal fuscous band on tergum V and lateral margins of tergum III fuscous.

Perkins (1939) described *B. atrisetosa* from 3 females but did not specify which specimen was the type. All 3 become syntypes.

Bactrocera (Paratridacus) coracinus (Drew), n. comb. (Fig. 359)

Dacus (Paratridacus) coracinus Drew, 1971: 46–8.

MATERIAL EXAMINED

Paratype ♂ in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6937) in QM.

DISTRIBUTION

Bainyik, Sepik District, Papua New Guinea (type locality).

DIAGNOSIS

Small species; small black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe reaching to humeral callus, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad fuscous costal band and anal streak, a narrow transverse fuscous band across wing, first costal cell colourless, outer ½ of second costal cell fuscous, microtrichia in ⅓ of second costal cell only; all abdominal terga black except brown along posterior margin of tergum V.
ATTRACTANT: No known record.

COMMENTS

B. coracinus was described adequately by Drew (1971). It is distinct from the other species of subgenus *Paratridacus* in having a transverse fuscous band across the wing in addition to the costal band and anal streak.

Bactrocera (Paratridacus) expandens (Walker), n. comb. (Figs. 360–362)

Dacus expandens Walker, 1859: 114.
Bactrocera garciniae Bezzi, 1913: 97; Hardy, 1951: 140 (syn.).
Dacus yayeyamanus Matsumura, 1916: 412; Hardy, 1951: 140 (syn.).
Paratridacus expandens: Perkins, 1939: 33.
Dacus (Paratridacus) expandens: Hardy, 1951: 140–2; Drew, 1973: 18–19.

MATERIAL EXAMINED

Two ♂♂ of *D. expandens* in BMNH; a series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: *D. expandens*, 2 ♂♂ in BMNH (not types, see COMMENTS); *B. garciniae*, ♂ ♀ syntypes in NMND; *D. yayeyamanus*, holotype ♀ in HUS.

DISTRIBUTION

Known from eastern coastal Queensland, north from Cairns and Bainyik, Sepik District, Papua New Guinea; type locality, Aru Is. Hardy (1951) stated that the species is widely distributed having seen specimens from Japan, Philippine Is, Ceylon and India.

DIAGNOSIS

Large species; medium sized black facial spots

present; humeral and notopleural calli yellow; mesonotum red-brown with a mottled appearance due to areas of attachment of flight muscles, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae present, medial postsutural vitta absent, scutellum yellow; wing with a broad dark fulvous costal band and anal streak, costal cells dark fulvous, microtrichia in second costal cell and outer corner of first costal cell; abdominal terga III–V orange-brown except for a narrow fuscous spot on anterolateral corners of tergum III and a narrow medial longitudinal fuscous band over posterior ½ of tergum IV and most of tergum V.

DESCRIPTION

FEMALE: Ovipositor apex of piercer with 2 very large subapical keels midway between gonopore and apex; 4 pairs of small subapical bristles (Fig. 361). Spicules at distal end of middle segment of medium width with 3–5 dentations, 1 long and broad centrally and remainder small (Fig. 362).

HOST PLANTS

NEW RECORD: *Garcinia dulcis* (Guttiferae), Cairns Botanical Gardens, 13.iii.1985, B. McCulloch.
ATTRACTANT: No known record.

COMMENTS

B. expandens was described adequately by Hardy (1951) and Drew (1973). It is similar to *B. atrisetosa* (Perkins) and *B. mesonotaitha* in possessing a red-brown mesonotum, lateral postsutural vittae, humeral calli and scutellum yellow and wings colourless except for costal band and anal streak but differs in lacking the medial postsutural vitta.

Hardy (1959) indicated a male of *D. expandens* in BMNH as the type but Walker (1859) based his description on a female. Hardy (1959) and Perkins (1939) studied 2 separate males, both of which are in BMNH. 1 male labelled "*expandens*" in Walker's handwriting, "Borneo, Aru Is, W. Saunders, BM 1868-4", a green Walker type label added by BMNH staff, a circular label "Aru 28", plus a Hardy 1954 determination label; 1 male labelled "*expandens*" in Walker's handwriting, "Aru Island off New Guinea, A.R. Wallace, BM 1858-48", a circular label "Aru Is 58-48", a Perkins determination label. As discussed under *B. curvifera*, there appears to be no valid lectotype designation "by inference of holotype" and the males in BMNH should not be regarded as types.

Bactrocera (Paratridacus) mesonotaitha, n. sp. (Fig. 363)

TYPE SPECIMEN

Holotype ♀, PAPUA NEW GUINEA, Sepik District: Bainyik, 13.i.1973, D. Sands.
LOCATION OF TYPE: Holotype (T.10583) in QM.

DISTRIBUTION

Known only from Bainyik, Sepik District, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with small irregularly oval black spots; humeral and notopleural calli yellow; mesonotum red-brown, lateral and medial postsutural vittae present, mesopleural stripe broad reaching midway between anterior npl. bristle and humeral callus, scutellum yellow; wing with a pale fuscous tint and a broad fuscous costal band and anal streak, costal cells pale fuscous, microtrichia in outer ⅓ of second costal cell only; abdominal terga II–V pale orange-brown except for a small area of pale fuscous anterolaterlly on tergum III, aculeus with 1 pair of subapical lobes.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 2.13 mm. Frons narrowing slightly posteriorly, length 1.29 times breadth; fulvous without dark markings; anteromedial hump with a large number of short pale setae; orbital bristles black: 1 s.or., 5 i.or., well developed except for 2 small i.or. on 1 side; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small irregularly oval black spots; length of face 0.75 mm. Genae fulvous, small fuscous subocular spot present; a well developed dark fuscous bristle and a large number of smaller dark fuscous bristles present. Occiput fulvous, yellow along eye margins; occipital row with 12 well developed dark bristles and a large number of smaller pale bristles. Antennae with all segments fulvous except fuscous on apex of segment 3; a small pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.35 mm; 1.05 mm.

Thorax mesonotum red-brown with no dark markings. Pleural areas red-brown except fuscous above hind coxae. Yellow markings as follows: humeral calli; notopleural calli; broad mesopleural stripe, reaching midway between anterior npl. bristle and humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; 2 broad parallel sided lateral postsutural vittae beginning in a spot anterior to mesonotal suture and ending behind upper pa.

bristles; a broad medial postsutural vitta broadly rounded at level of prsc. bristles and narrowing to a point just anterior of mesonotal suture; upper hypopleural calli (posterior apices red-brown); anterior 5/7 lower hypopleural calli (remainder red-brown). Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black except scp. small and red-brown.

Legs all segments fulvous; mid tibiae each with an apical black spur; fore femora with a row of long pale setae on dorsal surface.

Wings length 9.0 mm; costal cells pale fuscous, microtrichia in outer ⅓ of second costal cell only; remainder of wings with a pale fuscous tint, fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and overlapping this vein at its extremity, broad fuscous anal streak ending at wing margin; no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen oval; terga free; pecten absent on tergum III; tergum I and sterna I and II slightly wider than long. Tergum I orange-brown with pale fuscous markings. Terga II–V pale orange-brown except tending whitish posteriorly on tergum II and a small area of pale fuscous anterolaterally on tergum III. A pair of oval orange-brown shining spots on tergum V. Basal segment of ovipositor orange-brown, dorsoventrally flattened and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 1:1. Apex of piercer with 1 pair of strong subapical lobes (Fig 363A).

ATTRACTANT: No known record.

COMMENTS

B. mesonotaitha is similar to *B. atrisetosa* (Perkins) in possessing a red-brown mesonotum, lateral and medial postsutural vittae, humeral calli and scutellum yellow and wings colourless or with a pale tint except for costal band and anal streak. It differs from this species in having the costal band broad (confluent with R_{4+5}), mesonotum uniformly red-brown without fuscous patterns, costal cells pale fuscous, wings with a pale fuscous tint and abdominal terga II–V pale orange-brown with pale fuscous anterolaterally on tergum III.

Bactrocera (Paratridacus) unichromata, n. sp. (Fig. 364)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central District: 20 km SE of Port Moresby, hand swept off bushes, 1.i.1982, J.W. Ismay.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Mt Kaindi (1230 m), attracted to methyl eugenol, 2.iii.1981, A. Allison; 1 ♀, Wau, 21.xii.1972, O.W. Richards. LOCATION OF TYPES: Holotype (T.10584) in QM; 1 paratype in BMNH; 1 paratype in DPI.

DISTRIBUTION

Known from the Central District and Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with medium sized oval black spots present; humeral and notopleural calli yellow; mesonotum uniformly red-brown without dark markings, lateral and medial postsutural vittae present, lateral postsutural vittae beginning anterior to mesonotal suture, mesopleural stripe of medium width reaching midway between anterior margin of notopleural calli and anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga I–V uniformly orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of uniform width, length 1.4 times breadth; fulvous without dark markings, anteromedial hump covered by a large number of short dark setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized oval black spots; length of face 0.53 mm. Genae fulvous, no subocular spot present; fulvous bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of small pale to dark bristles. Antennae with all segments fulvous; arista black (fulvous basally); length of segments: 0.13 mm; 0.28 mm; 0.78 mm.

Thorax mesonotum and pleural areas uniformly red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior 3/5 lower hypopleural calli (remainder red-brown); 2 moderately broad lateral postsutural vittae beginning anterior to mesonotal suture and narrowing slightly posteriorly to end just behind upper pa. bristles; a medial postsutural vitta of medium width broadly rounded posteriorly just anterior of prsc.

bristles and narrowing to a point anteriorly to end at level of mesonotal suture. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous; rows of long pale setae on dorsal surfaces of fore femora; mid tibiae each with an apical red-brown to fuscous spur.

Wings length 5.7 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and narrowing apically to end just beyond extremity of R_{4+5}, a broad pale fuscous anal streak ending well before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen oval; terga free; no pecten on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 1:1. Apex of piercer with a pair of weak subapical keels.

ATTRACTANT: Methyl eugenol.

COMMENTS

B. unichromata is similar to *B. atrisetosa* (Perkins) and *B. mesonotaitha* in possessing a red-brown mesonotum, lateral and medial postsutural vittae, humeral calli and scutellum entirely yellow and wings colourless except for costal band and anal streak. It differs from *B. atrisetosa* in having the costal band confluent with R_{4+5} and the mesonotum uniformly red-brown without dark patterns, and from *B. mesonotaitha* in having the costal cells colourless, wings without a pale fuscous tint and abdominal terga I–V uniformly orange-brown.

Subgenus **Sinodacus** Zia

Bactrocera (Sinodacus) abdopallescens (Drew), n. comb. (Fig. 365)

Dacus (*Asiadacus*) *abdopallescens* Drew, 1971: 31–3.
Dacus (*Pacifodacus*) *abdopallescens*: Drew, 1972a: 12.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6929) in QM.

DISTRIBUTION

Known from several localities throughout the Morobe and Central Provinces, Papua New Guinea (type locality, Lumi, Sepik District).

DIAGNOSIS

Medium sized species; small elongate black facial spots present; humeral and notopleural calli yellow; mesonotum black, mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta absent, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, first costal cell colourless to extremely pale fulvous, second costal cell pale fulvous, microtrichia in outer ⅓ of second costal cell only; all abdominal terga generally orange-brown.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. abdopallescens was described adequately by Drew (1971). It is similar to *B. perpusilla* (Drew) in possessing clear wings except for costal band and anal streak, lateral postsutural vittae present and medial postsutural vitta absent but differs in having lateral postsutural vittae present and beginning anterior to mesonotal suture, no yellow band along anterior margin of mesonotal suture, mesonotum dull black with small brown markings and abdominal terga predominantly orange-brown.

Bactrocera (Sinodacus) aneuvittata (Drew), n. comb. (Fig. 366)

Dacus (*Asiadacus*) *aneuvittatus* Drew, 1971: 33–5.
Dacus (*Pacifodacus*) *aneuvittatus*: Drew, 1972a: 12.

MATERIAL EXAMINED

Holotype ♂, Sarramea, New Caledonia, December 1967, P. Cochereau.

LOCATION OF TYPE: Holotype (T.6930) in QM.

DISTRIBUTION

New Caledonia (type locality, Sarramea).

DIAGNOSIS

Medium sized species; facial spots absent; humeral and notopleural calli yellow; mesonotum

rich red-brown with fuscous markings along posterior margin, mesopleural stripe equal in width to notopleural callus, lateral and medial postsutural vittae absent, broad yellow triangular marking above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow; wing with a broad dark fuscous costal band and anal streak, a broad dark fuscous band along r–m crossvein, costal cells fuscous, microtrichia covering both costal cells; abdominal terga III–V red-brown except broad fuscous lateral longitudinal bands on all 3 terga and a narrow medial longitudinal fuscous band running from centre of tergum II to posterior margin of tergum V.

ATTRACTANT: No known record.

COMMENTS

B. aneuvittata was described adequately by Drew (1971). It is distinct from all other species of subgenus *Sinodacus* in having the postsutural vittae absent in addition to possessing a broad costal band expanding in apex of wing and a broad infuscation along r–m crossvein.

Bactrocera (Sinodacus) angusticostata, n. sp.
(Fig. 367)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Eastern Highlands Province: Kassam Pass, attracted to cue lure, 19.vi.1980, R.A.I.Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Eastern Highlands Province: 1 ♂, Kassam Pass, attracted to cue lure, 19.vi.1980, R.A.I.Drew and D. W. Currey. Western Highlands District: 1 ♂, 10.x.1978, 2 ♂♂, 30.x.1978, 1 ♂, 30.xi.1978, 1 ♂, 7.xii.1978, Kuk Agriculture Research Station, Mt Hagen, B. Thistleton, all attracted to Dak Pot trap. Morobe Province: 1 ♂, Mt Missim (1500 m), attracted to cue lure, 26.xi.1981, A. Allison.

LOCATION OF TYPES: Holotype (T.10585) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 5 paratypes in DPI.

DISTRIBUTION

Known from Eastern Highlands Province, Western Highlands District and Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots absent; humeral calli yellow; notopleural calli fuscous; mesonotum red-brown with dark markings, lateral and medial postsutural vittae present; mesopleural stripe broad almost reaching humeral callus, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells almost colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown with 2 broad lateral longitudinal glossy black bands over all 3 terga and a broad medial longitudinal glossy black band on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.2 mm. Frons narrowing slightly posteriorly, length 1.32 times breadth; fulvous with no dark markings; anteromedial hump covered by a small number of short dark setae; orbital bristles well developed and black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous, facial spots absent; length of face 0.43 mm. Genae fulvous, small fuscous subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of small, pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex; a red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.10 mm; 0.23 mm; 0.58 mm.

Thorax mesonotum red-brown with dark markings as follows: 2 lateral bands beginning at anterior margin enclosing scp. bristles and narrowing posteriorly before running at right angles along anterior margin of mesonotal suture; dark fuscous around notopleural calli; dark fuscous below pa. bristles; in some specimens there is a broad dark fuscous band enclosing inner scp. bristles and running to anterior end of medial longitudinal yellow postsutural vitta. Pleural areas red-brown except dark fuscous to black on sternopleuron, above hind coxae and on pteropleuron. Yellow markings as follows: humeral calli; broad mesopleural stripe reaching almost to humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; anterior ½ of upper hypopleural calli (remainder dark fuscous); anterior ¾ lower hypopleural calli (remainder dark fuscous); a broad medial longitudinal postsutural vitta beginning just anterior to level of mesonotal suture and broadening posteriorly to end at level of upper pa. bristles; 2 narrow lateral postsutural vittae ending midway between sa. and upper pa. bristles. Notopleural calli fuscous. Postnotum black laterally, fuscous centrally. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent (in 3 specimens there is a single weak prsc. bristle present); pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous to black.

Legs all segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.2 mm; first costal cell with a very pale fuscous tint, second costal cell colourless,

microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, very narrow fuscous costal band confluent with R_{2+3} and ending at extremity of M, narrow pale fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I dark fuscous to black except for a broad transverse orange-brown band on posterior ½ and narrowing at lateral margins; tergum II orange-brown except for a narrow transverse black band along anterior margin which broadens on lateral margins; terga III–V orange-brown except for 2 broad lateral longitudinal glossy black bands on all 3 terga which connect with a narrow transverse fuscous band along anterior margin of tergum III and a broad medial longitudinal glossy black band on tergum V. A pair of circular orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure (Dak Pot).

COMMENTS

B. angusticostata is similar to *B. paulula* in possessing a narrow costal band confluent with R_{2+3}, lateral and medial postsutural vittae present with lateral vittae beginning before mesonotal suture, yellow humeral and notopleural calli not joined by a lateral yellow band and wings colourless except for costal band and anal streak. It differs from this species in having the mesonotum red-brown with fuscous markings, abdominal terga III–V orange-brown with 2 broad lateral longitudinal black bands and a medial longitudinal band on tergum V.

Bactrocera (Sinodacus) buvittata, n. sp. (Fig. 368)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Central Province: 51 km NW of Port Moresby on Moresby–Bereina road, 26.vi.1980, attracted to cue lure, R.A.I. Drew and D.W. Currey.

Paratype, PAPUA NEW GUINEA, Central Province: 1 ♂, Brown River, attracted to Willison's lure, 3.iii.1970, T.L. Fenner.

LOCATION OF TYPES: Holotype (T.10589) in QM; paratype in DPI.

DISTRIBUTION

Known from the Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face black; humeral and notopleural calli yellow and connected by a broad yellow band; mesonotum black, lateral and medial postsutural vittae present; mesopleural stripe broad but not reaching mesonotum dorsally, scutellum yellow; wing with a broad dark fuscous costal band, anal streak absent, costal cells pale fuscous, microtrichia in outer corner of second costal cell only; abdominal terga III–V fulvous with a medial longitudinal black band and narrow transverse black band along posterior margin of tergum V, fuscous oval shining spots.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.33 mm. Frons of even width, length 1.36 times breadth; fulvous with fuscous adjacent to lunule; anteromedial hump absent; bristles black: 1 s.or., 3 i.or.; lunule dark fuscous and continuing as a dark fuscous line down each side of face. Ocellar triangle fuscous. Vertex fulvous. Face black, length of face 0.43 mm. Genae fulvous, subocular spot absent; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of small fulvous bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 absent on both specimens; a strong dark fulvous dorsal bristle on segment 2; length of segments: 0.13 mm; 0.25 mm.

Thorax mesonotum black tending dark brown anteriorly and below and behind lateral postsutural vittae. Pleural areas fulvous. Yellow marking as follows: humeral calli; notopleural calli; mesopleural stripe broad, reaching beyond anterior npl. bristle, continuing to sternopleuron as a large transverse spot, anterior margins strongly convex (there is a broad black margin below the mesopleural suture so that the mesopleural stripe does not extend dorsally to this suture — this character is unique in the Dacinae); upper hypopleural calli (posterior apices black); anterior ¾ lower hypopleural calli (remainder black); a large medial longitudinal postsutural vitta beginning at level of anterior npl. bristle and ending at posterior margin of mesonotum where it is broad and rounded; 2 broad parallel sided lateral postsutural vittae beginning anterior to mesonotal suture and ending behind upper pa. bristles; a broad band connecting humeral and notopleural calli. Postnotum black laterally, red-brown centrally. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 2; all bristles well developed and black.

Legs all segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells pale fuscous;

microtrichia in outer ⅓ of second costal cell; remainder of wings colourless except for a dark fuscous subcostal cell and a broad dark fuscous costal band overlapping R_{4+5} for its entire length; anal streak reduced to a pale fuscous tint in basal portion of anal cell; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga free; pecten present on tergum III. All terga fulvous except for the following dark markings on tergum V: a medial longitudinal black band, a transverse black band along posterior margin, a pair of fuscous oval shining spots. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. buvittata is similar to *B. angusticostata* and *B. paulula* in possessing lateral and medial postsutural vittae and wings colourless except for costal band and anal streak. It differs from these species in having humeral and notopleural calli joined by a lateral yellow band, lateral postsutural vittae beginning anterior to mesonotal suture and costal band broad (overlapping R_{4+5} for entire length).

Bactrocera (Sinodacus) emarginata (Perkins), n. comb. (Fig. 369)

Neodacus emarginatus Perkins, 1939: 24.
Dacus (Neodacus) emarginatus: Hardy, 1954: 10.
Dacus (Pacifodacus) emarginatus: Drew, 1973: 8–10.

MATERIAL EXAMINED

Holotype ♂, Mondo (1500 m), Central District, Papua New Guinea, February 1934, L.E. Cheesman.
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION

Mondo, Central District, Papua New Guinea (type locality).

DIAGNOSIS

Medium sized species; small fuscous facial spots present; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum generally black, mesopleural stripe equal in width to notopleural callus, lateral and medial postsutural vittae present, scutellum yellow; wing with a broad fuscous costal band and narrow fuscous anal streak, a large indefinite fuscous spot over apical ½ of wing, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga II and III orange-brown, tergum IV orange-brown with broad lateral fuscous margins joined by a fuscous band across posterior margin, tergum V fuscous with a narrow medial longitudinal black band.

ATTRACTANT: No known record.

COMMENTS

B. emarginata was described adequately by Drew (1973). It is similar to *B. strigifinis* (Walker) and *B. surrufula* in possessing lateral and medial postsutural vittae, humeral and notopleural calli joined by a lateral yellow band, wings infuscated in addition to costal band and anal streak and in lacking a yellow triangle above notopleural calli. It differs from *B. surrufula* in having the apical ½ of wing lightly infuscated and abdominal terga basically red-brown. It differs from *B. strigifinis* in having lateral postsutural vittae short (beginning behind mesonotal suture and ending well before upper pa. bristle), a broad costal band confluent with R_{4+5}, apical ½ of wing lightly infuscated, no infuscation along dm–cu crossvein, mesonotum basically black and abdominal terga II–IV orange-brown with posterior and lateral margins of tergum IV and all of tergum V fuscous.

Bactrocera (Sinodacus) paulula, n. sp. (Fig. 370)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Gumi-Watut, attracted to cue lure, 26.v.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂ (26.v.1980), 1 ♂ (30.v.1980), Gumi-Watut, P. Daur; 1 ♂, Mt Kaindi (2160 m), 16.vi.1980, A. Allison; 1 ♂, 15.vi.1980, 4 ♂♂, 16.vi.1980, Wau Ecology Institute (1400 m), R.A.I. Drew and D.W. Currey; 2 ♂♂, Kunai Creek, Mt Kaindi, 27.vii.1981; 1 ♂, Mt Kaindi (1650 m), 21.ix.1981, A. Allison. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10590) and 1 paratype (T.10591) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 6 paratypes in DPI.

DISTRIBUTION

Known only from the Morobe Province, Papua New Guinea.

DIAGNOSIS

Very small species; facial spots absent; humeral calli yellow; notopleural calli glossy black; mesonotum glossy black, lateral postsutural vittae very short, medial postsutural vitta present, mesopleural stripe broad almost reaching humeral callus, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells with a pale fuscous tint, microtrichia in outer corner of second costal cell only; abdominal terga

III–V orange-brown with a medial longitudinal and 2 broad lateral longitudinal glossy black bands.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 0.9 mm. Frons of even width, length 1.25 times breadth; fulvous, with or without pale fuscous on anteromedial hump, latter covered by short dark setae; orbital bristles small and black: 1 s.or., 3 i.or; lunule fulvous to pale fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous, facial spots absent; length of face 0.3 mm. Genae fulvous, small fuscous subocular spot present; red-brown bristle present. Occiput red-brown with broad areas of fuscous, yellow along eye margins; occipital row with a large number of very small pale bristles. Antennae with segments 1 and 2 red-brown, segment 3 red-brown with pale fuscous on apex; a weak red-brown dorsal bristle on segment 2; arista black (red-brown basally); length of segments: 0.08 mm; 0.18 mm; 0.45 mm.

Thorax mesonotum glossy black. Pleural areas glossy black except red-brown between mesopleural stripe and fore coxae (there is a narrow band of glossy black below the humeral calli). Yellow markings as follows: humeral calli; broad mesopleural stripe, reaching almost to humeral callus dorsally, continuing to sternopleuron as a red-brown spot, anterior margin convex; upper hypopleural calli (posterior ½ glossy black); anterior ⅔ lower hypopleural calli (remainder glossy black); a broad medial postsutural vitta beginning just anterior of mesonotal suture and ending at level of upper pa. bristles; 2 short, narrow lateral postsutural vittae ending at level of sa. bristles. Notopleural calli glossy black. Postnotum glossy black. Scutellum yellow except for narrow glossy black basal band. Bristles: sc. 2; prsc. absent (present but weak in holotype); pa 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black except inner scp. weak and pale.

Legs fore coxae fulvous, mid and hind coxae fuscous; all other segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 4.2 mm; costal cells very pale fuscous, microtrichia in extreme outer portion of second costal cell only, remainder of wings with a very pale fuscous tint, fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending at extremity of M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Terga I and II glossy black except orange-brown centrally along intersegmental line and a transverse orange-brown band on posterior ½ of tergum II which narrows laterally; terga III–V orange-brown with a medial longitudinal glossy black band narrow or absent on tergum III and broadening on terga IV and V and 2 broad lateral longitudinal glossy black bands. In some specimens there are narrow transverse black bands along anterior margins of terga III and V. A pair of small round orange-brown shining spots covered by a dense fine pubescense on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. paulula is similar to *B. angusticostata* in having humeral and notopleural calli not joined by a lateral yellow band, lateral and medial postsutural vittae present with lateral vittae beginning behind mesonotal suture, wings colourless except for costal band and anal streak and costal band confluent with R_{2+3}. It differs from this species in having a glossy black mesonotum, abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum III.

Bactrocera (Sinodacus) perpusilla (Drew), n. comb. (Fig. 371)

Dacus (Asiadacus) perpusillus Drew, 1971: 42–4.
Dacus (Pacifodacus) perpusillus: Drew, 1972a: 12.

MATERIAL EXAMINED

A series of paratypes in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6934) in QM.

DISTRIBUTION

Noumea, New Caledonia (type locality).

DIAGNOSIS

Small species; facial spots absent; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. bristle, lateral and medial postsutural vittae absent, yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells fuscous, microtrichia covering both costal cells; abdominal tergum III black, terga IV and V orange-brown except anterior 3/5 of lateral margins of tergum IV and anterolateral corners of tergum V black and a

broad medial longitudinal black band over both terga.
ATTRACTANT: Cue lure.

COMMENTS
B. perpusilla was described adequately by Drew (1971). It is similar to *B. abdopallescens* (Drew) in having lateral postsutural vittae present, medial postsutural vitta absent and wings colourless except for costal band and anal streak but differs in having postsutural vittae absent, a triangular yellow band above each notopleural callus along anterior margin of mesonotal suture, mesonotum glossy black and abdominal terga black except for orange-brown areas on terga IV and V.

Bactrocera (Sinodacus) salamander
(Drew and Hancock), n. comb. (Fig. 372)

Dacus (Pacifodacus) salamander Drew and Hancock, 1981: 51–4.

MATERIAL EXAMINED
One ♂ paratype in DPI.
LOCATION OF TYPE: Holotype ♂ (T.8220) in QM.

DISTRIBUTION
Bamaga, north Queensland (type locality).

DIAGNOSIS
Medium sized species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown to dark red-brown without dark markings, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae absent, medial postsutural vitta present, yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow; wing with a broad fuscous costal band and anal streak, a fuscous tint across the general wing membrane, costal cells fuscous, microtrichia covering second costal cell and most of first costal cell; abdominal terga III–V red-brown laterally and orange-brown centrally with a medial longitudinal red-brown stripe over all 3 terga.
ATTRACTANT: Cue lure.

COMMENTS
B. salamander was described adequately by Drew and Hancock (1981). It is similar to *B. triangularis* (Drew), *B. emarginata* (Perkins), *B. strigifinis* (Walker), *B. surrufula* and *B. univittata* (Drew) in possessing postsutural vittae and infuscation on wing in addition to costal band and anal streak. It differs from these species in having a yellow triangular marking above notopleural calli along anterior margin of mesonotal suture and the humeral and notopleural calli not joined by a lateral yellow band.

Bactrocera (Sinodacus) sepikae, n. sp.
(Fig. 373)

TYPE SPECIMEN
Holotype ♂, PAPUA NEW GUINEA, West Sepik Province: Eliptamin (5° 03'S, 141° 40'E), 1500 m, hand collected on *Cardamom* sp., 19.xi.1985, J.W. Ismay.
LOCATION OF TYPE: Holotype (T.10592) in QM.

DISTRIBUTION
Known only from the West Sepik Province, Papua New Guinea.

DIAGNOSIS
Small species; face with a pair of small pale spots; humeral and notopleural calli yellow and joined by a yellow band; mesonotum black, lateral and medial postsutural vittae present, mesopleural stripe extending to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture as a small spot, scutellum yellow; wing with a moderately broad fuscous costal band and anal streak, a broad U-shaped fuscous band across wing, costal cells colourless with microtrichia in outer ⅓ of second cell; abdominal terga III–V orange-brown with an elongate black spot in centre of tergum V.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.1 mm. Frons of even width, length 1.2 times breadth; fulvous with a small pale fuscous patch on anteromedial hump; latter covered with a few short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with small pale fuscous spots; length of face 0.35 mm. Genae fulvous, fuscous subocular spot present; red-brown bristle present. Occiput fulvous ventrally, fuscous dorsally, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with pale fuscous on apex and outer surface; a strong dark dorsal bristle on segment 2; length of segments: 0.10 mm; 0.20 mm; 0.55 mm.

Thorax mesonotum black, tending dark fuscous along posterior margin and brown as follows: below and behind lateral postsutural vittae, inside humeral calli and as a broad medial longitudinal band running from anterior end of medial yellow vitta to anterior margin of mesonotum. Pleural

areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; a broad yellow band connecting humeral and notopleural calli; a pair of very narrow lateral postsutural vittae beginning anterior to mesonotal suture and narrowing posteriorly to end before upper pa. bristles; a broad medial longitudinal vitta rounded posteriorly at level of upper pa. bristles and narrowing to a point anteriorly to end just anterior to mesonotal suture; a moderately broad mesopleural stripe extending to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices dark fuscous); anterior 3/5 lower hypopleural calli (remainder dark fuscous). Postnotum dark fuscous. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black except mpl. red-brown.

Legs all segments fulvous except hind tibiae tending pale fuscous basally; mid tibiae without an apical spur.

Wings length 4.9 mm; costal cells colourless with microtrichia covering apical ⅓ of second costal cell only; remainder of wings colourless except dark fuscous subcostal cell, moderately broad fuscous costal band confluent with R_{4+5} except for a small area just distal of r–m crossvein and ending at apex of M, a broad U-shaped fuscous band across wing enclosing both crossveins but not joining with costal band apically, broad fuscous anal streak reaching wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga uniformly orange-brown except for dark fuscous laterally on tergum I and anterolaterally on tergum II, a narrow transverse dark fuscous band across anterior margin of tergum II but not reaching lateral margins, an elongate black spot on midline of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with posterior margin almost straight. ATTRACTANT: No known record.

COMMENTS

B. sepikae is similar to *B. strigifinis* (Walker) in abdominal and leg colour patterns and in the humeral and notopleural calli being joined by a yellow band but differs in having an almost entirely black mesonotum, very narrow lateral postsutural vittae and a unique U-shaped fuscous band across wing.

Bactrocera (Sinodacus) strigifinis (Walker), n. comb. (Figs 374–376)

Dacus strigifinis Walker, 1861: 295.
Neodacus lanceolatus Perkins, 1939: 22–3; Hardy, 1959: 183 (syn.).
Dacus (Chaetodacus) albolateralis Malloch, 1939b: 413; Hering, 1941a: 53 (syn.).
Dacus (Neodacus) lanceolatus: Hardy, 1954: 10–11, 1959: 183 (syn.).
Dacus (Neodacus) strigifinis: Hardy, 1959: 183.
Dacus (Pacifodacus) strigifinis strigifinis: Drew,1973: 10–13.
Neodacus strigifinis atritus May, 1962a: 65–6.
Dacus (Pacifodacus) strigifinis atritus: Drew, 1973: 10. New synonymy based on a study of the holotype of *N. atritus* and a large series of specimens of *B. strigifinis* from Queensland and Papua New Guinea.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION); the holotype of *N. strigifinis atritus* May and part of the type series of *N. lanceolatus* Perkins.

LOCATION OF TYPES: *D. strigifinis*, 1 ♂ labelled "Moluccas, Bachan, Pres. by Saunders, B.M. 1868-4" in BMNH (not a type, see COMMENTS); *N. lanceolatus*, 23 syntypes (both sexes) in BMNH, 11 syntypes (both sexes) in UQ; *D. albolateralis*, holotype ♀ unknown, paratype ♂ in BMNH; *N. strigifinis atritus*, holotype ♂ (T.5880) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Common in eastern coastal rainforests of Queensland north from Cairns and throughout Papua New Guinea; type locality, Bachan, Moluccas.

NEW RECORDS: Torres Strait islands: Horn, Yorke (records from Plant Quarantine Survey). There are 2 specimens in DPI, 1 labelled Nila Point, Shortland Is, 17.v.1985 and 1 labelled Alu Point, Western Province, Solomon Islands, 17.v.1985, both collected by R. MacFarlane. These are damaged and are either *B. strigifinis* or an undescribed sibling species.

DIAGNOSIS

Medium sized species; small fuscous to black facial spots present; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum rich red-brown with irregular fuscous to black markings, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a narrow fuscous costal band and anal streak, a narrow fuscous band along dm–cu crossvein which becomes paler as it continues around hind margin of wing to anal streak, costal cells pale fulvous (second cell paler than first), microtrichia in outer corner of second costal cell

only; abdominal terga mostly red-brown with fuscous on lateral margins of tergum III and a large elongate oval fuscous spot on centre of tergum V.

DESCRIPTION

FEMALE: Ovipositor apex of piercer with 1 pair of lateral keels near level of gonopore and 1 pair of subapical lateral keels; 2 pairs of small subapical bristles near apex (Fig. 375). Spicules at distal end of middle segment of medium width with 7–11 elongate dentations (Fig. 376).
ATTRACTANT: Cue lure.

COMMENTS

B. strigifinis was described adequately by Drew (1973). It is similar to *B. emarginata* (Perkins) and *B. sepikae* in possessing abdominal terga mostly orange-brown, lateral and medial postsutural vittae present, humeral and notopleural calli joined by a lateral yellow band and in lacking a yellow triangular marking above the notopleural calli. It differs from *B. emarginata* in having the lateral postsutural vittae long and beginning anterior to the mesonotal suture, costal band narrow (not confluent with R_{4+5}), no fuscous spot in wing apex, infuscation on dm–cu crossvein and mesonotum mostly red-brown. It differs from *B. sepikae* in having the mesonotum not entirely black, lateral postsutural vittae broader and infuscation only on dm–cu crossvein.

Since Walker (1861) based his description of *B. strigifinis* on a female, the male in BMNH should not be regarded as a type (see COMMENTS under *B. curvifera*). Hardy (1959) did not call this specimen a type.

Bactrocera (Sinodacus) surrufula, n. sp.
(Fig. 377)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute (1400 m), attracted to cue lure, 14.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 3 ♂♂ (14.vi.1980), 2 ♂♂, 16.vi.1980, 5 ♂♂, 18.vi.1980, Mt Kaindi (1600 m), R.A.I. Drew and D.W. Currey; 4 ♂♂, 15.vi.1980, 2 ♂♂, 16.vi.1980, Wau Ecology Institute, R.A.I. Drew and D.W. Currey; 1 ♂, Mt Kaindi (1450 m), 18.vi.1980, A. Allison; 1 ♂, Upper Manki logging area, Bulolo, 8.iv.1980, P. Daur. All paratypes attracted to cue lure.
LOCATION OF TYPES: Holotype (T.10593) and 2 paratypes (T.10594–T.10595) in QM; 6 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 8 paratypes in DPI.

DISTRIBUTION

Known only from the Morobe Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots small and circular; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum black, lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching midway between the notopleural callus and anterior npl. bristle, scutellum yellow; wing with a dark fuscous spot across apical ½ and a broad dark fuscous costal band and anal streak, costal cells colourless, microtrichia in outer corner of second costal cell; abdominal terga III–V black with dark fuscous each side of a broad medial longitudinal black band.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.18 mm. Frons of even width, length 1.44 times breadth; fulvous with fuscous on anteromedial hump; latter covered by short dark setae; bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous with a pair of small circular facial spots, length of face 0.43 mm. Genae fulvous, fuscous subocular spot present; black bristle present. Occiput fuscous, yellow along eye margins; occipital row with 7–10 well developed dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.18 mm; 0.63 mm.

Thorax mesonotum black except dark red-brown below lateral postsutural vittae. Pleural areas black with no pale markings. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a distinct spot, anterior margin straight; upper hypopleural calli (posterior halves black); anterior ⅔ lower hypopleural calli (remainder black); a broad medial longitudinal postsutural vitta beginning just anterior to level of mesonotal suture and ending at level of upper pa. bristles; 2 parallel sided lateral postsutural vittae ending before upper pa. bristles; a broad band connecting humeral and notopleural calli. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae dark fuscous; fore and mid femora fulvous, hind femora black (except fulvous apically); tibiae and tarsi fulvous (except fore tibiae fuscous); a row of

long dark setae on dorsal surface of fore femora; mid tibiae each with an apical black spur.

Wings length 5.1 mm; costal cells with a very pale fuscous tint; microtrichia in outer corner of second costal cell; remainder of wings with a dark fuscous subcostal cell, a broad dark fuscous costal band confluent with R_{4+5}, a broad dark fuscous anal streak ending at wing margin and a distinct fuscous spot across apical ½ of wing; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I black with a narrow transverse red-brown band on posterior margin but not reaching lateral margins; tergum II generally fuscous to black with red-brown across posterior margin but may vary to red-brown with an indistinct medial longitudinal fuscous to black band; terga III–V with a general black appearance but with more careful examination indistinct dark fuscous patterns are visible on terga III and IV either side of a broad medial longitudinal black band. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

B. surrufula is similar to *B. emarginata* (Perkins) and *B. strigifinis* (Walker) in possessing lateral and medial postsutural vittae, humeral and notopleural calli joined by a lateral yellow band and in lacking a yellow triangle above the notopleural calli but differs in having the apical ½ of wing heavily infuscated and abdominal terga mostly dark fuscous to black.

Bactrocera (Sinodacus) triangularis (Drew), n. comb. (Fig. 378)

Asiadacus triangularis Drew, 1968a: 21–3.
Dacus (Pacifodacus) triangularis: Drew, 1972a: 12.

MATERIAL EXAMINED

A series of specimens (including paratypes) in DPI (see DISTRIBUTION); 3 ♂♂, Lelet Plateau, New Ireland, hand collected in rainforest, 4.xi.1981, J.W. Ismay; 1 ♂ (in UH), Buin, Bougainville I., October 1971, N.L.H. Krauss.
LOCATION OF TYPE: Holotype (T.6574) in QM.

DISTRIBUTION

Known from New Britain (type locality), New Ireland and Bougainville I.

DIAGNOSIS

Medium sized species; large black facial spots present; posterior ⅓ humeral calli yellow (anterior ⅔ fulvous); anterior ½ notopleural calli yellow (posterior ½ fulvous), broad yellow band connecting humeral and notopleural calli; mesonotum generally uniformly fulvous, mesopleural stripe reaching to humeral callus, lateral postsutural vittae absent, medial postsutural vitta as a broad triangle, scutellum fulvous with yellow across centre but not extending to apex; wing with a narrow fuscous costal band and broad fuscous anal streak, a transverse fuscous band across centre but not reaching posterior margin and a transverse fuscous band across apex which continues around hind margin to join anal streak, first costal cell fulvous, second costal cell colourless, microtrichia in outer corner of second costal cell only; all abdominal terga fulvous except for a black spot in centre of tergum V.
ATTRACTANT: Cue lure.

COMMENTS

B. triangularis was described adequately by Drew (1968a). It is similar to *B. univittata* (Drew) in having medial postsutural vitta present and lateral postsutural vittae absent, humeral and notopleural calli joined by a lateral yellow band and no yellow triangular marking above notopleural calli. It differs from this species in having posterior ⅓ of humeral calli and anterior ½ of notopleural calli yellow (remainder fulvous), medial postsutural vitta triangular in shape, mesopleural stripes reaching humeral calli, a transverse fuscous band across wing enclosing dm–cu crossvein and continuing around wing margin to $A_1 + CuA_2$, a separate fuscous band enclosing r–m crossvein.

Bactrocera (Sinodacus) univittata (Drew), n. comb. (Fig. 379)

Dacus (Pacifodacus) univittatus Drew, 1972b: 189–91.

MATERIAL EXAMINED

A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6985) in QM.

DISTRIBUTION

Bougainville I. (type locality, Kieta).

DIAGNOSIS

Medium sized species; very large black facial spots present; humeral and notopleural calli yellow and joined by a broad yellow band; mesonotum red-brown with fuscous markings, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae absent, medial postsutural vitta present, scutellum yellow; wing with a narrow

pale fuscous costal band and narrow fulvous anal streak, pale fuscous along r–m crossvein and a narrow infuscation along dm–cu crossvein which becomes paler as it continues around hind wing margin to join anal streak, first costal cell with a pale fulvous tint, second costal cell almost colourless, microtrichia in outer corner of second costal cell only; all abdominal terga red-brown with a large oval dark fuscous to black spot in centre of tergum V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. univittata was described adequately by Drew (1972b). It is similar to *B. triangularis* (Drew) in the characters listed in the comments on this species. *B. univittata* differs from this species in having the humeral and notopleural calli entirely yellow, medial postsutural vitta long and narrower, mesopleural stripe not reaching humeral callus and wing with pale fuscous around crossveins.

Subgenus **Zeugodacus** Hendel

Bactrocera (Zeugodacus) abdoangusta
(Drew), n. comb. (Fig. 380)

Dacus (Zeugodacus) abdoangustus Drew, 1972b: 191–2.

MATERIAL EXAMINED
Paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6996) in QM.

DISTRIBUTION
Recorded from Central Sulawesi (Indonesia) by Hardy (1982), although he stated that the 2 specimens from Indonesia may represent a distinct species; type locality, Daru Village, Bougainville I.

DIAGNOSIS
Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with black markings, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a general pale fulvous tint throughout membrane and a broad fuscous costal band and anal streak, pale infuscation along r–m crossvein and dark infuscation along dm–cu crossvein, costal cells fulvous with microtrichia in outer ½ of second costal cell only; abdominal terga III–V fulvous with a narrow transverse black band across base of tergum III and broad medial and 2 broad lateral longitudinal dark fuscous to black band over all 3 terga.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. abdoangusta was described adequately by Drew (1972b). It is similar to *B. anchitrichota*, *B. chorista* (May) and *B. curta* (Drew) in possessing the costal band slightly widened in wing apex, a narrow infuscation along dm–cu crossvein and abdominal terga with ground colour orange-brown or fulvous. It differs from these species in having infuscation along r–m crossvein, costal cells fulvous, a black transverse band across base of tergum III joining the medial and lateral longitudinal black bands which extend over terga III–V.

Bactrocera (Zeugodacus) amoena
(Drew), n. comb. (Fig. 381)

Dacus (Zeugodacus) amoenus Drew, 1972b: 192–3.

MATERIAL EXAMINED
Paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6999) in QM.

DISTRIBUTION
Bougainville I. (type locality, Kieta).

DIAGNOSIS
Small species; face glossy black; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, a broad medial postsutural vitta present, scutellum yellow; wing with a broad dark fuscous costal band and anal streak, a broad dark fuscous Z-shaped band across wing, costal cells pale fuscous with microtrichia in outer corner of second costal cell only; abdominal terga III–V fulvous with a broad medial and 2 broad lateral longitudinal black bands.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. amoena was described adequately by Drew (1972b). It is similar to *B. reflexa* (Drew) in possessing a Z-shaped fuscous band across wing, mesonotum glossy black, abdomen with a broad medial and 2 broad lateral longitudinal black bands over terga III–V. It differs from this species in having yellow notopleural calli, lateral postsutural vittae ending at upper pa. bristles, mesopleural stripe not reaching humeral callus, microtrichia in outer corner of second costal cell

only and no transverse black band across base of tergum III.

Bactrocera (Zeugodacus) anchitrichota, n. sp. (Fig. 382)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, East Sepik Province: Maprik, Oct. 1958, Malaria Control Section. LOCATION OF TYPE: Holotype (T.10596) in QM.

DISTRIBUTION

Known only from Maprik, East Sepik Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots small and pale fuscous; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching almost to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum yellow; legs fulvous except hind tibiae pale fuscous; wing with a narrow fuscous costal band almost confluent with R_{4+5} but expanding at apex and a broad fuscous anal streak, narrow infuscation around dm–cu crossvein, costal cells with a pale fulvous tint and microtrichia in outer corner of second costal cell only; all abdominal terga uniformly orange-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.6 mm. Frons of even width, length 1.39 times breadth; fulvous without dark markings, anteromedial hump covered by a large number of small pale setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous with very small pale fuscous spots; length of face 0.53 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with 6–7 strong dark bristles and a large number of smaller pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.28 mm; 0.73 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder black); 2 broad lateral postsutural vittae beginning anterior to mesonotal suture and tapering posteriorly to end well before upper pa. bristles; a broad medial postsutural vitta broadly rounded posteriorly and narrowing to a point anterior to mesonotal suture. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except hind tibiae pale fuscous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.8 mm; costal cells with a pale fulvous tint; microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and widening at apex, a narrow infuscation along dm–cu crossvein, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe very strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. anchitrichota is similar to *B. abdoangusta* (Drew), *B. chorista* (May) and *B. curta* (Drew) in possessing infuscation on 1 or both crossveins in addition to costal band and anal streak. It differs from *B. abdoangusta* in lacking infuscation on r–m crossvein and having costal cells extremely pale fulvous, and from *B. chorista* and *B. curta* in possessing uniformly orange-brown abdominal terga.

Bactrocera (Zeugodacus) brachus (Drew), n. comb. (Fig. 383)

Dacus (Zeugodacus) brachus Drew, 1972b: 194–5.

MATERIAL EXAMINED

Paratype ♂ in DPI.

LOCATION OF TYPE: Holotype ♂ (T.6994) in QM.

DISTRIBUTION

Mt Lawes (250 m), Central Province, Papua New Guinea (type locality).

DIAGNOSIS

Medium sized species; face dark fuscous to black; humeral and notopleural calli yellow; mesonotum black with a variable pattern of red-brown markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a narrow dark fuscous costal band and broad dark fuscous anal streak, costal cells pale fuscous (second cell paler in centre), microtrichia in outer ½ of first and second costal cells; abdominal terga mostly orange-brown with a short narrow medial longitudinal dark fuscous spot in centre of tergum V.

ATTRACTANT: Cue lure.

COMMENTS

B. brachus was described adequately by Drew (1972b). It is similar to *B. daula* and *B. fallacis* (Drew) in possessing wings with no additional infuscation other than costal band of uniform width and anal streak, scutellum entirely yellow, lateral and medial postsutural vittae present and face entirely dark fuscous to black. It differs from *B. fallacis* in having the mesonotum mostly black and from *B. daula* in having microtrichia in outer ½ of each costal cell, abdominal terga III–V mostly orange-brown with a small medial longitudinal dark fuscous spot on tergum V.

Bactrocera (Zeugodacus) chorista (May), n. comb. (Figs 384–386)

Zeugodacus choristus May, 1962a: 72–4.
Dacus (Zeugodacus) choristus: Drew, 1973: 21–3.

MATERIAL EXAMINED

A large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.5874) in QM.

DISTRIBUTION

Widely distributed throughout the eastern coastal areas of Queensland (type locality, Atherton) and Papua New Guinea.

DIAGNOSIS

Medium sized species; medium sized fuscous to black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with fuscous to black markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, pale infuscation along dm–cu crossvein which becomes paler around posterior margin of wing to anal streak, first costal cell pale fuscous, second costal cell paler than first and with a tinge of pale fuscous around perimeter, microtrichia in outer corner of second costal only; abdominal terga III–V fulvous with a broad black band across base of tergum III and a broad medial and 2 broad lateral longitudinal dark fuscous to black band over all 3 terga.

DESCRIPTION

FEMALE: No dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.49:1. Apex of piercer broad and narrowing to a sharp tip with 5 pairs of subapical bristles (2 large and 3 small) (Fig. 385). Spicules at distal end of middle segment narrow, some elongate triangular and others with 3–5 dentations (1 or 2 elongate triangular, remainder small) (Fig. 386).

HOST PLANTS

NEW RECORD: *Diplocyclos palmatus* (Curcurbitaceae), Samford Valley, south-east Queensland, March 1987, E. Hamacek.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS

B. chorista was described adequately by May (1962a) and Drew (1973). The costal band is broader than as described by May, overlapping R_{2+3}. It is similar to *B. curta* (Drew) and *B. anchitrichota* in the absence of infuscation along r–m crossvein and in possessing costal cells extremely pale fulvous or fuscous. It differs from *B. anchitrichota* in having dark colour patterns on the abdomen and from *B. curta* in having the general wing membrane colourless, mesonotum basically red-brown with small dark markings and abdomen with a transverse black band across base of tergum III.

Bactrocera (Zeugodacus) cucurbitae (Coquillett) (Figs 387–389)

Dacus cucurbitae Coquillett, 1899: 129; Froggatt, 1909: 84–5.
Bactrocera cucurbitae: Bezzi, 1913: 96–7.
Chaetodacus cucurbitae: Bezzi, 1916: 109–10; Hendel, 1915: 426, 1927a: 28; Shiraki, 1933: 73–6.
Strumeta cucurbitae: Perkins, 1938: 127.

Dacus (*Strumeta*) *cucurbitae*: Hardy and Adachi, 1954: 164–5; Hardy, 1973: 38–40, 1974: 27–9.
Dacus (*Zeugodacus*) *cucurbitae*: Drew, 1973: 23–7; Hardy, 1977: 57, 1982: 203, 1983: 36.

MATERIAL EXAMINED
A large series of specimens in DPI (see DISTRIBUTION); 3 of Coquillett's types.
LOCATION OF TYPES: Lectotype ♀, 1 ♀ and 2 ♂ paralectotypes in NMNH. Type locality, Honolulu, Hawaii (not endemic here but first collected and described after introduction from South East Asia).

DISTRIBUTION
Widely distributed around the world. See Drew (1982) for its distribution range in the Asian and Pacific regions. Cogan and Munro (1980) have recorded it from Kenya, Mauritius and Tanzania and Munro (1984) from Kenya and Reunion.

DIAGNOSIS
Medium sized species; large black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with or without fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, narrow medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band expanding into a fuscous spot at wing apex, a broad fuscous anal streak, dark fuscous along dm–cu crossvein, pale infuscation along r–m crossvein, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga III–V orange-brown except for a narrow transverse black band across anterior margin of tergum III which expands over anterolateral corners, a narrow medial longitudinal dark fuscous to black band over all 3 terga and anterolateral corners of terga IV and V fuscous.

DESCRIPTION
FEMALE: Piercer needle shaped with 4 pairs of subapical bristles close to apex (2 very long and 2 short) (Fig. 388). Spicules at distal end of middle segment of medium width with 3–6 dentations mostly broad and elongate (Fig. 389).

HOST PLANTS
B. cucurbitae has been reared from a wide variety of commercial fruit and vegetable crops and is classified as a species of major economic importance. It primarily infests cucurbit crops. Little is known about the wild hosts in South East Asia (the area to which this species is endemic).
ATTRACTANT: Cue lure.

COMMENTS
B. cucurbitae was described adequately by Drew (1973). It is similar to *B. emittens* (Walker) in possessing only a slight widening of the costal band in wing apex, a narrow infuscation along dm–cu crossvein and abdominal terga with ground colour fulvous but differs in having the spot on apex of costal band not reaching M, costal cells colourless, abdominal tergum III with a narrow transverse black band across base and tip of piercer of ovipositor needle shaped.

In the original description, Coquillett listed the material studied as follows: "Two males and two females bred by Mr George Compere from larvae living in green cucumbers. Type No.4207, U.S. Nat. Museum". This does not appear to be a valid holotype designation (see comments for *B. facialis*). I have received 3 of these specimens for study and designate the specimen labelled "Type No.4207 USNM" by Coquillett as lectotype and the remaining specimens paralectotypes.

Bactrocera (Zeugodacus) curta (Drew), n. comb. (Fig. 390)

Dacus (*Zeugodacus*) *curtus* Drew, 1972b: 195–6.

MATERIAL EXAMINED
A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6997) in QM.

DISTRIBUTION
New Britain (type locality).

DIAGNOSIS
Medium sized species; a pair of medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum mostly black, mesopleural stripe reaching anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band and anal streak, a pale fulvous tint across wing membrane and dark infuscation along dm–cu crossvein which continues around posterior margin of wing to anal streak, costal cells fulvous with microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V fulvous with a broad medial and 2 broad lateral longitudinal dark fuscous to black bands over all 3 terga.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. curta was described adequately by Drew (1972b). It is similar to *B. chorista* (May) in possessing a medial and 2 lateral longitudinal dark

bands on terga III–V, no infuscation on r–m crossvein and costal cells extremely pale fulvous or fuscous. It differs from this species in having a pale fulvous tint in wing membrane, mesonotum basically black with irregular red-brown markings and abdomen short without a transverse black band across base of tergum III.

Bactrocera (Zeugodacus) daula, n. sp.
(Fig. 391)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Western Highlands District: Mt Hagen, 31.iii.1981, B. Thistleton.

Paratypes, PAPUA NEW GUINEA, Western Highlands District: 2 ♂♂, 16.xii.1980, 1 ♂, 22.iv.1981, Mt Hagen, B. Thistleton. All paratypes attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10597) in QM; 3 paratypes in DPI.

DISTRIBUTION

Known only from Mt Hagen, Western Highlands District, Papua New Guinea.

DIAGNOSIS

Medium sized species; face glossy black; humeral and notopleural calli yellow; mesonotum black with pale markings, lateral and medial postsutural vittae present, mesopleural stripe of medium width reaching midway between anterior margin of notopleural callus and anterior npl. bristle, scutellum yellow; wing with a narrow dark fuscous costal band and broad dark fuscous anal streak, costal cells pale fuscous, microtrichia covering second costal cell and most of first costal cell; abdominal terga III–V orange-brown except for a broad medial and 2 broad lateral longitudinal dark bands which meet along anterior margin of tergum III.

DESCRIPTION

MALE: Male generally fulvous. Vertical length 1.1 mm. Frons narrowing slightly posteriorly, length 1.17 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face glossy black; length of face 0.35 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput dark fulvous with fuscous markings, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 dark fulvous, segment 3 dark fulvous with fuscous on apex and outer surface; a weak dark fulvous dorsal bristle on segment 2; arista black (dark fulvous basally); length of segments: 0.13 mm; 0.23 mm; 0.65 mm.

Thorax mesonotum black except a medial longitudinal dark fuscous band between medial postsutural vitta and anterior margin of mesonotum, brown below and behind lateral postsutural vittae. Pleural areas black. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 lateral postsutural vittae of medium width beginning anterior to mesonotal suture and narrowing slightly posteriorly to end at upper pa. bristles; a medial postsutural vitta broadly rounded at prescutellar bristles and narrowing to a point anterior to level of mesonotal suture. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fulvous, mid and hind coxae fuscous to dark fuscous; all other segments fulvous; rows of short pale setae on dorsal surfaces of fore femora; apical black spur absent on mid tibiae.

Wings length 5.4 mm; costal cells pale fuscous, microtrichia covering all of second costal cell and most of first costal cell; remainder of wings colourless except for a very pale fuscous tint across central area of membrane, dark fuscous subcostal cell, narrow dark fuscous costal band overlapping R_{2+3} and ending at extremity of M, broad dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark fuscous except for a narrow orange-brown band along posterior margin but not reaching lateral margins; tergum II orange-brown except for a broad transverse black band across anterior ½ which widens to cover lateral margins; terga III–V orange-brown except for a broad medial longitudinal band which is dark fuscous on tergum III and black on terga IV and V, 2 broad lateral longitudinal dark fuscous bands. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. daula is similar to *B. brachus* (Drew) in having the mesonotum basically black, face entirely dark fuscous to black, scutellum yellow and lateral and medial postsutural vittae present but differs in microtrichia covering all of second costal cell and most of first costal cell, abdominal terga III–V orange-brown with a broad medial and 2 broad lateral longitudinal dark fuscous to black bands meeting along anterior margin of tergum III.

Bactrocera (Zeugodacus) emittens (Walker), n. comb. (Fig. 392)

Dacus emittens Walker, 1860: 152; Froggatt, 1909: 96.
Dacus chrysotoxus Hendel, 1912: 24; Perkins, 1939: 29 (syn.).
Zeugodacus emittens: Perkins, 1939: 29.
Dacus (Zeugodacus) emittens: Hardy and Adachi, 1954: 187–8; Hardy, 1959: 171, 1977: 58; Drew, 1973: 27–30.

MATERIAL EXAMINED

INDONESIA, Sulawesi: syntype ♀ in BMNH; 4 syntypes referred to as cotypes by Hardy and Adachi (1954) and labelled "*Dacus emittens*, Celebes" in Walker's handwriting, collected at Makassar, Celebes.
LOCATION OF TYPES: *D. emittens*, 4 syntypes (both sexes) in BMNH (Hardy, 1959), 4 syntypes in NMV, Walker mentioned both sexes in his original description; *D. chrysotoxus*, holotype ♀ unknown.

DISTRIBUTION

Known from Sulawesi, formerly Celebes (type locality, Makassar), Lesser Sunda Is and the Moluccas (Hardy, 1977). Large numbers were trapped on Sulawesi, July 1981, J. Turner (record from Plant Quarantine Survey).

DIAGNOSIS

Large species; medium sized black facial spots present; humeral and notopleural calli yellow; mesonotum red-brown with dark markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, a broad medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band and anal streak, a large fuscous spot in apex of wing which extends along dm–cu crossvein, costal cells pale fulvous (second cell tending paler in centre), microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V orange-brown with a narrow dark fuscous to black band along anterior margin of tergum III and a broad medial longitudinal dark fuscous band on terga IV and V.
ATTRACTANT: Cue lure.

COMMENTS

B. emittens was described adequately by Drew (1973). It is similar to *B. cucurbitae* (Coquillett) in having the costal band expanded into a distinct apical spot, a broad dark fuscous band along dm–cu crossvein, mesonotum mostly red-brown and abdominal terga basically orange-brown. It differs from this species in possessing the apical spot on the wing overlapping M and sometimes connected to the fuscous band along dm–cu crossvein, costal cells pale fulvous, abdominal tergum III with a moderately broad dark fuscous to black band across base, terga IV and V with a moderately broad medial longitudinal dark fuscous band without dark colouration on anterolateral corners and tip of piercer of ovipositor with a pair of subapical lobes.

Bactrocera (Zeugodacus) exornata (Hering), n. comb. (Fig. 393)

Zeugodacus exornatus Hering, 1941b: 55–6.
Dacus (Zeugodacus) exornatus: Drew, 1973: 30–1.

MATERIAL EXAMINED

Holotype ♂.
LOCATION OF TYPE: Holotype in HNHM.

DISTRIBUTION

Dammer I. (probably Damar), type locality.

DIAGNOSIS

Small species; face glossy black; humeral and notoplerual calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. bristle, lateral and medial postsutural vittae present, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only, abdominal colour patterns unknown.
ATTRACTANT: No known record.

COMMENTS

B. exornata was described adequately by Drew (1973). It is similar to *B. timorensis* (Perkins) in possessing an entirely black mesonotum, microtrichia in outer corner of second costal cell only, scutellum yellow, lateral and medial postsutural vittae present but differs from this species in having a glossy black face and lateral postsutural vittae ending at upper pa. bristles.

Bactrocera (Zeugodacus) fallacis (Drew), n. comb. (Fig. 394)

Dacus (Zeugodacus) fallacis Drew, 1972b: 196–8.

MATERIAL EXAMINED
Paratype ♂ in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6995) in QM.

DISTRIBUTION
Rocky River (type locality) and Peach Creek, Cape York Peninsula, Queensland.

DIAGNOSIS
Small species; face dark fuscous to black; humeral and notopleural calli yellow; mesonotum red-brown with a pattern of fuscous markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postusutural vitta present, scutellum yellow; wing with a narrow dark fuscous costal band and broad dark fuscous anal streak, costal cells pale fuscous with microtrichia in outer ½ of second costal cell only; abdominal terga III–V orange-brown with a narrow transverse fuscous band across anterior margin of tergum III and a medial longitudinal fuscous band over all 3 terga.
ATTRACTANT: Cue lure.

COMMENTS
B. fallacis was described adequately by Drew (1972b). It is similar to *B. daula* and *B. brachus* (Drew) in possessing a black face, lateral and medial postsutural vittae and yellow scutellum but differs in having the mesonotum mostly red-brown with a pattern of fuscous markings, a narrow transverse fuscous band across base of tergum III and a narrow medial longitudinal fuscous band on terga III–V.

Bactrocera (Zeugodacus) fulvifacies (Perkins), n. comb. (Fig. 395)

Zeugodacus fulvifacies Perkins, 1939: 32.
Dacus (Zeugodacus) fulvifacies: Drew, 1973: 31–3

MATERIAL EXAMINED
Holotype ♂, Dumbea, New Caledonia, January 1914, P.D. Montague.
LOCATION OF TYPE: Holotype in BMNH.

DISTRIBUTION
Dumbea, New Caledonia (type locality).

DIAGNOSIS
Small species; facial spots absent; humeral calli yellow (except anterodorsal corners black); notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching to anterior npl. bristle, lateral and medial postsutural vittae absent; scutellum yellow with a broad medial glossy black band; wing entirely colourless except for a pale fulvous tint in anal cell, costal cells colourless with microtrichia in outer corner of second costal cell only; all abdominal terga glossy black.
ATTRACTANT: No known record.

COMMENTS
B. fulvifacies was described adequately by Drew (1973). It is distinct from all other species of subgenus *Zeugodacus* in having postsutural vittae absent, scutellum with a broad black medial longitudinal band on dorsal surface, mesonotum and abdominal terga entirely black and wings entirely colourless except for a pale fulvous tint in anal cell.

Bactrocera (Zeugodacus) gracilis (Drew), n. comb. (Fig. 396)

Dacus (Zeugodacus) gracilis Drew, 1972b: 198–9.

MATERIAL EXAMINED
Paratype ♂ in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6998) in QM.

DISTRIBUTION
Malekula I. (type locality), Vanuatu (formerly New Hebrides).

DIAGNOSIS
Medium sized species; face glossy black; humeral and notopleural calli yellow; mesonotum black with a pattern of brown markings, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, broad medial postsutural vitta present, scutellum yellow; wing with a broad fuscous costal band and anal streak, an S-shaped fuscous band across wing, costal cells pale fuscous with microtrichia in outer ⅓ of second costal cell only; abdominal terga I–V mostly orange-brown except for a broad medial and 2 broad lateral longitudinal black bands over terga III–V.
ATTRACTANT: Cue lure, Willison's lure.

COMMENTS
B. gracilis was described adequately by Drew (1972b). It is similar to *B. amoena* (Drew) and *B. reflexa* (Drew) in having a recurved fuscous band across wing but differs in possessing an S-shaped band across wing which is connected to the costal band at the r–m crossvein and mesonotum black with large brown markings.

Bactrocera (Zeugodacus) macrovittata, n. sp. (Fig. 397)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central District: Moresby–Bereina road, 88 km NW Port Moresby, attracted to cue lure, 26.vi.1980, R.A.I. Drew and D.W. Currey. LOCATION OF TYPE: Holotype (T.10598) in QM.

DISTRIBUTION

Known only from the Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with medium sized black spots present; humeral and notopleural calli yellow; mesonotum red-brown with a mottled appearance, lateral and medial postsutural vittae present, a triangular marking above each notopleural callus, mesopleural stripe of medium width ending just before anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous (second cell paler), microtrichia in outer ⅓ of second costal cell only; abdominal terga III–V fulvous except for 2 lateral longitudinal red-brown bands joined along anterior margin of tergum III, a medial longitudinal band which is red-brown on anterior and black on posterior of each tergum.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.75 mm. Frons of even width, length 1.6 times breadth; fulvous with no dark markings; anteromedial hump covered with a small number of well developed pale setae; orbital bristles well developed and black: 1 s.or., 1 i.or. (plus 1 reduced i.or. on 1 side only); lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with medium sized circular black spots not reaching epistoma; length of face 0.58 mm. Genae fulvous, dark subocular spot absent; fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 1–2 well developed dark bristles and a large number of small pale bristles. Antennae with segments 1 and 2 fulvous; segment 3 fulvous except fuscous on apex and outer surface; a well developed pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.18 mm; 0.25 mm; 0.80 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachments of dorsoventral flight muscles. Pleural areas red-brown with no dark markings. Yellow markings as follows: humeral calli; notopleural calli; a triangular marking along anterior margin of mesonotal suture above each notopleural callus; mesopleural stripe of medium width, ending just before anterior npl. bristle dorsally, continuing to sternopleuron as a large oval spot, anterior margin straight; 2 moderately broad, parallel sided lateral postsutural vittae ending at upper pa. bristles; a moderately broad medial postsutural vitta, rounded posteriorly at level of prsc. bristles and narrowing to a point anteriorly at level of posterior margin of humeral calli (this vitta is much longer than in any other species of Dacine); upper hypopleural calli (posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous). Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 4; prsc. 1 (1 absent); pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black except mpl. red-brown.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur; fore femora with rows of long dark setae on dorsal surfaces.

Wings length 6.5 mm; costal cells pale fuscous (second cell paler), microtrichia in outer ⅓ of second costal cell only; remainder of wings colourless except for a fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. Terga I and II red-brown, tending whitish along posterior margin of tergum II. Terga III–V fulvous except 2 broad lateral longitudinal red-brown bands joined along anterior margin of tergum III, a medial longitudinal band which is narrow and red-brown anteriorly and broad and black posteriorly on each tergum. A pair of oval fulvous shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

B. macrovittata is similar to *B. sandaracina* and *B. trichota* (May) in possessing a red-brown mesonotum, a pair of dark facial spots, scutellum yellow, lateral and medial postsutural vittae present. It differs from these species in having a triangular yellow marking above notopleural callus along anterior margin of mesonotal suture, costal band confluent with R_{2+3} and the medial

postsutural vitta very long and narrow reaching level of anterior npl. bristles.

Bactrocera (Zeugodacus) reflexa (Drew), n. comb. (Fig. 398)

Dacus (Zeugodacus) reflexus Drew, 1971: 101–3.

MATERIAL EXAMINED
A series of paratypes in DPI.
LOCATION OF TYPE: Holotype ♂ (T.6974) in QM.

DISTRIBUTION
Known only from localities in New Britain (type locality, Keravat).

DIAGNOSIS
Medium sized species; face glossy black; humeral calli yellow; notopleural calli black except area on apex around base of bristle yellow; mesonotum glossy black, mesopleural stripe reaching humeral callus, lateral postsutural vittae beginning anterior to mesonotal suture, medial postsutural vitta present, scutellum yellow; wing with a broad dark fuscous costal band and anal streak, a broad Z-shaped dark fuscous band across wing, costal cells dark fuscous, microtrichia covering second costal cell only; abdominal terga III–V fulvous except for a broad medial and 2 broad lateral longitudinal glossy black bands over all 3 terga which join along anterior margin of tergum III.
ATTRACTANT: Cue lure.

COMMENTS
B. reflexa was described adequately by Drew (1971). It is similar to *B. amoena* (Drew) in possessing a Z-shaped dark fuscous band across wing, mesonotum glossy black and abdomen with a broad medial and 2 broad lateral longitudinal black bands over terga III– V. It differs from this species in having black notopleural calli with yellow on apex, lateral postsutural vittae ending behind the upper pa. bristles, mesopleural stripe reaching humeral callus, microtrichia covering all of second costal cell and a transverse black band across base of tergum III joining the longitudinal bands.

Bactrocera (Zeugodacus) sandaracina, n. sp. (Fig. 399)

TYPE SPECIMENS
Holotype ♂, PAPUA NEW GUINEA, East Sepik Province: Maprik, Oct.–Dec. 1957, Malaria Control Section.
Paratypes, PAPUA NEW GUINEA, East Sepik Province: 1 ♀ and 2 ♂♂, Maprik, Oct.–Dec. 1957, Malaria Control Section; 1 ♂, Maprik, Oct. 1958, Malaria Control Section.
LOCATION OF TYPES: Holotype (T.10599) in QM; 1 paratype in ANIC; 3 paratypes in DPI.

DISTRIBUTION
Known only from Maprik, East Sepik Province, Papua New Guinea.

DIAGNOSIS
Medium sized to large species; facial spots very small and pale fuscous; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning before mesonotal suture, medial postsutural vitta present, scutellum yellow; legs with all segments fulvous, wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fulvous (second cell paler) with microtrichia in outer corner of second costal cell only; all abdominal terga uniformly orange-brown without dark markings.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.8 mm. Frons of even width, length 1.31 times breadth; fulvous without dark markings, anteromedial hump covered by short pale setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with very small pale fuscous oval facial spots; length of face 0.55 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of strong red-brown bristles. Antennae with all segments fulvous; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.30 mm; 0.83 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); 2 parallel sided lateral postsutural vittae of medium width, beginning anterior to mesonotal suture and ending behind upper pa. bristles, a moderately broad medial postsutural vitta broadly rounded posteriorly at level of prsc. bristles and narrowing to a point anteriorly to end anterior to mesonotal suture. Postnotum red-brown. Scutellum yellow except for very narrow red-brown basal band. Bristles: sc. 4;

prsc. 2; pa. 2; sa 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and red-brown to black.

Legs all segments fulvous without dark markings; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 7.4 mm; costal cells pale fulvous (second cell paler); microtrichia in outer corner of second costal cell only; remainder of wings with a pale fulvous tint, narrow fuscous costal band almost confluent with R_{4+5} and ending between extremities of R_{4+5} and M, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe very strong.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga uniformly orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment orange-brown, oval in transverse cross section and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1.17:1. Apex of piercer with 1 pair of subapical keels (Fig. 399A).

ATTRACTANT: No known record.

COMMENTS

B. sandaracina is similar to *B. trichota* (May) in lacking a triangular yellow marking above notopleural calli and in possessing the costal band overlapping R_{2+3}, a reasonably short medial postsutural vitta (not extending anterior to mesonotal suture), mesonotum basically red-brown, face fulvous with dark spots and one or both costal cells coloured. It differs from this species in having the mesonotum uniformly red-brown without dark markings, abdominal terga uniformly orange-brown without dark markings, facial spots very small and pale fuscous, lateral postsutural vittae ending behind upper pa. bristles, costal band broad almost confluent with R_{4+5} and mesopleural stripes reaching midway between anterior margin of notopleural calli and anterior npl. bristles above.

Bactrocera (Zeugodacus) terminifera (Walker), n. comb.

Dacus terminifer Walker, 1860: 152.

Zeugodacus terminifer: Perkins, 1939: 28–9 (lectotype designation).

Dacus (Zeugodacus) terminifer: Hardy and Adachi, 1954: 195–6; Hardy, 1959: 183; Drew, 1973: 33.

MATERIAL EXAMINED

Lectotype ♀, labelled "Celebes, Macassar, W.W. Saunders, B.M. 1868-4" and other labels in Walker's handwriting "*terminifer*", "Mak", "68–4".

LOCATION OF TYPE: Lectotype in BMNH.

DISTRIBUTION

Makassar (type locality), Sulawesi (formerly Celebes).

DESCRIPTION

FEMALE: The female type is the only specimen known and is in poor condition with the abdomen missing. The following description has been taken from this specimen:

Head generally dark. Frons of even width, fulvous with fuscous laterally and across upper margin; orbital bristles: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex black. Face black. Genae fuscous, black subocular spot present; black bristle present. Occiput black. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; arista dark fuscous (fulvous basally).

Thorax mesonotum glossy black. Yellow markings as follows: humeral calli (anterodorsal corners glossy black); notopleural calli; broad mesopleural stripe reaching to humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); 2 very short and narrow lateral postsutural vittae ending at level of sa. bristles. Postnotum black. Scutellum yellow with a black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore, mid and apical ½ of hind femora black (basal ½ hind femora fulvous); fore and mid tibiae fulvous, hind tibia dark fuscous; all tarsal segments fulvous; rows of long black setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings costal cells colourless; microtrichia in outer corner of second costal cell only; remainder of wings colourless except pale fuscous subcostal cell, narrow very pale costal band confluent with R_{2+3} and ending at apex of this vein, a small fuscous spot at apex of wing around R_{4+5}, a broad fuscous anal streak ending before wing margin.

ATTRACTANT: No known record.

COMMENTS

B. terminifera is similar to *B. exornata* (Hering) in possessing a black face, glossy black mesonotum, yellow scutellum and colourless wings except for costal band and anal streak but differs in having very short lateral postsutural vittae and the medial postsutural vitta absent.

Perkins (1939) designated the lectotype of *B. terminifera* "by inference of holotype" according to Article 74b of the International Code of Zoological Nomenclature.

Bactrocera (Zeugodacus) timorensis (Perkins), n. comb. (Fig. 400)

Zeugodacus timorensis Perkins, 1939: 30–1.
Dacus (Zeugodacus) timorensis: Hardy and Adachi, 1954: 196; Drew, 1973: 33–5.

MATERIAL EXAMINED

Holotype ♀, Koepang, Timor, June 1929, I.M. Mackerras and the following specimens in BMNH: paratype ♀, Timor, vi.1929; 1 ♀ and 1 ♂, Mittel Flores, Endeh, 10–16.6.27; B. Rensch.
LOCATION OF TYPE: Holotype in ANIC.

DISTRIBUTION

Known only from Timor (type locality, Koepang) and Flores.

DIAGNOSIS

Small species; small fuscous facial spots present; humeral and notopleural calli yellow; mesonotum glossy black, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, a broad medial postsutural vitta present, scutellum yellow with a very broad black basal band; wing with a narrow fuscous costal band and anal streak, costal cells colourless with microtrichia in outer corner of second costal cell only; abdominal terga III–V fulvous with 2 broad lateral longitudinal dark fuscous bands over all 3 terga which join along anterior margin of tergum III.
ATTRACTANT: No known record.

COMMENTS

Previously a male has not been studied. The posterior lobe of surstylus is long, the posterior margin of abdominal sternum V has a shallow concavity and a pecten is present on abdominal tergum III. These characters now confirm the placement of this species in subgenus *Zeugodacus*. *B. timorensis* was described adequately by Drew (1973). It is similar to *B. exornata* (Hering) in possessing a glossy black mesonotum, colourless costal cells, scutellum entirely yellow, lateral and medial postsutural vittae present but differs in having a fulvous face with a pair of small fuscous spots and lateral postsutural vittae ending well before the upper pa. bristles.

Bactrocera (Zeugodacus) trichota (May), n. comb. (Figs 401–403)

Zeugodacus trichotus May, 1962a: 74–6.
Dacus (Zeugodacus) trichotus: Drew, 1973: 35–8.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.5857) in QM.

DISTRIBUTION

Known from New Britain and localities in the Eastern Highlands District (type locality, Kerowaghi) and Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots vary from small elongate fuscous spots to medium sized circular black spots; humeral and notopleural calli yellow; mesonotum generally red-brown, mesopleural stripe reaching to anterior npl. bristle, lateral postsutural vittae beginning anterior to mesonotal suture, a broad medial postsutural vitta present, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, first costal cell with a pale fulvous tint, second costal cell almost colourless, microtrichia in outer ⅓ of second costal cell only; abdominal terga I–V mostly orange-brown except for a narrow medial longitudinal dark fuscous to black band on posterior ½ of tergum IV and tergum V.

DESCRIPTION

FEMALE: Ovipositor apex of piercer needle shaped with 3 pairs of very small subapical bristles (Fig. 402). Spicules at distal end of middle segment with only 5–8 small dentations of even size visible above background membrane (Fig. 403).
ATTRACTANT: Cue lure.

COMMENTS

B. trichota was described adequately by May (1962a) and Drew (1973). It is similar to *B. sandaracina* in possessing the costal band overlapping R_{2+3}, lateral and medial postsutural vittae present, mesonotum red-brown, face fulvous with 1 pair of dark spots, scutellum entirely yellow and in lacking a yellow triangle above each notopleural callus. It differs from this species in

having the mesonotum red-brown with irregular fuscous markings, abdominal terga orange-brown with a narrow medial longitudinal fuscous band on posterior ½ of tergum IV and on tergum V, facial spots medium sized and elongate to circular, mesopleural stripe reaching to anterior npl. bristles, lateral postsutural vittae ending at upper pa. bristles and costal band just overlapping R_{2+3}.

Bactrocera (Zeugodacus) unilateralis, n. sp.
(Fig. 404)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central District: 20 km SE Port Moresby, hand swept off bushes, 6.ii.1982, J.W. Ismay.

LOCATION OF TYPE: Holotype (T.10600) in QM.

DISTRIBUTION

Central Province, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with very small and pale spots; humeral and notopelural calli yellow and joined by a broad yellow band; mesonotum black, lateral and medial postsutural vittae present, mesopleural stripe broad reaching to anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band, a pale infuscation along r–m crossvein, a pale fuscous tint in anal cell but no anal streak present, costal cells colourless, microtrichia in outer corner of second costal cell only; abdominal terga uniformly orange-brown with an elongate fuscous spot centrally on tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.5 mm. Frons of even width, length 1.4 times breadth; fulvous with fuscous on anteromedial hump and connecting along lateral margins with fuscous marking on vertex, anteromedial hump covered by a small number of short dark setae; orbital bristles black: 1 s.or., 3 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with very small pale spots present; length of face 0.53 mm. Genae fulvous, brown subocular spot present; red-brown bristle present. Occiput fulvous with 2 black spots, yellow along eye margins; occipital row with 4 well developed black bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong dark dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.25 mm; 0.80 mm.

Thorax mesonotum black with brown below and behind lateral postsutural vittae. Pleural areas black except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; a broad band connecting humeral and notopleural calli; broad mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (remainder black); a medial postsutural vitta of medium width, rounded posteriorly at level of prsc. bristles and narrowing to a point level with mesonotal suture; 2 broad parallel sided lateral postsutural vittae ending just behind upper pa. bristles. Postnotum black. Scutellum yellow except for a narrow black basal band. Bristles: sc. 4; prsc. 2; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except apical 4 segments of fore tarsi and the hind tibiae pale fuscous and the apical 4 segments of the mid and hind tarsi dark fulvous; rows of long pale setae on dorsal and ventral surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.6 mm; costal cells colourless, microtrichia in outer corner of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and narrowing apically to end between extremities of R_{4+5} and M, a pale fuscous tint along dm–cu crossvein, a very pale tint in basal section of anal cell; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga free; pecten present on tergum III. Tergum I and sterna I and II wider than long. All abdominal terga uniformly orange-brown except for an elongate pale fuscous spot in centre of tergum V. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

B. unilateralis is similar to *B. sandaracina*, *B. anchitrichota*, *B. brachus* (Drew) and *B. macrovittata* in possessing abdominal terga mostly orange-brown but differs in having the humeral and notopleural calli joined by a broad lateral yellow band.

KEY TO SPECIES OF GENUS *BACTROCERA*

1. Costal band absent ..... *nigra* (some specimens)
   Costal band present 2
2(1). Wings with infuscation in addition to costal band and anal streak (may be narrow infuscation along 1 or both crossveins) 3
   Wings colourless except for costal band and anal streak 71
3(2). Wings with an isolated apical fuscous spot or with at least apical ½ infuscated and not marked with a distinct pattern of transverse fuscous bands 4
   Wings marked with a distinct pattern of transverse fuscous bands 15
4(3). Facial spots absent 5
   Facial spots present 8
5(4). Lateral postsutural vittae absent ..... *ebenea*
   Lateral postsutural vittae present 6
6(5). Medial postsutural vitta absent ..... *fuscalata*
   Medial postsutural vitta present 7
7(6). Supra-alar bristles absent; medial postsutural vitta short and broad ..... *tigrina* (males)
   Supra-alar bristles present; medial postsutural vitta long and narrow ..... *penefurva*
8(4). Mesonotum basically red-brown; prsc. bristles present or absent 9
   Mesonotum black; prsc. bristles absent 11
9(8). Medial postsutural vitta absent; apical ½ of wing fuscous; sa. and prsc. bristles present ..... *amplexiseta*
   Medial postsutural vitta present; wing with a general fuscous colouration; sa. bristles present or absent; prsc. bristles absent 10
10(9). Lateral postsutural vittae present; sa. bristles absent ..... *neopagdeni*
   Lateral postsutural vittae absent; sa. bristles present ..... *salamander*
11(8). Medial postsutural vitta absent; sa. bristles present 12
   Medial postsutural vitta present; sa. bristles present or absent 13
12(11). Abdominal terga III-V orange-brown with broad medial and lateral longitudinal black bands joined by black across most of tergum V; dense microtrichia covering all of second costal cell and most of first costal cell ..... *honiarae*
   Abdominal terga III-V uniformly black; microtrichia in outer ½ of second costal cell only ..... *pepisalae*
13(11). Supra-alar bristles absent ..... *pagdeni*
   Supra-alar bristles present 14
14(13). Abdominal terga III-V mostly black except dark fuscous centrally on terga III and V surrounding a medial longitudinal black band; costal cells with a pale fuscous tint ..... *surrufula*
   Abdominal terga II-IV orange-brown except fuscous laterally and posteriorly and tergum V entirely fuscous; costal cells colourless ..... *emarginata*
15(3). Medial postsutural vitta present 16
   Medial postsutural vitta absent 37
16(15). Prescutellar bristles absent; sa. bristles present or absent 17
   Prescutellar and sa. bristles present 24
17(16). Supra-alar bristles absent ..... *visenda*
   Supra-alar bristles present 18
18(17). 4 scutellar bristles present; lateral postsutural vittae present 19
   2 scutellar bristles present; lateral postsutural vittae present or absent 20
19(18). A broad U-shaped fuscous band across wing; microtrichia covering most of second costal cell; mesopleural stripe extending to humeral callus above; apical segment of ovipositor (aculeus) needle shaped at its tip ..... *perplexa*
   An S-shaped pale fuscous band of irregular outline across wing; microtrichia in outer ⅓ of second costal cell; mesopleural stripe not extending to humeral callus above; apical segment of ovipositor (aculeus) with 1 pair of subapical lobes ..... *decipiens*
20(18). Lateral postsutural vittae present 21
   Lateral postsutural vittae absent 22

21(20). A broad U-shaped fuscous band across wing; mesonotum mostly black; lateral postsutural vittae very narrow ..... *sepikae*

Infuscation only on dm-cu crossvein; mesonotum red-brown with dark patterns; lateral postsutural vittae broad ..... *strigifinis*

22(20). Mesonotum black; humeral and notopleural calli not joined by a broad yellow band ..... *singularis*

Mesonotum red-brown or orange-brown; humeral and notopleural calli joined by a broad yellow band 23

23(22). Mesonotum entirely red-brown; humeral and notopleural calli entirely yellow; scutellum yellow with pale fuscous on apex; medial postsutural vitta pointed anteriorly and rounded posteriorly; mesopleural stripe not extending to humeral callus above; wing with narrow, pale infuscations around crossveins; abdominal terga red-brown with an oval dark fuscous to black spot in centre of tergum V ..... *univittata*

Mesonotum mostly fulvous; posterior ⅓ humeral calli and anterior ½ notopleural calli yellow (remainder fulvous); scutellum yellow with fulvous on apex; medial postsutural vitta short and triangular; mesopleural stripe extending to humeral callus above; wing with a transverse fuscous band running from R_{4+5} to enclose dm-cu crossvein and continuing around wing margin to extremity of $A_1 + CuA_2$, a transverse fuscous band enclosing r-m crossvein and continuing across discoidal cell; abdomen fulvous with a black spot in centre of tergum V ..... *triangularis*

24(16). 2 scutellar bristles present 25

4 scutellar bristles present 28

25(24). A single transverse fuscous band across wing; costal cells pale fuscous with microtrichia covering all of first and most of second costal cell; mesonotum mostly fuscous or .. black 26

Infuscation on 1 or both crossveins; costal cells colourless with microtrichia in outer corner of second costal cell only; mesonotum most red-brown 27

26(25). Mesonotum fuscous; abdominal terga III-V orange-brown with broad lateral longitudinal fuscous bands ..... *cheesmanae*

Mesonotum mostly black; abdominal terga III-V with at most narrow fuscous lateral margins ..... *neocheesmanae*

27(25). Costal band not expanded at apex of wing; infuscation on dm-cu crossvein; mesopleural stripe extending to humeral callus above ..... *bullata*

Costal band expanded into distinct spot at apex of wing; narrow fuscous tint on r-m crossvein and dark fuscous on dm-cu crossvein; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle....*cucurbitae* (some specimens)

28(24). Humeral and notopleural calli joined by a broad yellow band ..... *unilateralis*

Humeral and notopleural calli not joined by a yellow band 29

29(28). Wing with an S- or Z-shaped fuscous band in addition to costal band and anal streak; notopleural calli yellow or mainly black 30

Wing with infuscation only on 1 or both crossveins in addition to costal band and anal streak; notopleural calli yellow 32

30(29). An S-shaped fuscous band across wing, connected to costal band in only 1 position (at the r-m crossvein); mesonotum black with large brown markings; notopleural calli yellow; abdomen with a broad medial and 2 broad lateral longitudinal black bands on terga III-V and without a transverse black band across base of tergum III ..... *gracilis*

A Z-shaped dark fuscous band across wing, connected to costal band in 2 positions; mesonotum glossy black; notopleural calli yellow or mostly black; abdomen with a broad medial and 2 broad lateral longitudinal black bands on terga III-V and with or without a transverse black band across base of tergum III 31

31(30). Notopleural calli yellow; lateral postsutural vittae ending at upper pa. bristles; mesopleural stripe not extending to humeral callus above; microtrichia in outer portion of second costal cell only; abdomen without a transverse black band across base of tergum III ..... *amoena*

Notopleural calli black with yellow spot on apex; lateral postsutural vittae ending behind upper pa. bristles; mesopleural stripe extending to humeral callus above; microtrichia

covering all of second costal cell; abdomen with a transverse black band across base of tergum III ..... *reflexa*

32(29). Costal band expanded into a distinct dark fuscous spot at apex of wing; usually with a broad dark fuscous band along dm-cu crossvein; mesonotum mostly red-brown; abdominal terga with ground colour orange-brown 33

Costal band only slightly widened at apex of wing; a narrow and usually pale infuscation along dm-cu crossvein; mesonotum black or red-brown with a pattern of dark markings; abdominal terga with ground colour fulvous 34

33(32). Spot on apex of wing not reaching M; narrow tint of fuscous colouration along r-m crossvein; costal cells colourless; abdominal tergum III with a narrow transverse black band across base, a narrow medial longitudinal dark fuscous to black band on terga III-V, dark fuscous to black on anterolateral corners of terga IV and V; aculeus needle shaped at apex ..... *cucurbitae* (some specimens)

Spot on apex of wing overlapping M, sometimes connected to infuscation along dm-cu crossvein; sometimes with a broad fuscous band along r-m crossvein; costal cells pale fulvous; abdominal tergum III with a moderately broad dark fuscous to black band across base, terga IV and V with a moderately broad medial longitudinal dark fuscous band and without dark colouration on anterolateral corners; aculeus with a pair of subapical lobes ..... *emittens*

34(32). Wing with infuscation along r-m crossvein; costal cells fulvous; mesonotum red-brown with large black markings; abdomen elongate, with a black transverse band across base of tergum III in addition to a broad medial and 2 broad lateral longitudinal dark fuscous to black bands over terga III-V ..... *abdoangusta*

Wing without infuscation along r-m crossvein; costal cells extremely pale fulvous; mesonotum either red-brown with small fuscous markings or black with irregular red-brown and brown markings; abdomen short or elongate-oval, uniformly orange-brown with 3 longitudinal dark bands on terga III-V; with or without a black band across base of tergum III 35

35(34). Abdominal terga uniformly orange-brown ..... *anchitrichota*

Abdominal terga III-V with 3 longitudinal dark bands and with or without a black band across base of tergum III 36

36(35). Wing membrane colourless; mesonotum red-brown with a pattern of small fuscous markings; abdomen elongate-oval, with a black transverse band across base of tergum III ..... *chorista*

Wing membrane with a pale fulvous tint; mesonotum black with irregular red-brown and brown markings; abdomen short, without a black transverse band across base of tergum III ..... *curta*

37(15). Infuscation only on 1 or both crossveins 38

Infuscation as 1 or more transverse bands extending from costal band to hind margin of wing, as a broad medial band or a recurved band across central portion of wing 51

38(37). Lateral postsutural vittae absent 39

Lateral postsutural vittae present 42

39(38). Scutellum and notopleural calli entirely black ..... *melanotus*

Scutellum and notopleural calli yellow 40

40(39). Infuscation on dm-cu and r-m crossveins; abdominal terga I-IV mostly dark fuscous to black and tergum V orange-brown ..... *invisitata*

Infuscation on r-m crossvein; terga I-V generally pale coloured 41

41(40). Yellow triangular marking above notopleural callus; costal band confluent with R_{4+5}; mesonotum red-brown; abdominal terga III-V red-brown with a medial and 2 broad lateral longitudinal fuscous bands ..... *aneuvittata*

No yellow triangular marking above notopleural callus; costal band confluent with R_{2+3}; mesonotum black; abdominal terga I-V uniformly red-brown ..... *exigua*

42(38). Scutellum yellow with apical ½ fuscous ..... *brunnea*

Scutellum yellow or yellow with black markings 43

43(42). Scutellum yellow with a broad black triangular marking on dorsal surface 44

Scutellum entirely yellow 46

44(43). Costal band confluent with R_{4+5}; abdominal terga II-V orange-brown with lateral and medial longitudinal black bands joined along base of tergum II ..... *melanoscutata*
Costal band narrow (not overlapping R_{2+3}); abdominal terga black 45
45(44). Face black; costal band narrow (not overlapping R_{2+3}) and fuscous; r-m crossvein longer than dm-cu crossvein; a narrow infuscation along r-m crossvein which becomes paler as it extends to dm-cu crossvein; legs with all tibiae, apices of femora and apical 4 segments of tarsi fuscous; lateral postsutural vittae very short and narrow, ending just behind sa. bristles ..... *obliqua*
Face fulvous (with a pair of small pale spots in 75 percent of specimens); costal band narrow (not overlapping R_{2+3}) and pale fuscous; r-m crossvein shorter than dm-cu crossvein; infuscation around crossveins very narrow and pale; legs entirely fulvous; lateral postsutural vittae long, ending before upper pa. bristles ..... *psidii*
46(43). Mesonotum orange-brown or dark fuscous 47
Mesonotum black 48
47(46). Mesonotum and abdomen mostly orange-brown; notopleural calli fuscous; dm-cu crossvein infuscated; costal cells colourless ..... *hispidula*
Mesonotum and abdomen mostly dark fuscous; notopleural calli yellow; r-m crossvein infuscated; costal cells pale fuscous ..... *laticaudus*
48(46). Costal cells colourless; legs with some segments dark coloured; abdominal terga III-V mostly black 49
Costal cells coloured; legs mostly fulvous; abdominal terga III-V with ground colour orange-brown 50
49(48). Lateral postsutural vittae broad and ending at upper pa. bristles ..... *neonigrita*
Lateral postsutural vittae short and narrowing posteriorly to end well before upper pa. bristles ..... *melanogaster*
50(48). Mesopleural stripe not extending to humeral callus above; microtrichia covering all of second costal cell and outer corner of first costal cell; legs fulvous, hind tibiae dark fulvous; abdominal tergum III with a very narrow transverse fuscous band across anterior margin and merging into broad lateral black margins, the anterolateral corners of terga IV and V fuscous ..... *curvipennis*
Mesopleural stripe extending to humeral callus above; microtrichia in second costal cell only; legs entirely fulvous; abdominal tergum III with a black band across anterior margin and expanding laterally to cover outer margins of tergum III and anterolateral corners of tergum IV, a broad medial longitudinal black band on terga III-V ..... *phaea*
51(37). Scutellum yellow with a large fuscous or black triangular marking on dorsal surface.... 52
Scutellum entirely yellow with, at most, a small fuscous marking on apex 59
52(51). Costal band very pale and indistinct beyond extremity of R_1; a narrow transverse fuscous band across wing, just enclosing both crossveins .... *frauenfeldi* complex (see key page 238)
Costal band distinct beyond extremity of R_1; infuscation as 1 or 2 transverse bands or U- or Z-shaped markings 53
53(52). Mesonotum red-brown; a broad fuscous medial longitudinal band on scutellum; a narrow transverse fuscous band across wing ..... *strigata*
Mesonotum black; a black medial longitudinal band on scutellum, infuscation across wing as 1 or 2 transverse bands or as a U- or Z-shaped band 54
54(53). 1 or 2 transverse fuscous bands across wing from costal band to hind margin (1 may be recurved if 2 present) 55
A U- or Z-shaped fuscous band across wing 58
55(54). 2 transverse fuscous bands across wing from costal band to hind margin 56
1 narrow transverse fuscous band across wing from costal band to hind margin 57
56(55). Mesopleural stripe extending to humeral callus above; neither of the transverse fuscous bands across wing are recurved back from hind margin; lateral postsutural vittae broad and ending at level of pa. bristles ..... *lampabilis*
Mesopleural stripe not extending to humeral callus above; the transverse fuscous band across centre of wing recurved back along CuA_1; lateral postsutural vittae narrow and ending

before upper pa. bristles ..... *longicornis*

57(55). Abdominal terga black; humeral calli black around anterior and dorsal margins; costal cells with a pale fuscous tint; costal band confluent with R_{2+3} ..... *unilineata*

Abdominal terga II-V orange-brown with a medial and 2 broad lateral longitudinal black bands; humeral calli entirely yellow; costal cells fuscous; costal band overlapping R_{2+3} ..... *angustifasciata*

58(54). A broad wedge shaped fuscous marking enclosing r-m crossvein and a Z-shaped fuscous band across wing ..... *ismayi*

A U-shaped fuscous band across wing, enclosing both crossveins and recurving back along CuA_1 ..... *reclinata*

59(51). Wing with 3 distinct transverse fuscous bands ..... *umbrosa*

Wing not so marked 60

60(59). Lateral postsutural vittae absent 61

Lateral postsutural vittae present 62

61(60). Costal cells fuscous; a narrow transverse fuscous band across wing enclosing both crossveins; humeral calli yellow; abdominal terga uniformly dark fuscous ..... *pisinna*

Costal cells colourless; a broad dark fuscous blotch across wing enclosing both crossveins and most of discoidal cell; humeral calli black; abdominal terga uniformly black ..... *retrorsa*

62(60). 2 transverse fuscous bands across wing from costal band to hind margin 63

1 transverse fuscous band across wing or a U-, S- or Z-shaped fuscous band from costal band to hind margin 65

63(62). Transverse fuscous band across centre of wing as a broad irregular blotch enclosing both crossveins and at least distal ⅔ of discoidal cell 64

Transverse fuscous band across centre of wing narrow, covering approximately distal ⅓ of discoidal cell and recurving back along posterior side of CuA_1 .... *alyxiae* complex (see key page 234)

64(63). Mesopleural stripe extending to humeral callus above; costal cells fuscous (second cell colourless in centre); abdominal terga II-V fulvous with a broad medial longitudinal black band on all 4 terga and 2 broad lateral longitudinal black bands on terga III-V .... *seguyi*

Mesopleural stripe extending to anterior npl. bristle above; costal cells fulvous; abdominal terga III-V uniformly dark brown ..... *curvifera*

65(62). A U-, S- or Z-shaped fuscous band across wing .. *recurrens* complex (see key page 239)

A single transverse fuscous band across wing 66

66(65). 4 scutellar bristles present 67

2 scutellar bristles present 69

67(66). Transverse band across wing extending from costal band to hind margin; abdominal terga uniformly black ..... *coracinus*

Transverse band across wing broad and running from R_{4+5} to hind margin; abdominal terga mostly orange-brown 68

68(67). Humeral bristles absent; scutellum with apical ½ fuscous; mesonotum red-brown .... *aurea*

Humeral bristles present; scutellum entirely yellow; mesonotum black ..... *dissidens*

69(66). Transverse fuscous band across wing narrow, enclosing both crossveins and, at most, outer ⅓ of discoidal cell ..... *distincta* and *fulvicauda* complexes (see key page 236)

Transverse band across wing as a broad dark fuscous marking covering most of wing, enclosing both crossveins and more than outer ½ of discoidal cell 70

70(69). Abdominal terga uniformly black; mesopleural stripe narrow, only slightly wider than notopleural callus above ..... *biarcuata*

Abdominal terga III-V orange-brown with a broad medial and 2 broad lateral longitudinal black bands over all 3 terga and joining along posterior margin of tergum V; mesopleural stripe extending to anterior npl. bristle ..... *confluens*

71(2). Lateral and medial postsutural vittae present 72

Lateral postsutural vittae present or absent, medial postsutural vitta absent 99

72(71). 4 scutellar bristles present 73

2 scutellar bristles present 92
73(72). Prescutellar bristles absent 74
Prescutellar bristles present 79
74(73). Supra-alar bristles absent 75
Supra-alar bristles present 77
75(74). Costal cells colourless ..... *neopallescentis* (some specimens)
Costal cells pale fulvous or pale fuscous 76
76(75). Lateral postsutural vittae broad, parallel sided and ending behind upper pa. bristles; apex of piercer of ovipositor with a pair of subapical keels and with sensory setae close to apex ..... *cucumis*
Lateral postsutural vittae narrowing to end before upper pa. bristles; apex of piercer of ovipositor needle shaped and with sensory setae situated well back from apex ..... *signatifera* (some specimens)
77(74). Mesonotum orange-brown; humeral and notopleural calli joined by a lateral yellow band ..... *citroides*
Mesonotum black; humeral and notopleural calli not joined by a lateral yellow band 78
78(77). Lateral postsutural vittae broad and ending at upper pa. bristles; costal band overlapping R_{2+3} ..... *abdoaurantiaca*
Lateral postsutural vittae narrow and ending before upper pa. bristles; costal band confluent with R_{2+3} ..... *aurantiventer*
79(73). Supra-alar bristles absent ..... *neopallescentis* (some specimens)
Supra-alar bristles present 80
80(79). Face entirely dark fuscous to black 81
Face fulvous with or without dark spots 84
81(80). Mesonotum mostly red-brown ..... *fallacis*
Mesonotum mostly black 82
82(81). Lateral postsutural vittae beginning at mesonotal suture; costal cells colourless ..... *exornata*
Lateral postsutural vittae beginning anterior to mesonotal suture; costal cells pale fuscous 83
83(82). Abdominal terga orange-brown with a dark fuscous spot in centre of tergum V ..... *brachus*
Abdominal terga III-V with broad medial and lateral longitudinal dark fuscous to black bands ..... *daula*
84(80). Facial spots absent ..... *alampeta*
Facial spots present (but sometimes small and pale) 85
85(84). Mesonotum black ..... *timorensis*
Mesonotum mostly red-brown 86
86(85). Yellow triangular marking above notopleural callus; medial postsutural vitta elongate, reaching to level of anterior npl. bristle ..... *macrovittata*
No yellow triangular marking above notopleural callus (at most lateral postsutural vittae extending anterior to mesonotal suture); medial postsutural vitta reaching to level of mesonotal suture 87
87(86). Costal band broad, confluent or almost confluent with R_{4+5} 88
Costal band narrow, not confluent with R_{4+5} 89
88(87). Mesopleural stripe narrow, reaching midway between anterior margin of notopleural callus and anterior npl. bristle; costal cells with a pale fulvous tint ..... *sandaracina*
Mesopleural stripe broad, reaching midway between anterior npl. bristle and humeral callus; costal cells pale fuscous ..... *mesonotaitha*
89(87). Costal band overlapping R_{2+3} 90
Costal band confluent with R_{2+3} 91
90(89). Costal cells pale fulvous; abdominal terga II-V orange-brown with fuscous to black across anterior margin of tergum II, fuscous on lateral margins of tergum III and a narrow medial fuscous band on tergum V ..... *atrisetosa*
Costal cells almost colourless; abdominal terga orange-brown without a dark band across

anterior margin of tergum II and with a narrow medial longitudinal dark fuscous to black band on tergum V and posterior ½ of tergum IV ..... *trichota*

91(89). Costal cells fulvous; coloured tint in wing membrane; lateral postsutural vittae not extending anterior to mesonotal suture; abdominal terga III-V fulvous with red-brown medial and lateral longitudinal bands ..... *aglaiae*

Costal cells colourless; wing membrane colourless; lateral postsutural vittae extending anterior to mesonotal suture; abdominal terga uniformly orange-brown ..... *unichromata*

92(72). Prescutellar bristles present 93

Prescutellar bristles absent 95

93(92). Supra-alar bristles absent ..... *tigrina* (females)

Supra-alar bristles present 94

94(93). Notopleural calli orange-brown; humeral and notopleural calli joined by a lateral yellow band; scutellum orange-brown with lateral yellow margins ..... *xanthodes*

Notopleural calli with posterior ½ yellow and anterior ½ black; humeral and notopleural calli not joined by a yellow band; scutellum yellow ..... *eximia*

95(92). Supra-alar bristles absent 96

Supra-alar bristles present 97

96(95). Humeral and notopleural calli joined by a lateral yellow band; costal band confluent with R_{4+5}; abdominal terga III-V orange-brown with a narrow transverse fuscous band across anterior margin of tergum III, lateral margins of tergum III and anterolateral corners of terga IV and V fuscous ..... *mesonotochra*

Humeral and notopleural calli not joined by a yellow band; costal band confluent with R_{2+3}; abdominal terga uniformly orange-brown with a black spot centrally on tergum V ..... *signatifera* (some specimens)

97(95). Humeral and notopleural calli joined by a lateral yellow band; lateral postsutural vittae beginning anterior to mesonotal suture ..... *buvittata*

Humeral and notopleural calli not joined by a yellow band; lateral postsutural vittae beginning at or behind mesonotal suture 98

98(97). Mesonotum black; lateral postsutural vittae very short and ending at level of sa. bristles ..... *paulula*

Mesonotum basically red-brown; lateral postsutural vittae ending at a level between sa. and upper pa. bristles ..... *angusticostata*

99(71). Lateral postsutural vittae absent 100

Lateral postsutural vittae present 119

100(99). 4 scutellar bristles 101

2 scutellar bristles 103

101(100). Facial spots present ..... *nigra*

Facial spots absent 102

102(101). Legs entirely fulvous; a broad medial longitudinal black band on scutellum ..... *fulvifacies*

Legs fulvous with apical ⅓ of mid and hind femora black, mid tibiae fuscous and hind tibiae dark fuscous; a black triangle on scutellum with apex in centre ..... *abdominigra*

103(100). Scutellum entirely black or with a large black triangular marking on dorsal surface ... 104

Scutellum yellow with a narrow black basal band and sometimes with pale fuscous on apex 109

104(103). Scutellum entirely black 105

Scutellum yellow with a large black triangular marking on dorsal surface 106

105(104). Facial spots present ..... *atra*

Facial spots absent ..... *perfusca*

106(104). Humeral calli black 107

Humeral calli yellow with, at most, anterolateral corners black 108

107(106). Supra-alar bristles present ..... *morula*

Supra-alar bristles absent ..... *hypomelaina*

108(106). Notopleural calli black; facial spots absent ..... *setinervis*

Notopleural calli yellow; facial spots present ..... *kirki*

109(103). Humeral calli fuscous to black 110
Humeral calli yellow 113

110(109). Supra-alar bristles absent ..... *minuta*
Supra-alar bristles present 111

111(110). Facial spots present; fore and mid femora black, apical ½ hind femora black, fore and mid tibiae fuscous, hind tibiae dark fuscous ..... *thistletoni*
Facial spots absent; legs mostly fulvous 112

112(111). Abdominal terga mostly black ..... *passiflorae*
Abdominal tergum I black, terga II-V orange-brown with a medial dark fuscous band over terga III-V and 2 broad lateral glossy black bands over terga II-V ..... *samoae*

113(109). Mesonotum red-brown 114
Mesonotum black 115

114(113). Notopleural calli yellow; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle; yellow triangular marking along mesonotal suture; scutellum yellow with fuscous spot on apex; costal cells fuscous ..... *mendosa*
Notopleural calli shining orange-brown; mesopleural stripe reaching humeral callus; no yellow triangular marking along mesonotal suture; scutellum entirely yellow; costal cells colourless ..... *luteola*

115(113). Prescutellar bristles absent ..... *perpusilla*
Prescutellar bristles present 116

116(115). Abdominal terga uniformly black 117
Abdominal terga orange-brown with dark markings 118

117(116). Costal cells pale fulvous; legs fuscous except fore tibiae fulvous ..... *exspoliata*
Costal cells colourless; legs with femora black except basal ⅔ hind femora fulvous, fore tibiae fuscous, mid and hind tibiae dark fuscous ..... *diospyri*

118(116). Scutellum yellow with fuscous spot on apex; costal cells extremely pale fulvous; abdominal terga III-V orange-brown with a transverse dark fuscous spot on lateral margins of each tergum, a narrow medial longitudinal band which is fuscous to dark fuscous on terga III and IV and black on tergum V ..... *obscura*
Scutellum entirely yellow; costal cells pale fuscous; abdominal terga III-V red-brown with broad fuscous lateral margins on tergum III, narrow fuscous lateral margins on terga IV and V and a narrow medial longitudinal fuscous to dull black band on terga III-V ..... *allwoodi*

119(99). 4 scutellar bristles present 120
2 scutellar bristles present 123

120(119). Face black; lateral postsutural vittae short and narrow, ending at or before sa. bristles; wing without distinct costal band on entire margin; scutellum entirely yellow or yellow with black markings 121
Face fulvous with a pair of black spots; lateral postsutural vittae long, ending at or before upper pa. bristles; wing with distinct costal band along entire margin; scutellum entirely yellow 122

121(120). Scutellum yellow with a broad medial black band on dorsal surface; mesopleural stripe ending just before humeral callus above; humeral calli glossy black ..... *satanellus*
Scutellum entirely yellow; mesopleural stripe extending to humeral callus above; humeral calli yellow with anterodorsal corners black ..... *terminifera*

122(120). Mesonotum black; abdominal terga III-V black except for orange-brown bordering a medial longitudinal fuscous band on posterior regions of each tergum (on tergum V the orange-brown spreads along posterior margin); legs with basal ½ hind femora fulvous (remainder of all femora fuscous), fore tibiae fuscous, mid tibiae fulvous, hind tibiae dark fuscous, tarsi fulvous ..... *quadrisetosa*
Mesonotum red-brown; legs entirely fulvous; abdominal terga III-V orange-brown with a small fuscous spot laterally on anterior margin of tergum III, a narrow medial longitudinal fuscous band running over tergum V and posterior ½ of tergum IV ..... *expandens*

123(119). Costal band broad, extending to or below R_{4+5} for its entire length 124

Costal band narrow, not extending to R_{4+5} except beyond extremity of R_{2+3} 127

124(123). Mesonotum red-brown to fuscous ..... *furforosa* and *notatagena* complexes (see key page 238)

Mesonotum black 125

125(124). Abdominal terga III-V fulvous with a broad medial and 2 broad lateral longitudinal black bands not meeting along anterior margin of tergum III ..... *froggatti*

Abdominal terga either uniformly orange-brown or black, or with terga III-V orange-brown with medial and lateral longitudinal bands which join along tergum III 126

126(125). Pecten absent on abdominal tergum III of male ..... *calophylli*

Pecten present on abdominal tergum III of male ..*bryoniae* complex (see key page 236)

127(123). Humeral and notopleural calli joined by a broad yellow band 128

Humeral and notopleural calli not joined by a broad yellow band 130

128(127). Supra-alar bristles absent ..... *jarvisi*

Supra-alar bristles present 129

129(128). Mesopleural stripe not extending to humeral callus above; anterior ½ notopleural calli fuscous (remainder yellow); lateral postsutural vittae beginning anterior to mesonotal suture; microtrichia covering all of second costal cell and outer corner of first costal cell..*diaphana*

Mesopleural stripe extending to humeral callus above; notopleural calli entirely yellow; lateral postsutural vittae beginning at mesonotal suture; microtrichia in outer corner of second costal cell only ..... *ochromarginis*

130(127). Scutellum either entirely brown or black, or yellow with a very broad basal band usually as a black or brown triangular marking on dorsal surface 131

Scutellum yellow with a moderately narrow black basal band, or sometimes with fuscous on apex or mostly orange-brown 139

131(130). Scutellum entirely brown or black 132

Scutellum yellow with a broad basal band or a large black or brown triangular marking on dorsal surface 133

132(131). Scutellum entirely red-brown; humeral calli yellow (except anterior ⅓ brown) notopleural calli red-brown; facial spots absent; mesonotum and abdomen uniformly dark orange-brown ..... *phaleriae*

Scutellum entirely black; humeral and notopleural calli black; facial spots present; mesonotum and abdomen entirely black ..... *carbonaria*

133(131). Scutellum yellow with a broad basal band, ¼-½ width of scutellum ..... *fagraea* complex (see key page 237)

Scutellum yellow with a medial longitudinal fuscous or black band 134

134(133). Mesonotum black or almost so 135

Mesonotum red-brown with or without dark markings 137

135(134). Abdomen orange-brown with a broad medial and 2 broad lateral longitudinal black bands over terga I-V; costal cells pale fulvous ..... *trifaria*

Abdomen uniformly black; costal cells colourless 136

136(135). A large species (wing length 7.0 mm); humeral calli dark fuscous; lateral postsutural vittae narrow; longitudinal black band on scutellum narrow; legs with mid femora, apical ½ of hind femora and hind tibiae fuscous; wing with costal band present *atramentata*

A small species (wing length 5.0 mm); humeral calli glossy black with at most, a fulvous band through centre; lateral postsutural vittae broad; longitudinal black band on scutellum broad; legs with mid and hind femora and hind tibiae black; wing with costal band absent ..... *picea*

137(134). Humeral calli brown; costal cells pale fulvous ..... *enochra*

Humeral calli yellow; costal cells fuscous 138

138(137). Lateral postsutural vittae parallel sided and reaching upper pa. bristles; mesonotum red-brown without dark markings ..... *daruensis*

Lateral postsutural vittae tapering and ending well before upper pa. bristles; mesonotum red-brown with irregular fuscous markings ..... *buinensis*

139(130). Scutellum and notopleural calli entirely orange-brown ..... *aenigmatica*

Scutellum entirely yellow or with dark markings on apex; notopleural calli yellow... 140

140(139). Scutellum yellow with fuscous on apex ..... *bancroftii* (some specimens)
Scutellum entirely yellow with a narrow dark basal band 141
141(140). Supra-alar bristles absent 142
Supra-alar bristles present 149
142(141). Prescutellar bristles present 143
Prescutellar bristles absent 147
143(142). Mesonotum black 144
Mesonotum orange-brown or red-brown 145
144(143). Costal band confluent with R_{2+3}; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle; black transverse band across anterior margin of abdominal tergum III ..... *aberrans*
Costal band overlapping R_{2+3}; mesopleural stripe reaching to anterior npl. bristle; no dark transverse band across base of abdominal tergum III ..... *melanothoracica*
145(143). Facial spots absent ..... *mutabilis* (some specimens)
Facial spots present 146
146(145). Microtrichia covering all of second costal cell and outer ½ of first costal cell; lateral postsutural vittae ending at upper pa. bristles; mesopleural stripe reaching to anterior npl. bristle ..... *ochracea*
Microtrichia in outer corner of second costal cell only; lateral postsutural vittae ending well before upper pa. bristles; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle ..... *unirufa*
147(142). Mesonotum and humeral calli black ..... *toxopeusi*
Mesonotum red-brown; humeral calli yellow 148
148(147). Lateral postsutural vittae ending before upper pa. bristles; apex of piercer of ovipositor with 3 pairs of subapical lobes ..... *decurtans*
Lateral postsutural vittae ending at upper pa. bristles; apex of piercer of ovipositor needle shaped ..... *murrayi*
149(141). Mesonotum either mostly black or with definite dark fuscous to black patterns 150
Mesonotum mostly red-brown or orange-brown with or without small indistinct dark markings 160
150(149). Abdomen mostly black with, at most, pale colouration posteriorly on tergum II and posterocentrally on tergum V 151
Abdomen of uniform pale colouration or with a pattern of dark markings 152
151(150). Humeral calli dark brown or black ..... *lineata*
Humeral calli yellow ..... *anthracina* and *nigella* complexes (see key page 234)
152(150). Abdomen with at least terga III-V orange-brown or red-brown with, at most, pale fuscous narrow lateral margins and/or a narrow pale fuscous medial longitudinal band on 1 or all 3 terga 153
Abdominal terga III-V orange-brown with dark markings 154
153(152). Lateral postsutural vittae beginning anterior to mesonotal suture; prsc. bristles absent ..... *abdopallescens*
Lateral postsutural vittae beginning at mesonotal suture; prsc. bristles present .... *assita* and *musae* complexes (see key page 234)
154(152). Lateral postsutural vittae very short, not extending posteriorly past sa. bristles 155
Lateral postsutural vittae long, always extending posteriorly of sa. bristles 156
155(154). Abdomen broadly black on lateral margins of tergum III and on anterolateral corners of terga IV and V, a moderately broad medial longitudinal black band on terga III-V; lateral postsutural vittae short and narrow, ending at level of sa. bristles ..... *facialis*
Abdominal terga III-V with 2 broad lateral longitudinal black bands; lateral postsutural vittae short, ending just behind level of sa. bristles ..... *mucronis*
156(154). Costal cells colourless to very pale fulvous .... *aemula* and *dorsalis* complexes (see key page 233)
Costal cells pale fuscous to fuscous, or if colourless then the abdominal terga are entirely fuscous with orange-brown posterocentrally on terga IV and V 157
157(156). Costal cells colourless ..... *furvescens*

Costal cells pale fuscous to fuscous 158

158(157). Costal band overlapping R_{2+3}; abdominal terga III-V black with orange-brown posterocentrally on terga IV and V, mesonotum black with a broad dark fuscous longitudinal band anterocentrally ..... *petila*

Costal band confluent with R_{2+3}; abdominal terga III-V with broad medial and lateral longitudinal dark bands; mesonotum entirely black 159

159(158). Costal cells fuscous (second cell paler) with microtrichia in outer corner of second costal cell only; lateral postsutural vittae ending before upper pa. bristles; scutellum yellow with a broad basal band; mesopleural stripe narrow (equal in width to notopleural callus); legs with femora entirely fulvous ..... *congener*

Costal cells pale fuscous with dense microtrichia covering second costal cell and outer ½ of first costal cell; lateral postsutural vittae ending at upper pa. bristles; scutellum yellow with a narrow basal band; mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle); legs with apices of femora fuscous ..... *buloloensis*

160(149). Microtrichia covering most of second costal cell and a portion of first costal cell ... 161

Microtrichia confined to apical portion of second costal cell only 164

161(160). Facial spots absent ..... *mutabilis* (some specimens)

Facial spots present 162

162(161). All abdominal terga shining orange-brown with a large circular black spot on the anterocentral margin of tergum V ..... *unipunctata*

Abdomen with terga III-V either red-brown or fuscous with a pattern of darker markings 163

163(162). Costal cells fulvous; abdominal terga III-V with broad lateral longitudinal fuscous to red-brown bands; a small species ..... *humilis*

Costal cells fuscous; abdominal terga III-V with broad lateral longitudinal fuscous to dark fuscous bands; larger species ..... *tryoni* complex (see key page 240)

164(160). Abdominal terga of uniform pale colouration, without dark colour patterns 165

Abdominal terga III-V either entirely black or pale coloured with a pattern of dark colouration 166

165(164). Abdomen entirely fuscous; lateral postsutural vittae ending before upper pa. bristles ..... *abdofuscata*

Abdomen entirely pale orange-brown; lateral postsutural vittae ending behind upper pa. bristles ..... *dyscrita*

166(164). Abdominal terga III-V entirely black ..... *abdonigella*

Abdominal terga III-V not entirely black 167

167(166). No medial dark band on abdomen 168

A well defined or indistinct medial dark band on abdomen, either as a band on terga III-V or as an elongated spot on 1 or 2 of these terga 170

168(167). Abdominal tergum III with red-brown to very pale fuscous areas on lateral margins ..... *peninsularis* (some specimens)

Abdomen with broad lateral longitudinal dark fuscous bands on terga III-V 169

169(168). Lateral postsutural vittae parallel sided and ending behind upper pa. bristles; mesopleural stripe almost reaching anterior npl. bristle; a large species (wing length greater than 5.0 mm) ..... *barringtoniae*

Lateral postsutural vittae narrow and tapering to end at upper pa. bristles; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle; a small species (wing length less than 5.0 mm) ..... *aithogaster*

170(167). Abdominal terga III-V with broad lateral longitudinal dark bands ..... *silvicola* complex (see key page 240)

Abdominal terga III-V with narrow lateral longitudinal dark bands or without dark lateral margins 171

171(170). Abdominal terga III-V with distinct, narrow lateral dark colour patterns on at least 1 of these terga 172

Abdominal terga III-V without distinct lateral dark colour patterns 173

172(171). Abdominal tergum V with a pair of fuscous to black shining spots ..... *perkinsi*

Abdominal tergum V without dark shining spots .....
.....*quadrata* complex (see key page 239)

173(171). Costal cells colourless .....*mayi* complex (see key page 238)
Costal cells pale fulvous 174

174(173). Abdominal terga III-V with a narrow transverse black band across base of tergum III and a medial longitudinal fuscous to black band on at least 1 tergum 175
Abdominal terga III-V not so marked 176

175(174). A large species; apex of piercer of ovipositor with a pair of small subapical keels ..... *moluccensis*
A small species; apex of piercer of ovipositor with 2 pairs of strong subapical keels ....
..... *rutila*

176(174). Mesonotum uniformly red-brown; abdominal tergum V without a pair of fuscous to black shining spots ..... *bidentata* complex (see key page 235)
Mesonotum with a pair of longitudinal fuscous stripes; abdominal tergum V with or without a pair of fuscous to black shining spots 177

177(176). Abdominal tergum V with a pair of dark shining spots; lateral postsutural vittae ending at upper pa. bristles; mesopleural stripe reaching to anterior npl. bristle .....
..... *robiginosa*
Abdominal tergum V without a pair of dark shining spots; lateral postsutural vittae ending before upper pa. bristles; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle ..... *hastigerina*

KEY TO SPECIES OF SUBGENUS *BACTROCERA* PLACED IN COMPLEXES

aemula and **dorsalis** complexes

1. Lateral postsutural vittae ending before upper pa. bristles 2
Lateral postsutural vittae ending at or behind upper pa. bristles 8

2(1). Costal cells colourless ..... *endiandrae*
Costal cells with a pale fulvous tint 3

3(2). Mesopleural stripe equal in width to notopleural callus ..... *diallagma*
Mesopleural stripe wider than notopleural callus 4

4(3). Mesopleural stripe reaching or anterior to anterior npl. bristle 5
Mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle 6

5(4). Mesopleural stripe reaching anterior npl. bristle ..... *consectorata*
Mesopleural stripe reaching almost to humeral callus ..... *fuliginus*

6(4). Costal band confluent with R_{2+3}; pale infuscation covering wing membrane .....
..... *inconstans*
Costal band overlapping R_{2+3}; wing membrane colourless 7

7(6). Costal band almost confluent with R_{4+5}; abdominal terga mostly orange-brown with narrow medial and lateral longitudinal pale fuscous bands ..... *mimulus*
Costal band reaching midway between R_{2+3} and R_{4+5}; abdominal terga mostly dark in colour ..... *aemula*

8(1). Costal cells colourless 9
Costal cells with a pale fulvous tint 12

9(8). Mesonotum generally red-brown with a distinct black pattern 10
Mesonotum entirely black 11

10(9). Costal band overlapping R_{2+3} ..... *opiliae*
Costal band confluent with R_{2+3} and widening slightly after crossing this vein .....
..... *cacuminata*

11(9). Prescutellar bristles absent; abdominal terga III-V orange-brown with a broad medial longitudinal black band and moderately broad black lateral margins on tergum III .
..... *nigrescens*

Prescutellar bristles present; abdominal terga III-V dark fuscous to black except orange-brown posterocentrally on tergum III and medially on terga IV and V ..... *trivialis*

12(8). Mesopleural stripe reaching to anterior npl. bristle 13
Mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle 14

13(12). Costal band overlapping R_{2+3}; lateral postsutural vittae narrowing posteriorly; prsc. bristles present ..... *vulgaris*
Costal band confluent with R_{2+3}; lateral postsutural vittae parallel sided; prsc. bristles absent ..... *indecora*

14(12). Costal band almost confluent with R_{4+5} ..... *laticosta*
Costal band reaching midway between R_{2+3} and R_{4+5} 15

15(14). Abdomen oval; costal band expanded at apex of wing; lateral postsutural vittae narrowing to end at upper pa. bristles; abdominal terga III-V with a medial and 2 lateral longitudinal broad dark bands joined along anterior margin of tergum III ..... *dapsiles*
Abdomen elongate-oval; costal band of uniform width; lateral postsutural vittae parallel sided and ending behind upper pa. bristles; abdomen with a narrow medial longitudinal pale fuscous band on terga II-V and 2 moderately broad lateral longitudinal pale fuscous bands on terga III-V ..... *abdolonginqua*

alyxiae complex

1. Mesonotum entirely black; abdominal terga III-V orange-brown with 2 broad lateral longitudinal fuscous bands ..... *alyxiae*
Mesonotum fuscous with 2 irregularly shaped lateral longitudinal black bands; abdominal terga III-V uniformly orange-brown except for a narrow transverse fuscous band anterolaterally on tergum III ..... *repanda*

anthracina and **nigella** complexes

1. Costal cells colourless or almost colourless 2
Costal cells fulvous or fuscous 4

2(1). Lateral postsutural vittae ending well before upper pa. bristles; mesopleural stripe reaching almost to humeral callus ..... *aterrima*
Lateral postsutural vittae ending at upper pa. bristles; mesopleural stripe not extending past midline between anterior margin of notopleural callus and anterior npl. bristle 3

3(2). Facial spots small and triangular; legs fulvous except hind tibiae fuscous ..... *nigella*
Facial spots large and oval; fore femora dark fuscous, mid femora and apical ⅓ hind femora black; fore and mid tibiae fuscous, hind tibiae dark fuscous ..... *terminaliae*

4(1). Microtrichia covering all of second and most of first costal cell 5
Microtrichia in outer corner of second costal cell only 6

5(4). Lateral postsutural vittae narrow and ending well before upper pa. bristles; scutellum with a broad black basal band; mesopleural stripe not extending to humeral callus ..... *caliginosa*
Lateral postsutural vittae parallel sided and ending at upper pa. bristles; scutellum with a narrow dark basal band; mesopleural stripe extending to humeral callus ..... *kelaena*

6(4). Lateral postsutural vittae narrowing sharply to end before upper pa. bristles; legs fulvous except hind tibiae fuscous ..... *batemani*
Lateral postsutural vittae broad and ending behind upper pa. bristles; legs with apices of all femora and all tibiae fuscous ..... *anthracina*

assita and **musae** complexes

1. Notopleural calli with anterior ½ black, posterior ½ yellow; scutellum with a broad black basal band ..... *robertsi*
Notopleural calli entirely yellow; scutellum with a narrow dark basal band 2

2(1). Lateral postsutural vittae ending before upper pa. bristles 3
Lateral postsutural vittae ending at upper pa. bristles 5

3(2). Costal cells pale fulvous; abdominal terga III-V orange-brown with narrow medial and lateral longitudinal pale fuscous to fuscous bands joined along anterior margin of tergum III ..... *commina*
Costal cells colourless; abdominal terga II-V mostly orange-brown 4

4(3). Costal band overlapping R_{2+3}; abdomen elongate-oval with terga II-V uniformly orange-brown ..... *prolixa*
Costal band confluent with R_{2+3}; abdomen oval with a narrow medial longitudinal fuscous band on tergum V ..... *brevistriata*

5(2). Mesonotum with a distinct lanceolate black pattern interspersed with red-brown ..... *musae* (some specimens)
Mesonotum uniformly black 6

6(5). Costal cells colourless 7
Costal cells coloured, at least by a pale fulvous tint 9

7(6). Costal band only just overlapping R_{2+3} and narrowing towards apex of wing; apex of piercer of ovipositor curved upwards, elongate and pointed sharply ..... *tinomiscii*
Costal band dark fuscous and distinct well below R_{2+3}; apex of piercer of ovipositor not curved 8

8(7). Costal band overlapping R_{2+3}; piercer of ovipositor narrowing sharply between gonopore and apex, spicules on distal end of middle segment of ovipositor with up to 5 large dentations and occasional small dentations (Figs 151, 152) ..... *musae* (some specimens)
Costal band almost confluent with R_{4+5} and of uniform width; piercer of ovipositor narrowing gradually between gonopore and apex, spicules on distal end of middle segment of ovipositor with 8-12 dentations of approximately equal size (Figs 52, 53) ..... *finitima*

9(6). Costal cell fuscous and covered with microtrichia ..... *assita*
Costal cells pale coloured with microtrichia in outer corner of second cell only 10

10(9). Costal cells fulvous; mesopleural stripe reaching anterior npl. bristle; facial spots extremely small and pale ..... *circamusae*
Costal cells pale fulvous; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle; facial spots distinct 11

11(10). Brown spot on apex of scutellum; costal band narrower than subcostal cell beyond extremity of R_{2+3}; abdominal terga uniformly orange-brown especially terga III-V ..... *bancroftii*
Scutellum entirely yellow; costal band at least as wide as subcostal cell beyond extremity of R_{2+3}; abdominal terga III-V orange-brown with or without small pale fuscous markings 12

12(11). Abdominal terga uniformly orange-brown; apex of piercer of ovipositor long and slender (length:width-7:1), spicules at distal end of middle segment of ovipositor at least 4 times wider than long and with 9-12 small dentations of approximately equal size (Figs 46, 47) ..... *contermina*
Abdominal terga III-V with pale fuscous anterolateral corners on tergum III and a narrow medial longitudinal pale fuscous band over all 3 terga; apex of piercer of ovipositor short and stout (length:width-4.4:1), spicules at distal end of middle segment of ovipositor approximately 2.5 times wider than long and with 1-3 very large dentations (Figs 49, 50) ..... *contigua*

bidentata complex

1. Lateral postsutural vittae broad, parallel sided, ending at upper pa. bristles; hind tibiae fulvous; costal band confluent with R_{2+3} ..... *aeroginosa*
Lateral postsutural vittae narrow, tapered sharply posteriorly and ending before upper pa. bristles; hind tibiae brown; costal band overlapping R_{2+3} ..... *bidentata*

bryoniae complex

1. Costal band overlapping R_{4+5} for entire length ..... *simulata*
Costal band confluent with R_{4+5} 2
2(1). Abdominal terga II-V with, at most, pale fuscous on anterior and lateral margins of tergum III ..... *paramusae*
Abdominal terga mostly black or with distinct dark colour patterns 3
3(2). Abdominal terga mostly black 4
Abdominal terga red-brown or orange-brown with dark colour patterns 6
4(3). Wings with microtrichia in outer corner of second costal cell only ..... *epicharis*
Wings with microtrichia covering all of both costal cells 5
5(4). Anterodorsal corners of humeral calli pale fuscous; basal band of scutellum narrow; fore tibiae fuscous; 4 sc. bristles present ..... *quadrisetosa*
Humeral calli entirely yellow; basal band of scutellum broad; fore tibiae fulvous; 2 sc. bristles present ..... *varipes*
6(3). Lateral postsutural vittae ending at upper pa. bristles; abdominal terga III-V red-brown with a broad dark fuscous band across anterior margin of tergum III and expanding over lateral margins, anterolateral corners of terga IV and V fuscous, a medial longitudinal dark fuscous band over all 3 terga ..... *bryoniae*
Lateral postsutural vittae ending before upper pa. bristles; abdominal tergum III black, terga IV and V orange-brown with broad lateral longitudinal bands which are black on tergum IV and dark fuscous on tergum V, a broad medial longitudinal dark fuscous band on terga IV and V joining lateral bands along anterior margin of tergum IV ..... *latissima*

distincta and **fulvicauda** complexes

1. Humeral and notopleural calli joined by a lateral yellow band 2
Humeral and notopleural calli not joined by a lateral yellow band 3
2(1). Mesonotum generally red-brown; abdominal terga mostly orange-brown .... *morobiensis*
Mesonotum black; abdominal terga orange-brown with lateral and medial longitudinal black bands on terga III-V ..... *unifasciata*
3(1). Humeral calli dark fuscous ..... *curreyi*
Humeral calli yellow 4
4(3). Notopleural calli dark fuscous to black 5
Notopleural calli yellow 6
5(4). Transverse band across wing recurved along CuA_1 for a short distance; lateral postsutural vittae ending at upper pa. bristles; abdomen with a broad medial and 2 broad lateral longitudinal black bands on terga II-V ..... *ampla*
Transverse band across wing not recurved along CuA_1; lateral postsutural vittae ending before upper pa. bristles; abdomen with a broad medial longitudinal black band on terga II-V and 2 broad lateral longitudinal black bands on terga III-V ..... *decumana*
6(4). Mesopleural stripe reaching humeral callus ..... *fulvicauda*
Mesopleural stripe not reaching humeral callus 7
7(6). Transverse fuscous band across wing broad, maximum width equal to or greater than ⅓ length of discoidal cell 8
Transverse fuscous band narrower than above 9
8(7). Costal cells pale fuscous with microtrichia in outer corner of second costal cell only; lateral postsutural vittae broad and ending at upper pa. bristles; mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle ..... *unistriata*
Costal cells fuscous and covered by dense microtrichia; lateral postsutural vittae narrow and ending before upper pa. bristles; mesopleural stripe equal in width to notopleural callus ..... *pulchra*
9(7). Lateral postsutural vittae ending before upper pa. bristles 10
Lateral postsutural vittae ending at upper pa. bristles 12

10(9). Scutellum yellow without a dark apical spot; transverse band across wing straight and of medium width (covering almost ⅓ of discoidal cell) ..... *atriliniellata*
Scutellum yellow with a fuscous apical spot; transverse band across wing curved and narrower than above 11

11(10). Costal cells fulvous, microtrichia in outer corner of second costal cell only; costal band paler towards centre of wing; legs fulvous except apical 4 segments of all tarsi fuscous and hind tibiae dark fulvous; abdominal terga fulvous with a broad medial and 2 irregularly shaped lateral longitudinal glossy black bands on terga III-V ..... *anomala*
Costal cells dark fuscous, microtrichia in all of second costal cell; costal band entirely dark fuscous; legs fulvous except apex of hind tibiae and apical 4 segments of all tarsi fuscous; abdominal terga II-V orange-brown with a broad transverse black band on base of tergum II, a broad medial and 2 broad lateral longitudinal black bands running from transverse band on tergum II to apex of abdomen ..... *distincta*

12(9). Costal band overlapping R_{2+3} but not confluent with R_{4+5} 13
Costal band confluent with R_{4+5} 15

13(12). Costal cells pale fuscous; transverse band across wing narrow and covering outer corner of discoidal cell only; abdominal terga II-V orange-brown with a broad medial longitudinal dark band on all 4 terga and 2 lateral longitudinal dark bands of medium width on terga III-V ..... *furvilineata*
Costal cells fulvous; transverse band across wing covering almost apical ⅓ of discoidal cell; abdominal terga mostly orange-brown with, at most, small irregular fuscous markings or red-brown with broad medial and lateral longitudinal dark bands on terga III-V 14

14(13). Abdominal terga III-V red-brown with a broad medial longitudinal dark fuscous to black band and 2 broad lateral longitudinal dark fuscous bands which join along anterior margin of tergum III ..... *latilineata*
Abdominal terga mostly orange-brown occasionally with a narrow fuscous band on terga III-V or IV and V and a small fuscous spot on anterolateral corners of tergum III ..... *rhabdota*

15(12). Costal cells colourless; abdominal terga black except orange-brown posterocentrally on terga IV and V ..... *oblineata*
Costal cells coloured; abdominal terga either uniformly orange-brown or orange-brown with longitudinal dark bands 16

16(15). Abdominal terga uniformly orange-brown with, at most, a very pale fuscous narrow medial longitudinal band on terga III and IV ..... *propedistincta*
Abdominal terga orange-brown with a distinct pattern of longitudinal dark bands ... 17

17(16). Costal cells fuscous; microtrichia covering all of second and most of first costal cell; abdominal terga with broad lateral longitudinal dark bands on terga I-V .... *fergussoniensis*
First costal cell fulvous, second costal cell fuscous; microtrichia covering outer ½ of second costal cell only; abdominal terga with broad lateral longitudinal dark bands on terga III-V ..... *pseudodistincta*

fagraea complex

1. Abdomen with a well defined medial black band on terga III-V ..... *rufescens*
Abdomen without a medial black band 2

2(1). Abdominal terga III and IV with lateral fuscous markings 3
Abdominal terga III and IV uniformly coloured, without fuscous markings 4

3(2). Mesonotum and abdomen uniformly red-brown; rarely with narrow longitudinal fuscous bands on mesonotum; fuscous areas on extreme lateral margins of abdominal terga III and IV only; mesopleural stripe not wider than notopleural callus; lateral postsutural vittae not broad and narrowing posteriorly ..... *halfordiae*
Mesonotum red-brown with or without a pattern of fuscous markings; abdomen usually fuscous over most of terga III and IV and laterally on tergum V; mesopleural stripe 1.5 times width of notopleural callus; lateral postsutural vittae parallel sided for most of

its length ..... *kraussi*

4(2). Abdominal tergum V with a pair of dark shining spots; mesonotum red-brown; basal band of scutellum approximately ½ length of scutellum ..... *russeola*

Abdominal tergum V without dark shining spots; mesonotum orange-brown; basal band of scutellum approximately ⅓ length of scutellum ..... *fagraea*

frauenfeldi complex

1. Humeral calli yellow with anterolateral corners black; width of black basal band on scutellum approximately ⅓ the scutellum length ..... *caledoniensis*

Humeral calli entirely black; scutellum with dorsal black marking generally extending to apex 2

2(1). Lateral postsutural vittae present; black marking on dorsal surface of scutellum triangular and when reaching apex it ends in a point between apical bristles ..... *frauenfeldi*

Lateral postsutural vittae absent; black marking on dorsal surface of scutellum broader and enclosing the apical bristles 3

3(2). Face fulvous with medium sized oval black spots; costal cells pale fuscous; microtrichia covering most of second costal cell; costal band absent beyond subcostal cell; legs fulvous except apical ⅔ to ¾ of mid femora and apical ½ hind femora black, fore and mid tibiae fuscous and hind tibiae dark fuscous ..... *parafrauenfeldi*

Face glossy black; costal cells extremely pale fuscous; microtrichia on outer ½ of second costal cell only; costal band present but pale beyond subcostal cell; legs fulvous except apical ⅓ hind femora and hind tibiae fuscous ..... *trilineola*

furfurosa and **notatagena** complexes

1. Costal cells colourless or with a very pale tint ..... *furfurosa*

Costal cells coloured 2

2(1). Costal cells pale fulvous or pale fuscous with microtrichia covering all or part of second costal cell 3

Costal cells fuscous with dense microtrichia covering both cells 4

3(2). Costal cells pale fulvous with microtrichia covering all of second cell; humeral calli entirely yellow; mesonotum uniformly fuscous; legs fulvous except hind tibiae pale fuscous ..... *popondettiensis*

Costal cells pale fuscous with microtrichia on outer ½ of second cell only; humeral calli yellow except anterior ⅓ fuscous; mesonotum dark fuscous with paler markings; legs fulvous except apices of fore and hind femora red-brown to pale fuscous and fore and hind tibiae fuscous tending darker basally ..... *obfuscata*

4(2). Humeral calli yellow except anterior ⅓ fuscous ..... *romigae*

Humeral calli entirely yellow 5

5(4). Lateral postsutural vittae ending at upper pa. bristles; abdominal terga mostly black; legs with femora generally dark fuscous, tibiae pale fuscous except mid tibiae fulvous ... . *nigrovittata*

Lateral postsutural vittae ending before upper pa. bristles; abdominal terga and legs not entirely dark coloured 6

6(5). Mesonotum red-brown with a dark fuscous lanceolate pattern; abdominal terga III-V with broad lateral longitudinal dark fuscous bands; legs fulvous except fore and mid femora and hind tibiae fuscous ..... *notatagena*

Mesonotum pale fuscous with 2 lateral longitudinal dark fuscous to black bands; abdominal terga III-V with an indistinct narrow medial longitudinal pale fuscous band and broad lateral longitudinal dark fuscous to black bands; legs fulvous except fore tibiae pale fuscous and hind tibiae fuscous ..... *ustulata*

mayi complex

1. Anal streak narrow, approximating width of anal cell (or much paler if extending towards base of discoidal cell) with microtrichia never extending over the entire coloured streak

(see Fig. 15, Drew et al. 1981); mesonotum pale red-brown; abdomen pale orange-brown ..... *pallida*

Anal streak broad, reaching almost to base of discoidal cell and covered with microtrichia for entire width (see Fig. 15, Drew et al. 1981); mesonotum and abdomen red-brown or dark red-brown 2

2(1). Lateral postsutural vittae broad, almost parallel sided for part of length; mesonotum and abdomen red-brown; mesonotum seldom marked with fuscous and then only laterally before mesonotal suture and along inner margins of lateral postsutural vittae ..... *tenuifascia*

Lateral postsutural vittae not broad, narrowing sharply posteriorly; mesonotum and abdomen dark red-brown; mesonotum usually with a pair of longitudinal parallel black bands centrally ..... *mayi*

quadrata complex

1. Abdominal terga III-V with a more or less distinct medial fuscous band 2

Abdominal terga IV and V only with a distinct medial fuscous band 4

2(1). Abdominal terga III-V with broad lateral fuscous patches; medial band well defined ..... *antigone*

Abdominal tergum III with broad lateral fuscous patches, terga IV and V with patches narrow or absent; medial band not well defined 3

3(2). Lateral postsutural vittae broad, parallel sided; costal band of wing barely overlaps vein R_{2+3}; hind tibiae fulvous ..... *peninsularis* (some specimens)

Lateral postsutural vittae tapered posteriorly; costal band of wing almost reaches vein R_{4+5}; hind tibiae fuscous on basal ⅔ ..... *erubescentis*

4(1). Mesonotum orange-brown; abdominal terga III-V with a very narrow lateral fuscous margin; hind tibiae fulvous; femora fulvous ..... *aurantiaca*

Mesonotum red-brown; abdominal tergum III with lateral fuscous patches, remaining terga dark fulvous; hind tibiae fuscous; femora fuscous at apex ..... *quadrata*

recurrens complex

1. A U-shaped coloured band across wing between costal band and hind margin 2

A S- or Z-shaped coloured band across wing between costal band and hind margin .. 3

2(1). Abdominal terga III-V orange-brown with narrow pale fuscous lateral margins ..... *absidata*

Abdominal terga mostly orange-brown with a medial longitudinal fuscous band on terga I-V and lateral margins of tergum III brown ..... *resima*

3(1). Coloured band across wing S-shaped 4

Coloured band across wing Z-shaped 5

4(3). Mesonotum red-brown with diffuse black markings; lateral postsutural vittae broad and reaching upper pa. bristles; abdominal terga III-V with a narrow medial longitudinal pale fuscous band and pale fuscous on lateral margins of tergum III ..... *recurrens*

Mesonotum red-brown with a lanceolate fuscous pattern; lateral postsutural vittae narrow and ending before upper pa. bristles; abdominal terga III-V orange-brown with broad medial and lateral longitudinal bands joined along anterior margin of tergum III ... . *manskii*

5(3). Lateral postsutural vittae short, tapering and ending well before upper pa. bristles; wing markings fuscous to dark fuscous; abdominal terga III-V with a broad medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum III ..... *nigrescentis*

Lateral postsutural vittae broad, parallel sided and reaching to or behind upper pa. bristles; wing markings pale fuscous; abdominal terga III-V with medial and lateral longitudinal dark bands not joined on tergum III 6

6(5). Abdominal terga mostly orange-brown with a narrow medial longitudinal fuscous band on terga II-V and anterolateral corners of tergum II fuscous (in some specimens, the medial

band is wider and the lateral margins of terga III-V are infuscated) .... *anfracta*
Abdominal terga orange-brown with 2 broad lateral longitudinal black bands on terga III-V and a broad medial longitudinal black band on terga II-V ..... *redunca*

silvicola complex

1. Costal cells fulvous 2
Costal cells colourless or with a very pale tint 4
2(1). Lateral postsutural vittae broad and ending at upper pa. bristles; mesonotum with broad lateral longitudinal black bands ..... *turneri*
Lateral postsutural vittae narrowing posteriorly and ending before or just reaching upper pa. bristles; mesonotum with small fuscous patterns 3
3(2). Mesopleural stripe ending midway between anterior margin of notopleural callus and anterior npl. bristle; fulvous tint across wing (in some specimens); scutellum with a broad red-brown basal band (in some specimens) ..... *abundans*
Mesopleural stripe reaching anterior npl. bristle; no coloured tint across wing; scutellum always with a narrow dark basal band ..... *abscondita*
4(1). Lateral postsutural vittae ending before upper pa. bristles ..... *silvicola*
Lateral postsutural vittae ending at or behind upper pa. bristles 5
5(4). Costal band confluent with R_{2+3}; abdominal terga III-V with an indistinct narrow medial longitudinal fuscous band and 2 lateral longitudinal fuscous bands not joined on tergum III ..... *breviaculeus*
Costal band overlapping R_{2+3}; abdominal terga III-V with a medial and 2 lateral longitudinal fuscous bands joined along anterior margin of tergum III 6
6(5). Mesonotum uniformly red-brown without dark markings; legs with hind tibiae and apices of all femora fuscous ..... *quasisilvicola*
Mesonotum with variable dark markings; legs with femora entirely fulvous 7
7(6). Face with a pair of large oval black spots; mesonotum dark red-brown with fuscous lateral longitudinal bands; abdominal terga without a dense golden pubescence .... *rufofuscula*
Face with a pair of very small pale spots; mesonotum with a broad medial longitudinal fuscous area surrounded laterally and posteriorly by irregular dark fuscous to black patterns; abdominal terga covered by a dense golden pubsecence ..... *cinnamea*

tryoni complex

1. Humeral calli brown or dark brown ..... *neohumeralis*
Humeral calli yellow 2
2(1). Mesonotum and abdominal terga fuscous with a pattern of dark fuscous to black markings; apical ½ of mid and hind femora fuscous ..... *melas*
Mesonotum and abdominal terga generally red-brown or fulvous, often with fuscous markings; legs either entirely fulvous or fore and hind tibiae and apices of fore and hind femora infuscated 3
3(2). Mesonotum pale red-brown and abdominal terga fulvous without distinct fuscous markings; piercer of ovipositor needle shaped and pointed at apex (Fig. 186) ..... *aquilonis*
Mesonotum and abdominal terga red-brown with distinct fuscous markings; piercer of ovipositor needle shaped and rounded at apex (Fig. 195) ..... *tryoni*

Genus **Dacus** Fabricius

Subgenus **Callantra** Walker

Dacus (Callantra) axanus (Hering), n. comb. (Figs 405–407)

Callantra (Mellesis) axana Hering, 1938: 410.
Callantra axana: Hardy and Adachi, 1954: 149; Drew, 1973: 2.
Callantra auricoma May, 1955: 153–5 (new syn.).
Callantra smieroides: Drew, 1972a: 10; 1972b: 189; 1973: 2–6; Drew et al. 1981: 85 (misidentification).

MATERIAL EXAMINED

Holotype ♂ of *C. auricoma*; a large series of specimens in DPI (see DISTRIBUTION). Also, the following specimens in BMNH: holotype ♂ of *C. axana* (abdomen and 1 wing missing), Kei I., with a label "Purch. from E.M. Hering, B.M. 1965—270"; 1 ♂, N. Guinea Mer., Kapakapa, Mag. Giugno. 1891, L. Loria det. *Callantra axana* Hering by Hering in 1941, with a label "Purch. from E.M. Hering, B.M. 1965—270"; 1 ♀, Kei I., V. Roder, with a label "Purch. from E.M. Hering, B.M. 1965—270".

LOCATION OF TYPES: *C. axana*, holotype in BMNH; *C. auricoma*, holotype (T.5309) in QM.

DISTRIBUTION

Widespread and abundant in the northeastern and northwestern zones of Australia, Torres Strait islands, Papua New Guinea, New Britain, New Ireland, Lihir I. and Kei I. (type locality).

DIAGNOSIS

Large species; face dark fulvous with a pair of large irregularly oval spots; humeral calli yellow to yellow-brown; notopleural calli yellow; mesonotum red-brown with irregular fuscous patterns, lateral and medial postsutural vittae absent, mesopleural stripe of varying width (equal to width of notopleural callus or extending midway between anterior margin of notopleural callus and anterior npl. bristle), yellow triangle extending along anterior margin of mesonotal suture, scutellum yellow or fulvous with a broad red-brown basal band or entirely red-brown; bristles: sc. 2, prsc. absent, sa. 1; wing with a very broad fuscous costal band overlapping R_{4+5} and broad fulvous anal streak, costal cells orange-brown with dense microtrichia covering both cells; abdominal tergum III fuscous, terga IV and V fuscous with an oval orange-brown spot medially across intersegmental suture and connected to posterior margin of tergum V by a narrow medial longitudinal orange-brown band; all abdominal terga covered with a dense golden pubescence.

DESCRIPTION

FEMALE: Ovipositor basal segment red-brown, cylindrical and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.29:1. Apex of piercer needle shaped with 3 pairs of short subapical bristles (Fig. 406). Spicules at distal end of middle segment consisting almost entirely of flat triangular dentations which vary markedly in size (Fig. 407).

ATTRACTANT: Cue lure.

COMMENTS

Previously, the status of *D. axanus* could not be determined, as the single specimen from which it was described could not be located but Drew (1973) suggested that it may be a synonym of *D. smieroides* (Walker). Since then the holotype and 2 specimens identified by Hering have been found and *D. axanus* can now be defined. It is clear that the description of *Callantra smieroides* Walker by Drew (1973) is in fact of *D. axanus* and adequately defines this species. *D. smieroides* is restricted to Celebes, Brunei and what was formerly Borneo, while *D. axanus* is more eastern. *D. axanus* is similar to *D. capillaris* (Drew) in having a red-brown mesonotum and costal band overlapping R_{4+5} and in lacking postsutural vittae, spines on the ventral surfaces of fore femora and black spots on the eye margins. It differs from this species in having a pattern of large longitudinal fuscous bands on the mesonotum, costal band fuscous and abdominal terga III–V fuscous with orange-brown patterns.

Dacus (Callantra) capillaris (Drew), n. comb. (Fig. 408)

Callantra capillaris Drew, 1972b: 185–7.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6982) in QM.

DISTRIBUTION

Known only from Bougainville I. (type locality, Kieta).

DIAGNOSIS

Large species; face with large pear shaped black spots; humeral calli generally red-brown to brown; notopleural calli yellow; mesonotum red-brown with irregular fuscous markings, lateral and medial postsutural vittae absent, mesopleural stripe of medium width (extending midway between anterior margin of notopleural callus and anterior npl.

bristle), yellow triangle extending along anterior margin of mesonotal suture, scutellum generally red-brown to dark red-brown; bristles: sc. 2, prsc. absent, sa. 1 present in ⅔ of specimens (absent in remaining ⅓); wing with a broad fulvous costal band overlapping R_{4+5} and anal streak, costal cells fulvous with dense microtrichia covering both cells; abdominal terga II–V uniformly orange-brown without dark markings, posterior lobe of surstylus short, abdominal sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

This species was described adequately by Drew (1972b) and it is similar to *D. smieroides* (Walker).

Dacus (Callantra) discors, n. sp.
(Fig. 409)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, attracted to cue lure, 11.iv.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: Upper Manki logging area, Bulolo, 2 ♂♂, 25.iii.1980, 2 ♂♂, 1.iv.1980, 2 ♂♂, 8.iv.1980, 1 ♂, 11.iv.1980, P. Daur; 2 ♂♂, Kunai Creek (1450 m) and 1 ♂, Pitpit Gully (1550 m), Mt Kaindi, 29.xii.1980, A. Allison. All attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10452) and 1 paratype (T.10453) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 6 paratypes in DPI.

DISTRIBUTION

Known only from the Bulolo–Wau area, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with a small fulvous area surrounded by dark fuscous to black; humeral calli entirely dark fuscous or with a central yellow spot surrounded by dark fuscous; notopleural calli yellow; mesonotum fuscous to brown with large black markings, lateral postsutural vittae absent, medial postsutural vitta present, mesopleural stripe very narrow (equal in width to notopleural callus), yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow with a broad fuscous to brown basal band; wing with a broad fuscous costal band and anal streak, costal cells fuscous and covered with microtrichia; abdominal terga III–V black with transverse orange-brown bands along posterior margins of terga IV and V.

DESCRIPTION

MALE: Head generally fuscous. Vertical length 1.68 mm. Frons narrowing slightly posteriorly, length 1.17 times breadth; fuscous with black spots around orbital bristles and fulvous ventrally and irregular fulvous markings laterally; anteromedial hump covered with short dark setae, orbital bristles black: 1 s.or., 2 i.or. (i.or. not well developed); lunule dark fuscous. Ocellar triangle black. Vertex fuscous. Face fulvous in centre, surrounded dorsally and ventrally with dark fuscous and laterally with large elongate, black facial spots which cover antennal furrows; length of face 0.58 mm. Genae dark fuscous, large black subocular spot present; black bristle present. Occiput fuscous to black, yellow along eye margins; occipital row with a large number of well developed black bristles. Antennae with segments 1 and 2 fuscous, segment 3 dark fuscous; without dorsal bristle on segment 2; arista dark fuscous (fulvous basally); length of segments: 0.41 mm; 0.50 mm; 1.19 mm.

Thorax mesonotum black with an irregular brown area posteriorly which also extends along lateral margins and around medial postsutural vitta. Pleural areas black with small areas of dark fuscous below humeral calli and above mid coxae. Yellow markings as follows: notopleural calli; a triangle extending along anterior margin of mesonotal suture from notopleural callus; narrow mesopleural stripe equal in width to notopleural callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (anterior and posterior apices dark fuscous); a dorsocentral spot on lower hypopleural calli (remainder dark fuscous); a narrow medial longitudinal vitta from level of upper pa. bristles and narrowing anteriorly to level of mesonotal suture. Humeral calli entirely dark fuscous in 4 specimens and with a central yellow spot surrounded by dark fuscous in remaining specimens. Lateral postsutural vittae absent. Postnotum black laterally, dark fuscous centrally. Scutellum yellow with a broad fuscous to brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 2 outer (reduced inner scp. sometimes present); all bristles well developed and black.

Legs fore and mid coxae dark fuscous, hind coxae black; fore femora black on outer and dark fuscous on inner lateral surface, mid femora black except for a dark fuscous band dorsally, hind femora black; all tibiae fuscous to dark fuscous; tarsi fulvous; fore femora with rows of long pale setae on dorsal surface; mid tibiae each with an apical black spur.

setae on dorsal surface; mid tibiae each with an apical black spur.

Wings length 6.9 mm; costal cells dark fuscous, dense microtrichia covering both costal cells; subcostal cell dark fuscous, broad dark fuscous costal band confluent with M, narrow fuscous anal streak ending at wing margin, remainder of wings with a pale fuscous tint; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate, terga fused but overlapping laterally except between terga I and II; pecten present on tergum III; tergum I long and narrow; sterna I and II longer than wide. Terga black except for narrow transverse orange-brown bands across posterior margins of all terga (except III), the transverse band on tergum IV does not extend to the lateral margins. A pair of oval shining spots on tergum V. Posterior lobe of surstylus of medium length, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

D. discors is similar to *D. mayi* in possessing a broad dark fuscous to black triangle on the dorsal surface of the scutellum, but differs from this species in possessing a medial postsutural yellow vitta on the mesonotum.

Dacus (Callantra) impar, n. sp.
(Figs 410–412)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Susu, Bulolo, 5.v.1980, P. Daur.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 3 ♂♂, Mt Susu, Bulolo, 24.iv.1980, P. Daur; 1 ♂, Morobe District, August 1971, J. Maiyel; 1 ♂, Gabensis (on Lae–Bulolo road), 18–22.vi.1980, R.A.I. Drew and D.W.Currey; 1 ♀ (at M.V. light), Stony logging area, Bulolo, 18.iv.1979, H. Roberts; 2 ♂♂, Mt Missim (1100 m), 18.xii.1980 and 4.vi.1981, A. Allison. Western Highlands District: 1 ♂, H.A.T.I., Mt Hagen, 18.xi.1980, B. Thistleton. LOCATION OF TYPES: Holotype (T.10454) and 1 paratype (T.10455) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 5 paratypes in DPI.

DISTRIBUTION

Known only from the Bulolo–Wau area and Mt Hagen, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with a pair of large black spots; humeral calli yellow (fuscous on anterior margins); notopleural calli yellow; mesonotum black, lateral and medial postsutural vittae absent, mesopleural stripe of medium width (extending almost to anterior npl. bristle), yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow with a broad dark basal band; wing with a broad dark fuscous costal band, anal streak absent, costal cells fuscous with microtrichia covering second costal cell and outer ½ of first cell; abdominal tergum III black, terga IV–V orange-brown with 2 broad lateral and 1 broad medial longitudinal black bands.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.1 mm. Frons narrowing slightly posteriorly, length 1.6 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered with short dark setae; orbital bristles black: 1 s.or., 2 i.or. (some specimens have a pair of reduced i.or. bristles between the 2 larger i.or.); lunule dark fulvous, large and smooth in texture. Ocellar triangle black. Vertex fuscous. Face dark fulvous with a pair of large, irregularly oval, black facial spots; length of face 0.35 mm. Genae dark fulvous, large dark fuscous subocular spot present; black bristle present. Occiput dark fuscous, yellow along eye margins; occipital row with a large number of small dark bristles. Antennae with segment 1 fuscous, segments 2 and 3 dark fuscous; a pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.37 mm; 0.40 mm; 0.78 mm.

Thorax mesonotum black. Pleural areas black with small areas of dark fuscous below humeral calli and above mid coxae. Yellow markings as follows: humeral calli (except fuscous on anterior margins); notopleural calli; a triangle extending along anterior margin of mesonotal suture from notopleural callus; mesopleural stripe of medium width, extending almost to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅔ lower hypopleural calli (posterior ⅓ and ventral margins black); lateral and medial postsutural vittae absent. Postnotum black. Scutellum yellow with a narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs coxae dark fuscous; fore femora fuscous, mid femora dark fuscous to black, hind femora fulvous with apical ⅓ dark fuscous; fore tibiae fuscous, mid and hind tibiae dark fuscous; tarsi fulvous; fore femora with a few long black setae

on dorsal surface; mid tibiae each with an apical black spur.

Wings length 4.6 mm; costal cells fuscous, microtrichia covering all of second and outer ½ of first costal cells; remainder of wings colourless except for dark fuscous subcostal cell, broad dark fuscous costal band confluent with R_{4+5} and ending just beyond extremity of R_{4+5}; anal streak absent; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate, terga fused; pecten present on tergum III; tergum I long and narrow; sterna I and II longer than wide. Tergum I black except for a narrow transverse orange-brown band across posterior margin; tergum II black except for orange-brown transverse spots on posterior margin each side of the medial longitudinal black band; tergum III black, terga IV–V orange-brown except for 2 broad lateral longitudinal black bands meeting along anterior margin of tergum IV and ending at posterior margin of tergum V and a broad medial longitudinal black vitta narrowing to end just before posterior margin of tergum V. A pair of oval shining spots on tergum V. Posterior lobe of surstylus 6 times length of anterior lobe, sternum V with posterior margin straight.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, dorsoventrally flattened and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.38:1. Apex of piercer needle shaped with 4 pairs of very short subapical bristles (Fig. 411). Spicules at distal end of middle segment with a small number of very large thick dentations, 1 always much larger (Fig. 412).

ATTRACTANT: No known record.

COMMENTS

D. impar is similar to *D. melanohumeralis* in possessing a black mesonotum and a scutellum of uniformly pale colouration but differs from this species in having the humeral calli mostly yellow and hind femora fulvous with apical ⅓ dark fuscous.

Dacus (Callantra) mayi (Drew), n. comb. (Fig. 413)

Not *Dacus mayi* Hardy, 1951: 161–2.
Callantra mayi Drew, 1972b: 187–8.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.6984) in QM.

DISTRIBUTION

Known only from Morobe Province (type locality, Wau), Papua New Guinea.

DIAGNOSIS

Large species; face with medium sized oval black spots; humeral calli brown; notopleural calli yellow; mesonotum dull black, lateral and medial postsutural vittae absent, mesopleural stripe narrow, equal in width to notopleural callus, yellow triangle extending along anterior margin of mesonotal suture, scutellum yellow with a broad dark fuscous triangle on dorsal surface; bristles: sc. 2, prsc. absent, sa. 1; wing with a broad fuscous costal band and broad fulvous anal streak, costal cells fulvous with dense microtrichia covering both cells; abdominal terga III–V dull black except for a dark red-brown band along posterior margin of tergum V and a medial longitudinal red-brown band on tergum V, posterior lobe of surstylus short, abdominal sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

D. mayi was described adequately by Drew (1972b). It is similar to *D. discors* but differs from this species in lacking a medial postsutural vitta on the mesonotum. Although the name *mayi* has been used in *Dacus* by Hardy (1951) no replacement name is required for *D. mayi* (Drew), according to Article 59c of the International Code of Zoological Nomenclature, as these two taxa are not considered congeneric.

Dacus (Callantra) melanohumeralis, n. sp. (Fig. 414)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central District: Hombrom Bluff, attracted to methyl eugenol, 16–24.xi.1973, Entomology Staff.

LOCATION OF TYPE: Holotype (T.10456) in QM.

DISTRIBUTION

Known only from Hombrom Bluff, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with a pair of large black spots; humeral calli fuscous; notopleural calli

yellow; mesonotum black, lateral and medial postsutural vittae absent, mesopleural stripe narrow, just wider than notopleural callus, yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow with a narrow dark basal band; wing with a broad dark fuscous costal band, anal streak absent, costal cells fuscous with microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown with 2 broad lateral and 1 broad medial longitudinal black bands.

DESCRIPTION

MALE: Head generally dark fulvous. Vertical length 1.58 mm. Frons narrowing slightly posteriorly, length 1.63 times breadth; dark fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered with short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous, large and smooth in texture. Ocellar triangle black. Vertex fuscous. Face dark fulvous to fuscous with a pair of large irregularly oval, black facial spots; length of face 0.45 mm. Genae fuscous, black subocular spot present; black bristle present. Occiput fuscous laterally, dark fulvous centrally, fulvous along eye margins; occipital row with 5–7 large dark bristles. Antennae with segments 1 and 2 fuscous, segment 3 missing; a pale dorsal bristle on segment 2; length of segments: 0.46 mm; 0.51 mm.

Thorax mesonotum black. Pleural areas black except dark fuscous below humeral calli and above mid coxae. Yellow markings as follows: notopleural calli; a triangle extending along anterior margin of mesonotal suture from notopleural callus; narrow mesopleural stripe just wider than notopleural callus dorsally, anterior margin straight; upper hypopleural calli (posterior apices black); anterodorsal spot on lower hypopleural calli (remainder black). Lateral and medial postsutural vittae absent. Humeral calli fuscous. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 5; all bristles well developed and black.

Legs all coxae and fore and hind femora fuscous to dark fuscous; mid femora dark fuscous; fore tibiae fuscous, mid and hind tibiae fuscous to dark fuscous; tarsi fulvous; mid tibiae each with an apical black spur; fore femora with a row of long dark setae on dorsal surface.

Wings length 6.0 mm; costal cells fuscous, microtrichia covering second and outer ½ of first costal cells; remainder of wing colourless except for a dark fuscous subcostal cell, broad dark fuscous costal band confluent with R_{4+5} and ending between extremities of R_{4+5} and M; anal streak absent; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate; terga fused; pecten present on tergum III; tergum I long and narrow; sterna I and II longer than wide. Tergum I black except for a narrow transverse orange-brown band across posterior margin; tergum II black except for large transverse orange-brown spots on posterior margin each side of a medial longitudinal black band; terga III–V orange-brown except for 2 broad lateral longitudinal black bands which join along anterior margin of tergum III and run over all 3 terga and a broad medial longitudinal black band running from tergum III to end just before posterior margin of tergum V. A pair of oval shining spots on tergum V. Posterior lobe of surstylus of medium length, sternum V with posterior margin straight.

ATTRACTANT: Methyl eugenol.

COMMENTS

D. melanohumeralis is similar to *D. impar* in having a black mesonotum and a scutellum of uniformly pale colouration but differs from this species in possessing fuscous humeral calli and hind femora fuscous to dark fuscous.

Dacus (Callantra) petioliforma
(May), n. comb. (Figs 415–418)

Callantra petioliforma May, 1955: 151–3; May, 1962a: 63.

MATERIAL EXAMINED

Holotype ♂, Rockhampton, Queensland, iv.1955, T. Passlow; 1 ♂ paratype in DPI, Ayr, north Queensland, 30.viii.1955, A.W.S. May; 1 ♀ in QM labelled "allotype, Lawes, v.1955".

LOCATION OF TYPE: Holotype (T.5308) in QM.

DISTRIBUTION

Known from coastal areas of Queensland, north of Rockhampton; type locality, Rockhampton.

DIAGNOSIS

Large species; face with small elongate black spots connected by a transverse black band across ventral margin; humeral and notopleural calli yellow; mesonotum fuscous with longitudinal dark fuscous bands, lateral and medial postsutural vittae absent, mesopleural stripe narrow, slightly wider than notopleural callus, a small oval yellowish spot in centre of mesonotum, yellow triangle extending from notopleural callus along anterior margin of

mesonotal suture, scutellum yellow; wing with a broad fuscous costal band and narrow fuscous anal streak, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V dark fuscous except for 2 orange-brown spots on posterior margins of terga IV and V either side of a medial longitudinal dark fuscous to black band.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 2.2 mm. Frons narrowing slightly posteriorly, length 1.17 times breadth; fulvous with fuscous on anteromedial hump, latter covered by a small number of short dark setae; 2 large black spots on the lateroventral margins of the frons, lateral to the antennae; orbital bristles red-brown: 1 s.or.; i.or. absent; lunule fulvous. Ocellar triangle black. Vertex with black spots either side of ocellar triangle. Face fulvous with small elongate black spots connected by a narrow transverse black band across ventral margin; length of face 0.68 mm. Genae fulvous, dark fuscous subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 pale fuscous; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.50 mm; 0.60 mm; 1.28 mm.

Thorax mesonotum fuscous except for a medial longitudinal dark fuscous band which is broader at the posterior margin and 2 very narrow lateral longitudinal dark fuscous bands. Pleural areas dark fuscous except red-brown above mid coxae and below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; narrow mesopleural stripe, slightly wider than notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; anterior corner of upper hypopleural calli (remainder dark fuscous); anterior ¾ lower hypopleural calli (remainder dark fuscous); a small oval yellowish spot in mid-line of mesonotum, slightly posterior of the centre point; yellow triangle extending from notopleural callus along anterior margin of mesonotal suture. Lateral postsutural vittae absent. Postnotum dark fuscous. Scutellum yellow except for narrow fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. a variable number of small bristles; bristles generally well developed and black except sa. and upper pa. weak.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; femora entirely fuscous; tibiae pale fuscous; all tarsal segments fulvous; mid tibiae each with an apical black spur; 2–3 strong black spines on anteroventral surface of fore femora.

Wings length 8.7 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint except fuscous subcostal cell, broad fuscous costal band confluent with M except beyond r–m crossvein; no dark coloured anal streak; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate; terga fused; pecten present on tergum III. Tergum I and sterna I and II longer than wide. Tergum I orange-brown; tergum II dark fuscous except for a narrow transverse fulvous band across posterior margin but not reaching lateral margins; tergum III dark fuscous; terga IV and V dark fuscous except for 2 orange-brown spots on posterior margins either side of a medial longitudinal dark fuscous to black band. A pair of oval dark fuscous shining spots on tergum V. Posterior lobe of surstylus short, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, cylindrical and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.71:1. Apex of piercer laterally compressed with several keels and very short subapical bristles (Figs 416, 417). Spicules at distal end of middle segment flat with 7–9 irregularly sized broad dentations (Fig. 418).

ATTRACTANT: No known record.

COMMENTS

D. petioliforma is similar to *D. capillaris* (Drew) and *D. smieroides* (Walker) in having the costal band overlapping R_{4+5} and the mesonotum basically red-brown or fuscous with fuscous to dark fuscous patterns. It differs from these 2 species in having a row of 3–4 black spines on the ventral surface of the fore femora and black spots on the eye margins level with the base of each antenna. In the description above, the following characters differ from May (1955) (original characters in brackets): humeral calli yellow (humeral calli pale brown); scutellum yellow with narrow fuscous basal band (scutellum yellow with a semicircular brown area covering basal ½); costal band confluent with M from base of wing to r–m crossvein (costal band not confluent with M). Originally May (1955) designated only the male holotype and one male paratype. A female (in QM) designated allotype by May (1962a) is not a type

as it was not in the original series. May (1955) stated that the paratype in DPI was collected by G.W. Saunders, but the label reads A.W.S. May.

Dacus (Callantra) pusillus (May), n. comb. (Fig. 419)

Callantra pusilla May, 1965: 58–61.
Not *Dacus pusillus* Hardy, 1983: 18–20.

MATERIAL EXAMINED
Holotype ♂; 6 ♂ paratypes in DPI, Kuranda, north Queensland, Feb., Apr., May 1964, R. Grattidge; a series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype (T.6307) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: North Queensland (type locality, Kuranda).
NEW RECORDS: Torres Strait islands: Thursday, Yam (records from Plant Quarantine Survey).

DIAGNOSIS
Small species; large oval black facial spots present; humeral calli brown; notopleural calli yellow; mesonotum red-brown to fuscous with irregularly shaped lateral longitudinal black bands, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral and medial postsutural vittae absent; scutellum yellow to red-brown; wing with a broad fuscous costal band, anal streak absent, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V orange-brown except for a moderately broad medial and 2 broad lateral longitudinal black bands over all 3 terga.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.81 times breadth; fulvous with pale fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of small dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with large oval black spots; length of face 0.43 mm. Genae fulvous, brown subocular spot present; black bristle present. Occiput red-brown, yellow along eye margins; occipital row with 6–8 weak dark bristles. Antennae with segments 1 and 2 fulvous, segemnt 3 fuscous; a weak fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments; 0.45 mm; 0.48 mm; 0.90 mm.

Thorax mesonotum red-brown to fuscous except for 2 irregularly shaped lateral longitudinal black patterns. Pleural areas black except red-brown above mid coxae and below humeral calli. Yellow markings as follows: notopleural calli; medium sized mesopleural stripe, ending midway between anterior margin of notopleural callus and anterior npl. bristle, continuing to sternopleuron as a large transverse spot, anterior margin straight; upper hypopleural calli (posterior apices black); anterior ⅓ lower hypopleural calli (remainder black). Humeral calli brown. Lateral and medial postsutural vittae absent. Postnotum black. Scutellum either yellow or red-brown. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; fore and mid femora pale fuscous, hind femora with basal ½ fulvous and apical ½ fuscous; fore and mid tibiae pale fuscous, hind tibiae fuscous; all tarsal segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.2 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band confluent with R_{4+5} and ending just beyond extremity of this vein; no dark coloured anal streak; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate; terga fused; pecten present on tergum III. Tergum I and sterna I and II longer than wide. Tergum I fuscous except for a medial longitudinal elongate black spot on posterior ½; orange-brown along intersegmental line betweeen terga I and II; tergum II fulvous except for a broad transverse black band across anterior ½ and widening to cover lateral margins and a broad medial longitudinal black band; terga III–V orange-brown except for 2 broad lateral longitudinal black bands and an irregular medium to broad medial longitudinal black band over all 3 terga (these bands are connected along anterior ½ of tergum III). A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.
ATTRACTANT: Methyl eugenol.

COMMENTS
D. pusillus is similar to *D. capillaris* (Drew), *D. smieroides* (Walker) and *D. petioliforma* (May) in having the mesonotum red-brown or fuscous with a pattern of darker markings but differs from these species in being very small and having the costal band confluent with R_{4+5} (not overlapping this vein).

In the description above the following characters

differ from May (1965) (original characters in brackets): humeral calli brown (humeral calli yellow); scutellum either yellow or red-brown (scutellum red-brown).

Dacus (Callantra) smieroides (Walker)
(Fig. 420)

Callantra smieroides Walker, 1860: 154; Bezzi, 1916: 120 (as *smicroides*, lapsus); Hardy and Adachi, 1954: 151–2; Drew, 1973: 2–6.
Dacus (*Callantra*) *smieroides*: Malloch, 1939b: 411–2.

MATERIAL EXAMINED

One ♂ labelled "type", Makassar, Celebes, A.R. Wallace; 1 ♂ and 1 ♀, bred ex *Luffa acutangula*, Tamparuli, Borneo, Jan. 1951, F. Skinner; 1 ♂, bred ex *Luffa acutangula*, Lumapu Agriculture Station, Brunei, 7.ix.1981, coll. Asman. All specimens on loan from BMNH.
LOCATION OF TYPE: 1 ♂ labelled "type" in BMNH (not a type, see COMMENTS).

DISTRIBUTION

Known from Borneo (now composed of Sabah, Sarawak, Brunei and Kalimantan) and Makassar (type locality), Sulawesi (formerly Celebes).

DIAGNOSIS

Large species; face with medium sized circular to subquadrate black spots; humeral calli yellow (posterodorsal corners tending fuscous in some specimens); notopleural calli yellow; mesonotum uniformly red-brown without dark markings, lateral and medial postsutural vittae absent, mesopleural stripe narrow, slightly wider than notopleural callus, yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow with broad fuscous basal band; wing with a broad fuscous costal band, anal streak absent, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V dark fuscous to black except for a large orange-brown spot posterocentrally on tergum IV and a medial longitudinal orange-brown band expanding along posterior margin of tergum V, abdomen extremely petiolate.

DESCRIPTION

MALE: Head generally dark fulvous. Vertical length 2.1 mm. Frons of even width, length 1.18 times breadth; dark fulvous with fuscous across lower margin and extending upwards to lateral margins; orbital bristles fuscous to black: 1 s.or.; i.or. absent; lunule dark fulvous. Ocellar triangle dark fulvous. Vertex dark fulvous. Face dark fulvous with medium sized circular to subquadrate black spots; length of face 0.7 mm. + Genae dark fulvous, dark fuscous subocular spot present; black bristle present. Occiput pale fuscous, dark fulvous along eye margins; occipital row with a large number of well developed black bristles. Antennae with segments 1 and 2 dark fulvous (fuscous laterally), segment 3 fuscous; a strong red-brown dorsal bristle on segment 2; arista black (dark fulvous basally); length of segments: 0.48 mm; 0.48 mm; 1.40 mm.

Thorax mesonotum uniformly red-brown without dark markings. Pleural areas dark fulvous except pale fuscous to fuscous anterior and posterior to mesopleural stripe. Yellow markings as follows: humeral calli (posterodorsal corners tending fuscous in some specimens); notopleural calli; narrow mesopleural stripe slightly wider than notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; entire lower hypopleural calli; a yellow triangle extending from notopleural callus along anterior margin of mesonotal suture. Upper hypopleural calli entirely fuscous. Lateral and medial postsutural vittae absent. Postnotum fuscous. Scutellum yellow except for a broad fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 3; bristles generally well developed and black.

Legs fore and hind coxae dark fuscous, mid coxae dark fulvous; all femora fuscous to dark fuscous except mid femora fulvous on basal 1/5; all tibiae fuscous to dark fuscous; fore tarsi fuscous, mid and hind tarsi fulvous; mid tibiae each with an apical black spur.

Wings length 8.1 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band overlapping R_{4+5}; no dark coloured anal streak; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and extremely petiolate; terga fused; pecten present on tergum III. Tergum I ca. 2.5 times longer than wide; sterna I and II longer than wide. Tergum I dark red-brown with fuscous along anterior margin and posteriorly; fulvous along intersegmental line between terga I and II; tergum II red-brown with dark fuscous to black anteriorly and along lateral margins, fulvous along posterior margin; tergum III dark fuscous to black; tergum IV dark fuscous to black except for a large orange-brown spot posterocentrally; tergum V dark fuscous to black along anterior and lateral margins and with an orange-brown medial longitudinal band which expands posteriorly to cover posterior margin. A pair of oval dark fuscous to black shining spots

on tergum V. Posterior lobe of surstylus short, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

A description attributed to *D. smieroides* by Drew (1973) is *D. axanus* (see comments on *D. axanus*). These species are similar in the general colour patterns of the thorax, wing and abdomen. *D. smieroides* differs in having a much more petiolate abdomen, mesonotum red-brown without dark markings, abdominal terga III–V with dark fuscous to black patterns and with a dark fuscous to black band along anterior margin of tergum V dividing the central orange-brown marking.

Since Walker (1860) based his description of *C. smieroides* on a female, the male in BMNH should not be regarded as a type (see COMMENTS under *B. curvifera*).

Dacus (Callantra) solomonensis Malloch (Fig. 421)

Dacus (*Callantra*) *solomonensis* Malloch, 1939a: 236–8.
Callantra solomonensis: Drew, 1973: 6–8.

MATERIAL EXAMINED

A series of specimens in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♀ in BMNH.

DISTRIBUTION

Known from Bougainville I. and the Solomon Islands (type locality, Lunga, Guadalcanal I.)

DIAGNOSIS

Large species; face with a pair of large oval black spots; humeral calli yellow to yellow-brown; notopleural calli yellow; mesonotum dark fuscous with a large irregular red-brown area on posterior region, lateral and medial postsutural vittae absent, mesopleural stripe of medium width (extending midway between anterior margin of notopleural callus and anterior npl. bristle), yellow triangle extending along anterior margin of mesonotal suture, scutellum usually red-brown; bristles: sc. 2, prsc. absent, sa. 1; wing with a broad fuscous costal band and broad fulvous anal streak, costal cells orange-brown with dense microtrichia covering both cells; abdominal terga III and IV dull black with orange-brown along posterior margins and tergum V dark fuscous to dull black except for orange-brown medially and along posterior margin, posterior lobe of surstylus short, abdominal sternum V with a slight concavity on posterior margin.

HOST PLANTS

NEW RECORDS: Tenaru F.E.S., Guadalcanal I., Solomon Is, April 1987, C. Williams, bred ex cucumber; Kakabona Village, Guadalcanal I., August 1987, C. Williams, bred ex pumpkin.

ATTRACTANT: Cue lure.

COMMENTS

D. solomonensis was described adequately by Drew (1973) and is distinct from all other *Callantra* in possessing a large hump on abdominal tergum V.

Dacus (Callantra) unicolor (Hendel), n. comb.

Callantra unicolor Hendel, 1927b: 58–9; Drew, 1973: 8.

MATERIAL EXAMINED

None.

LOCATION OF TYPE: The holotype ♂ was placed in the Hamburg Museum, Germany and lost when this museum was destroyed by fire in 1943.

DISTRIBUTION

New Britain (type locality).

ATTRACTANT: No known record.

COMMENTS

The status of this species cannot be determined as the type has been lost (Drew, 1973) and no additional material collected. Also the original description is not satisfactory for an accurate definition of the species. Drew (1973) suggested that *D. unicolor* may be a synonym of *D. smieroides* (Walker). It now appears that the species in New Britain referred to as *D. smieroides* (Drew, 1973) is actually *D. axanus*.

KEY TO SPECIES OF SUBGENUS *CALLANTRA* (excluding *D. unicolor*)

1. Abdominal tergum V with a large hump protruding dorsally .....*solomonensis*
   Abdominal tergum V without a hump protruding dorsally 2
2(1). Scutellum with a broad dark fuscous to black triangle on dorsal surface 3
   Scutellum uniformly yellow, yellow-brown or red-brown 4
3(2). Medial postsutural yellow vitta present on mesonotum .....*discors*
   Medial postsutural yellow vitta absent on mesonotum .....*mayi*
4(2). Mesonotum black without paler markings 5
   Mesonotum mostly red-brown or fuscous with a pattern of dark markings 6

5(4). Humeral calli fuscous; hind femora fuscous to dark fuscous .....*melanohumeralis*
Humeral calli mostly yellow; hind femora fulvous with apical ⅓ dark fuscous .. ..*impar*

6(4). Costal band confluent with R_{4+5}; mesonotum red-brown with black markings ..... *pusillus*
Costal band overlapping R_{4+5}; mesonotum red-brown or fuscous with fuscous to dark fuscous patterns 7

7(6). Abdomen strongly petiolate (tergum I with length ca. 2.5 times width) 8
Abdomen not strongly petiolate (tergum I with length ca. 1.2 times width) 9

8(7). A row of 3–4 strong black spines on ventral surfaces of fore femora; a black spot on each eye margin level with base of antenna; facial spots elongate ....*petioliforma*
No spines on ventral surfaces of fore femora; no black spots on eye margins; facial spots circular or subquadrate .....*smieroides*

9(7). Mesonotum with a pattern of small fuscous markings; scutellum red-brown to dark red-brown or brown; humeral callus yellow, red-brown or brown; wing with a very broad fulvous costal band overlapping R_{4+5} and darkening to fuscous beyond r–m crossvein; abdominal terga orange-brown with no dark markings .....*capillaris*
Mesonotum with a pattern of large, longitudinal fuscous bands; scutellum yellow, yellow-brown or red-brown; humeral callus yellow to yellow-brown; wing with a very broad fuscous costal band overlapping R_{4+5} and not darkened beyond r–m crossvein; abdominal terga I and II orange-brown with a fuscous tinge, terga III–V fuscous with orange-brown along posterior and lateral margins and with a large medial orange-brown spot across intersegmental line between terga IV and V .....*axanus*

Subgenus **Dacus** Fabricius

Dacus (Dacus) absonifacies (May)
(Figs 422, 423)

Polistomimetes absonifacies May, 1955: 156–8.
Dacus absonifacies: May, 1963: 41–2, 49.

MATERIAL EXAMINED

AUSTRALIA, Queensland: holotype ♂; 3 ♂ paratypes (ex lure in citrus), Stanthorpe, 21.x.1953; 1 ♂ paratype, (ex lure in avocado), Brisbane, 5.x.1953; 1 ♀ paratype (bred from *Marsdenia rostrata*), Mt Glorious, Dec. 1952; 1 ♀ paratype (ex lure in citrus), Gatton, Sept. 1951; all paratypes in DPI collected by A.W.S. May.

LOCATION OF TYPE: Holotype (T.5305) in QM.

DISTRIBUTION

Known only from south-east Queensland where it is common at high altitudes; type locality, Stanthorpe.

DIAGNOSIS

Medium sized species; large elongate black facial spots present; humeral calli fuscous; notopleural calli yellow; mesonotum fuscous, mesopleural stripe narrow, equal in width to notopleural callus, lateral and medial postsutural vittae absent, scutellum yellow; wing with a broad fuscous costal band (confluent with M and broad fuscous anal streak, costal cells fuscous with dense microtrichia covering both cells; abdominal terga III–V generally fuscous except for narrow longitudinal pale fuscous to orange-brown bands each side of a moderately broad medial longitudinal fuscous band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.7 mm. Frons narrowing slightly posteriorly, length 1.33 times breadth; fulvous with, at most, pale fuscous around i.or. bristles; anteromedial hump with just a few short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex dark fuscous. Face fulvous with large elongate black spots ⅔ the length of the antennal furrow; length of face 0.6 mm. Genae fulvous, pale fuscous subocular spot present; fuscous bristle present. Occiput fuscous, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.15 mm; 0.35 mm; 0.85 mm.

Thorax mesonotum fuscous with often a blotched pattern due to sites of attachment of dorsoventral flight muscles. Pleural areas dark fuscous except paler below humeral calli. Yellow markings as follows: notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; a

triangular mark along anterior margin of mesonotal suture with base on notopleural calli; upper hypopleural calli (posterior apices dark fuscous); anterior ⅓ lower hypopleural calli (remainder dark fuscous). Lateral and medial postsutural vittae absent. Humeral calli fuscous. Postnotum dark fuscous. Scutellum yellow except for broad fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae dark fuscous; fore and mid femora fuscous, apical ⅓ hind femora fuscous (remainder fulvous); all tibiae fuscous; all tarsal segments fulvous; mid tibiae each with an apical black spur.

Wings length 5.9 mm; costal cells fuscous; dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint, except fuscous subcostal cell, broad fuscous costal band confluent with M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten present on tergum III. Tergum I and sterna I and II as wide as long. Tergum 1 fuscous; tergum II fuscous except for a narrow transverse fulvous spot along posterior margin each side of mid-line; terga III–V fuscous except for narrow longitudinal bands either side of a moderately broad medial longitudinal fuscous band (these lateral bands are pale fuscous on tergum III and orange-brown on terga IV and V). A pair of oval orange-brown shining spots on tergum V. The medial longitudinal fuscous band generally extends onto tergum II. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, cylindrical and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 1:1. Apex of piercer laterally compressed. Spicules at distal end of middle segment with a small number of very large thick dentations, 1 always much larger (Fig. 423).

ATTRACTANT: Cue lure.

COMMENTS

D. absonifacies from all other South Pacific species of the subgenus *Dacus* in possessing a very broad costal band which is confluent with M for its entire length and in having fuscous humeral calli.

Dacus (Dacus) alarifumidus, n. sp.
(Fig. 424)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute, attracted to cue lure, 15.vi.1980, R.A.I. Drew and D.W. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Wau Ecology Institute, 15.vi.1980, R.A.I. Drew and D.W. Currey; 1 ♂, Namie Creek (1600 m) and 1 ♂, Pitpit Gully (1550 m), Mt Kaindi, 1.xii.1980, A. Allison; 3 ♂♂, Pitpit Gully (1550 m) and 2 ♂♂, Barker Plantation (1750 m), Mt Kaindi, 15.xii.1980, A. Allison; 1 ♂, Car Park (1350 m), Mt Missim, 15.xii.1980, A. Allison; 1 ♂, Watut Village (1500 m), 1 ♂, Namie Creek (1650 m), 5 ♂♂, Pitpit Gully (1550 m); 9 ♂♂, Kunai Creek (1450 m), Mt Kaindi, 29.xii.1980, A. Allison. All attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10457) and 1 paratype (T.10458) in QM; 4 paratypes in ANIC; 4 paratypes in BMNH; 1 paratype in DPI(PNG); 15 paratypes in DPI.

DISTRIBUTION

Known only from the Wau area, Papua New Guinea.

DIAGNOSIS

Medium sized species; face with a pair of large irregularly shaped black spots; humeral and notopleural calli yellow; mesonotum dark fuscous (tending red-brown along lateral margins), lateral postsutural vittae absent, medial postsutural vitta present, mesopleural stripe narrow (just wider than notopleural callus), yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow with a narrow dark basal band; wing with a general fuscous tint, a broad dark fuscous costal band and anal streak, costal cells fuscous with microtrichia covering both cells; abdominal terga III–V orange-brown with 2 broad lateral and 1 broad medial longitudinal black bands.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.43 mm. Frons narrowing slightly posteriorly, length 1.29 times breadth; fulvous with dark fuscous to black around orbital bristles and fuscous on anteromedial hump; latter covered with short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule dark fulvous to fuscous. Ocellar triangle black. Vertex dark fuscous to black. Face fulvous with large irregularly oval black facial spots reaching epistoma; length of face 0.43 mm. Genae fulvous, large black subocular spot present; black bristle present. Occiput dark fuscous, fulvous along eye margins; occipital row with a large number of small pale bristles. Antennae with

segments 1 and 2 dark fulvous, segment 3 fulvous with dark fuscous to black on apex and outer surface; a fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.24 mm; 0.32 mm; 0.84 mm.

Thorax mesonotum dark fuscous, tending red-brown along lateral margins. Pleural areas dark fuscous except fuscous below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; a triangle extending along anterior margin of mesonotal suture from notopleural callus; narrow mesopleural stripe just wider than notopleural callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices dark fuscous to black); anterior 3/5 lower hypopleural calli (remainder dark fuscous to black); a medial longitudinal postsutural vitta, from level of lower pa. bristles to level of mesonotal suture. Lateral postsutural vittae absent. Postnotum dark fuscous. Scutellum yellow with a narrow fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent in holotype, present but weak in paratype; mpl. 1; npl. 2; scp. 2–4; all bristles well developed and black except sa. and some scp.

Legs coxae dark fuscous; fore femora fuscous to dark fuscous, mid femora dark fuscous, hind femora with basal ½ fulvous and apical ½ dark fuscous; fore and mid tibiae fulvous, hind tibiae fuscous; tarsi fulvous; mid tibiae each with an apical black spur; fore femora with rows of long pale setae on dorsal surfaces.

Wings length 5.7 mm; costal cells fuscous, microtrichia covering both costal cells; remainder of wings with a fuscous tint, becoming paler towards wing base, a dark fuscous subcostal cell, a broad dark fuscous costal band confluent with R_{4+5} and merging with the fuscous tint across the wing, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate-oval to clavate but not strongly petiolate; terga fused; pecten present on tergum III; tergum I as long as it is wide; sterna I and II longer than wide. Terga covered with a dense golden pubescence. Tergum I black except for small transverse orange-brown spots on posterior margin each side of a medial longitudinal black band; tergum II black except for large transverse orange-brown spots posteriorly each side of a medial longitudinal black band; terga III–V orange-brown with 2 broad lateral longitudinal black bands joining on tergum III and extending over all 3 terga, and a broad medial longitudinal black band running from base of tergum III to end just before posterior margin of tergum V. A pair of oval shining spots on tergum V. Posterior lobe of surstylus short, sternum V with posterior margin straight.

ATTRACTANT: Cue lure.

COMMENTS

D. alarifumidus is similar to *D. badius* and *D. concolor* in possessing a medial postsutural yellow vitta on the mesonotum and a broad costal band of uniform width. It differs from these species in having a dark fuscous mesonotum, abdominal terga with medial and lateral longitudinal black bands, humeral calli entirely yellow and a narrow mesopleural stripe equal in width to notopleural callus.

Dacus (Dacus) alulapictus, n. sp.
(Fig. 425)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Stony logging area, Bulolo, collected under leaf of *Musa* sp., 3.viii.1979, H. Ivagai.

Paratype ♂, PAPUA NEW GUINEA, Morobe Province: Robbies Creek, Bulolo, collected under leaf of *Musa* sp., 26.vii.1979, H. Ivagai.

LOCATION OF TYPES: Holotype (T.10459) in QM; paratype in DPI.

DISTRIBUTION

Known only from the Bulolo area, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with large oval black spots; humeral and notopleural calli yellow; mesonotum red-brown to pale fuscous with a mottled appearance, medial longitudinal postsutural vitta present, lateral postsutural vittae absent, mesopleural stripe broad reaching humeral callus, a triangular yellow marking along anterior margin of mesonotal suture, scutellum yellow with a broad triangular pale fuscous marking; wing with a dark fuscous costal band which expands into a large dark fuscous spot covering apical ⅓ of wing and a narrow transverse dark fuscous band across wing, costal cells colourless, microtrichia around outer and anterior margins of second cell only; abdominal terga I–IV orange-brown and tergum V dark fuscous to black.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.78 mm. Frons narrowing slightly posteriorly, length 1.41 times breadth; fulvous with dark fuscous around orbital bristles and fuscous on

anteromedial hump; latter covered by a large number of short dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex fuscous. Face fulvous with large oval black spots almost reaching to epistoma; length of face 0.63 mm. Genae fulvous, large dark fuscous to black spot present; black bristle present. Occiput pale fuscous, yellow along eye margins; occipital row with 4–7 well developed black bristles and a large number of smaller dark bristles. Antennae with segments 1 and 2 pale fuscous, segment 3 fuscous except fulvous on inner basal surface; a pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.35 mm; 0.40 mm; 1.18 mm.

Thorax mesonotum red-brown to pale fuscous with a mottled appearance resulting from sites of attachment of the dorsoventral flight muscles. Pleural areas red-brown to pale fuscous. Yellow markings as follows: humeral calli; notopleural calli; a broad mesopleural stripe reaching humeral callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly concave; a triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of suture; a short narrow medial longitudinal postsutural vitta rounded posteriorly and narrowing to a point anteriorly; upper hypopleural calli (posterior apices red-brown to pale fuscous); anterior ⅔ lower hypopleural calli (remainder red-brown to pale fuscous). Lateral postsutural vittae absent. Postnotum red-brown to pale fuscous. Scutellum yellow with a broad triangular pale fuscous pattern on dorsal surface. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae fuscous, mid and hind coxae pale fuscous: all femora, tibiae and tarsi fulvous; fore femora with a row of long pale setae on dorsal surface; mid tibiae each with an apical black spur.

Wings length 7.0 mm; costal cells colourless, microtrichia adjacent to outer and anterior margins of second cell only; remainder of wings colourless except for a dark fuscous costal band which expands into a large dark fuscous spot across apical ⅓ of wing, a narrow dark fuscous transverse band across wing enclosing r–m crossvein and posterior ½ of dm–cu crossvein; anal streak absent but with pale fuscous in anal cell extension; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten present on tergum III. Tergum I wider than long; sterna I and II slightly longer than wide. Terga I–IV orange-brown without dark markings; tergum V dark fuscous anteriorly and black posteriorly. Oval shining spots on tergum V not visible. Posterior lobe of surstylus of medium length, sternum V with a slight concavity on posterior margin.

ATTRACTANT: No known record.

COMMENTS

D. alulapictus is similar to other species of subgenus *Dacus* in having the costal band not confluent with M and humeral calli entirely or mostly yellow but differs in possessing a narrow transverse fuscous band across centre of wing, a large fuscous spot over apex of wing and a fuscous triangle on dorsal surface of scutellum.

Dacus (Dacus) badius, n. sp.
(Fig. 426)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Wau Ecology Institute (1150 m), deserted garden (Allison's), attracted to Willison's lure, 3–10.iv.1965, E.N. Marks.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Ant Plant Gully (1200 m), Mt Missim, 18.xii.1980, A. Allison; 1 ♂, Wau Ecology Institute (1230 m), 24.xi.1980, A. Allison; 1 ♂ (1200 m), 5.x.1981, 1 ♂ (1350 m), 16.ii.1981, 1 ♂ (1450 m), 7.iv.1981, 1 ♂ (1450 m), 27.iv.1981, 1 ♂ (1450 m), 14.xii.1981, 1 ♂ (1500 m), 23.xi.1981, Mt Kaindi, A. Allison; 1 ♂, Stony logging area, Bulolo, collected on leaf of ginger, 23.iii.1979, H. Ivagai. East Sepik Province: 1 ♂, Maprik, Oct.–Dec. 1957, Malaria Control Section. All paratypes except 2 attracted to cue lure.

LOCATION OF TYPES: Holotype (T.10460) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 7 paratypes in DPI.

DISTRIBUTION

Known only from Morobe and East Sepik Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with large circular black spots; humeral calli with posterior ⅔ yellow (anterior ⅓ fuscous); notopleural calli yellow; mesonotum red-brown with a mottled appearance, medial longitudinal postsutural vitta present, lateral postsutural vittae absent, mesopleural stripe broad (reaching midway between anterior npl. bristle and humeral callus), a triangular yellow marking along anterior margin of mesonotal suture, scutellum yellow; wing with a broad fuscous costal band overlapping R_{4+5}, costal cells fuscous and covered with microtrichia; abdomen with a diffuse medial longitudinal dark fuscous band over all terga and with terga III–V orange-brown with broad lateral longitudinal red-brown bands.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.68 mm. Frons narrowing slightly posteriorly, length 1.56 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump; latter covered with a small number of short dark setae; orbital bristles well developed and black: 1 s.or., 2 i.or. (3 on 1 side in holotype); lunule pale fuscous. Ocellar triangle black. Vertex fulvous. Face fulvous with large circular black facial spots not reaching epistoma; length of face 0.48 mm. Genae fulvous, large fuscous to dark fuscous subocular spot present; black bristle present. Occiput fulvous, yellow along eye margins; occipital row with a large number of pale bristles. Antennae with segments 1 and 2 pale fuscous, segment 3 fulvous except fuscous on apex and outer surface; a weak pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.38 mm; 0.48 mm; 1.05 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown to pale fuscous. Yellow markings as follows; posterior ⅔ humeral calli (anterior ⅓ fuscous); notopleural calli; broad mesopleural stripe reaching midway between anterior npl. bristle and humeral callus dorsally, extending to sternopleuron as an oval spot, anterior margin straight or slightly concave; a triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of each suture; a moderately broad medial longitudinal postsutural vitta rounded posteriorly at level of upper pa. bristles and pointed anteriorly (just anterior of mesonotal suture); upper hypopleural calli (dorsal and posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous). Lateral postsutural vittae absent. Postnotum red-brown. Scutellum yellow except for a narrow pale fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs fore coxae pale fuscous, mid and hind coxae red-brown; all femora fulvous, tending red-brown on apical ⅓; fore and hind tibiae fulvous tending pale fuscous proximally, mid tibiae fulvous; all tarsi fulvous; mid tibiae each with an apical black spur; fore femora with a row of long pale setae on dorsal surface.

Wings length 6.9 mm; costal cells fuscous, dense microtrichia covering second costal cell and most of first costal cell; remainder of wings colourless except for fuscous subcostal cell, broad fuscous costal band becoming paler as it overlaps R_{4+5}, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval, terga fused, pecten present on tergum III. Tergum I wider than long; sterna I and II slightly longer than wide. Terga I and II red-brown, tending whitish posteriorly on tergum II and with a diffuse medial longitudinal dark fuscous band on both terga; terga III–V orange-brown with broad lateral longitudinal red-brown bands and with a diffuse medial longitudinal dark fuscous band which is continuous with the black band on terga I and II. A pair of oval shining spots on tergum V. Posterior lobe of surstylus of medium length, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure; Willison's lure.

COMMENTS

D. badius is similar to *D. concolor* in possessing a red-brown mesonotum, abdominal terga of uniform pale colouration, humeral calli yellow with anterior ⅓ fuscous and mesopleural stripe extending to anterior npl. bristle. It differs from this species in having the wing membrane colourless, the costal band uniformly overlapping R_{4+5} and all femora fulvous with apices red-brown.

Dacus (Dacus) bellulus Drew and Hancock (Fig. 427)

Dacus (*Dacus*) *bellulus* Drew and Hancock, 1981: 50–1.

MATERIAL EXAMINED

A large series of specimens (including paratypes) in DPI (see DISTRIBUTION).

LOCATION OF TYPE: Holotype ♂ (T.8214) in QM.

DISTRIBUTION

PREVIOUSLY RECORDED: Coastal areas of the Northern Territory and Cape York Peninsula (type locality, near Laura), Queensland and Moa (Banks) (Torres Strait islands).

NEW RECORDS: Torres Strait islands: Badu, Boigu, Horn, Sue, Thursday, Yam, Yorke (records from Plant Quarantine Survey). Papua New Guinea: 20 km SE Port Moresby, 26.iii.1983, J.W. Ismay.

DIAGNOSIS

Small species; facial spots present in shape of small narrow vertical lines; humeral and notopleural calli yellow; mesonotum red-brown, mesopleural stripe reaching to anterior npl. bristle, lateral and medial postsutural vittae absent, yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum

yellow; wing with a narrow fuscous costal band and anal streak, costal cells fuscous with dense microtrichia covering both cells; all abdominal terga orange-brown without dark markings.
ATTRACTANT: Cue lure.

COMMENTS

D. bellulus is similar to *D. newmani* (Perkins) and *D. signatifrons* (May) in having a narrow costal band confluent with or just overlapping R_{2+3}. It differs from *D. newmani* in possessing dark facial spots, broader mesopleural stripes reaching npl. bristles and mesonotum uniformly red-brown and from *D. signatifrons* in having the facial spots small and narrow, costal band confluent with R_{2+3} and hind tibiae fulvous.

Dacus (Dacus) concolor, n. sp.
(Fig. 428)

TYPE SPECIMENS

Holotype ♂, AUSTRALIA, north Queensland: Bamaga airstrip, attracted to cue lure, 13.iv.1981, D. Currey.

Paratypes, AUSTRALIA, north Queensland: 4 ♂♂, Bamaga airstrip, attracted to cue lure, 13.iv.1981, D. Currey.
LOCATION OF TYPES: Holotype (T.10461) in QM; 1 paratype in ANIC; 3 paratypes in DPI.

DISTRIBUTION

Known only from Bamaga, Cape York, north Queensland.

DIAGNOSIS

Medium sized species; medium sized circular facial spots present; humeral calli yellow (anterior ⅓ fuscous); notopleural calli yellow; mesonotum red-brown, mesopleural stripe of medium width reaching almost to anterior npl. bristle above, lateral postsutural vittae absent, medial postsutural vitta present, a yellow triangular band along anterior margin of mesonotal suture, scutellum yellow; legs entirely fulvous; wing with a broad fuscous costal band extending as a pale tint across entire wing membrane and a broad fuscous anal streak, costal cells fuscous and covered with dense microtrichia; abdominal terga II–V fulvous except for a broad transverse dark red-brown band across anterior margin of tergum II, a narrow medial longitudinal pale fuscous band over all 4 terga and broad dark red-brown lateral longitudinal bands over terga III–V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.7 mm. Frons of even width, length 1.62 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles red-brown: 1 s.or., 2 or 3 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous with medium sized circular black spots; length of face 0.53 mm. Genae fulvous, subocular spot absent; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 4–8 well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.38 mm; 0.40 mm; 1.13 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: posterior ⅔ humeral calli (anterior ⅓ including broad ventral margin fuscous); notopleural calli; medium sized mesopleural stripe, reaching almost to anterior npl. bristle dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); a narrow medial longitudinal postsutural vitta; a yellow triangular band running along anterior margin of mesonotal suture and with base at notopleural callus. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Lateral postsutural vittae absent. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and dark fuscous.

Legs all segments fulvous without dark markings; rows of long fulvous setae on dorsal surface of fore femora; mid tibiae each with an apical black spur.

Wings length 6.4 mm; costal cells fuscous; dense microtrichia covering second costal cell and most of first costal cell; remainder of wings with a broad fuscous costal band which expands into a pale tint across the entire membrane, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten present on tergum III. Tergum I and sterna I and II wider than long. Tergum I dark red-brown; terga II–V fulvous except for a broad transverse dark red-brown band along anterior margin of tergum II and expanding to cover lateral margins of that tergum, a narrow medial longitudinal pale fuscous band over all 4 terga, broad lateral longitudinal dark red-brown bands over terga III–V. A pair of oval pale fuscous shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

D. concolor is similar to *D. badius* in possessing a red-brown mesonotum, a pale coloured abdomen without black patterns, mesopleural stripe extending to anterior npl. bristle and humeral calli yellow (except anterior ⅓ fuscous). It differs from this species in possessing a pale fuscous tint over wing membrane, costal band confluent with R_{4+5} and all femora uniformly fulvous.

Dacus (Dacus) newmani (Perkins)
(Fig. 429)

Neodacus newmani Perkins, 1937: 58–9.
Dacus newmani: May, 1963: 41, 49.

MATERIAL EXAMINED

AUSTRALIA: lectotype ♀, labelled holotype, Carnarvon, Western Australia, September 1929, I.M. Mackerras; 2 ♂ and 5 ♀ paralectotypes labelled paratype, native fruits, Carnarvon, Western Australia, 1918, Newman; a large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPES: Lectotype (T.8586) in QM; paralectotypes in UQ.

DISTRIBUTION

D. newmani is common in semi-arid regions of east, north-west (type locality, Carnarvon) and central Australia. It is distinct among the Dacinae in not occurring in the wet coastal areas. Although its host is unknown it is unlikely that the pupae could survive in soil in such hot dry localities. It probably has a behaviour similar to *D. aequalis* Coquillett pupating within the host fruit which remain on the plant.

DIAGNOSIS

Small species; facial spots absent; humeral and notopleural calli yellow; mesonotum uniformly red-brown, mesopleural stripe of medium width extending to anterior npl. bristle, lateral postsutural vittae absent, medial postsutural vitta reduced to a small elongate yellow spot, a broad yellow triangle along anterior margin of mesonotal suture with base at notopleural calli, scutellum yellow; legs fulvous with hind tibiae pale fuscous; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells fuscous (second cell paler), dense microtrichia covering both costal cells; abdominal terga uniformly red-brown.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.3 times breadth; fulvous without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous, facial spots absent; length of face 1.3 mm. Genae fulvous, small pale brown subocular spot present; black bristle present. Occiput red-brown, yellow along eye margins; occipital row with a large number of short pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong fuscous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.28 mm; 0.63 mm.

Thorax mesonotum and pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin convex; upper hypopleural calli (posterior apices red-brown); anterior 7/10 lower hypopleural calli (remainder red-brown); medial postsutural vitta reduced to a small eliptical spot; a triangular marking along anterior margin of mesonotal suture with base at notopleural calli. Lateral postsutural vittae absent. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all segments fulvous except hind tibiae pale fuscous; mid tibiae each with an apical black spur.

Wings length 4.7 mm; costal cells fuscous (second cell paler); dense microtrichia covering both costal cells; remainder of wings colourless, except fuscous subcostal cell, narrow fuscous costal band confluent with R_{2+3} and expanding beyond extremity of this vein into an irregular apical spot, broad fuscous anal streak ending before wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga fused; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga uniformly red-brown without dark markings. A pair of oval red-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment fuscous, dorsoventrally compressed and tapering posteriorly in dorsal view. Ratio of length of oviscape to length of tergum V 0.38:1.
ATTRACTANT: Cue lure.

COMMENTS

D. newmani is similar to *D. bellulus* Drew and Hancock and *D. signatifrons* (May) in possessing a narrow costal band confluent with or just overlapping R_{2+3} but differs from these species in having facial spots absent, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, mesonotum rich chocolate brown with a central elliptical yellow spot. Originally, Perkins (1937) listed collection data for the specimens studied but did not designate types. There is no doubt that the type series consisted of the specimens noted above, labelled holotype and paratypes. I designate the specimen labelled holotype as lectotype and the 7 labelled paratype as paralectotypes.

Dacus (Dacus) secamoneae, n. sp.
(Figs 430–432)

TYPE SPECIMENS

Holotype ♂, AUSTRALIA, Northern Territory: Fogg Dam, 14.vi.1985, G. Crawford.

Paratypes, AUSTRALIA, Northern Territory: 2 ♀ ♀ and 1 ♂, Fogg Dam, 14.vi.1985, G. Crawford; 1 ♀ and 1 ♂, 5.v.1976, 1 ♀, 25.iii.1976, 20 km S of Dunmarra, bred ex *Secamone elliptica*, A. Allwood; 2 ♂ ♂, Yirrkala Mission, Gove Peninsula, attracted to cue lure, 20.iv.1982, A. Allwood. LOCATION OF TYPES: Holotype (T.10462) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 5 paratypes in DPI.

DISTRIBUTION

Known only from the Northern Territory.

DIAGNOSIS

Medium sized pale coloured species; large oval facial spots present; humeral calli red-brown; notopleural calli yellow; mesonotum red-brown, lateral and medial postsutural vittae absent, mesopleural stripe narrow equal in width to notopleural callus, scutellum yellow; wing with a broad fuscous costal band expanding apically to overlap M and a narrow fuscous anal streak, costal cells fuscous, microtrichia covering both costal cells; abdominal terga III–V fulvous except for 2 broad lateral longitudinal red-brown bands and a narrow medial longitudinal pale fuscous band which meet along anterior margin of tergum III.

DESCRIPTION

FEMALE: Head generally fulvous. Vertical length 1.7 mm. Frons of even width, length 1.71. times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short black setae; orbital bristles black: 1 s.or., 2 i.or.; lunule red-brown. Ocellar triangle black. Vertex fulvous. Face fulvous with large oval black spots reaching epistoma; length of face 0.45 mm. Genae fulvous, large fuscous subocular spot present; black bristle present. Occiput fulvous; occipital row with a large number of small bristles. Antennae with segments 1 and 2 fulvous, segment 3 fuscous; a weak fulvous dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.48 mm; 0.50 mm; 1.08 mm.

Thorax mesonotum red-brown with paler markings resulting from attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: notopleural calli; narrow mesopleural stripe equal in width to notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of each suture; upper hypopleural calli (posterior apices red-brown); anterior ⅓ lower hypopleural calli (remainder red-brown). Humeral calli red-brown. Lateral and medial postsutural vittae absent. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 4; all bristles weak and black.

Legs all coxae red-brown; all other segments red-brown except basal ½ of fore femora, basal ⅔ hind femora and all tarsi fulvous; rows of long dark setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.9 mm; costal cells fuscous, microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, broad fuscous costal band which expands apically to overlap M, narrow fuscous anal streak ending before wing margin; no dense aggregation of microtrichia around $A_1 + CuA_2$, supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten on tergum III absent. Tergum I slightly wider than long; sterna I and II as wide as long. Terga I and II red-brown except for 2 transverse fulvous markings on posterior margin of tergum II. Terga III–V fulvous except for 2 broad lateral longitudinal red-brown bands which meet along anterior margin of tergum III and a very narrow medial longitudinal pale fuscous band over all 3 terga. A pair of oval fulvous shining spots on tergum V. Basal segment of ovipositor red-brown, dorsoventrally compressed and narrowing posteriorly in dorsal view; ratio of length of oviscape to length of tergum V 0.93:1; apex of piercer strongly sclerotized, red-brown, needle

shaped at its tip with 3 pairs of short subapical bristles (Fig. 431). Spicules at distal end of middle segment with irregularly shaped broad flat teeth extremely variable in size (Fig. 432).

MALE: As for female except dense aggregation of microtrichia around $A_1 + CuA_2$ present; pecten present on abdominal tergum III; posterior lobe of surstylus long; abdominal sternum V with a slight concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

D. secamoneae is similar to *D. alarifumidus*, *D. badius* and *D. concolor* in possessing a broad costal band confluent with or overlapping R_{4+5} but differs from these species in lacking a medial postsutural yellow vitta and having the costal band expanded beyond the centre of the wing to overlap M.

Dacus (Dacus) signatifrons (May)
(Fig. 433)

Neodacus signatifrons May, 1955: 155–6.
Dacus signatifrons: May, 1963: 41, 49.

MATERIAL EXAMINED

AUSTRALIA, Queensland: holotype ♂, Brisbane, 12.x.1953, A.W.S. May; large series of specimens in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype (T.5307) in QM.

DISTRIBUTION

Restricted to coastal and sand island habitats along the coast of southern Queensland; type locality, Brisbane.

DIAGNOSIS

Small to medium sized species; long narrow black facial spots present; humeral and notopleural calli yellow; mesonotum pale fuscous, mesopleural stripe reaching anterior npl. bristle, lateral and medial postsutural vittae absent, broad yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow; wing with a narrow dark fuscous costal band expanding apically and a broad fuscous anal streak, costal cells dark fuscous with dense microtrichia covering both costal cells; all abdominal terga uniformly red-brown.

DESCRIPTION

MALE: Head generally red-brown. Vertical length 1.6 mm. Frons narrowing slightly posteriorly, length 1.54 times breadth; red-brown without dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule red-brown. Ocellar triangle black. Vertex fuscous. Face fulvous with long elongate black facial spots filling most of antennal furrow; length of face 0.58 mm. Genae red-brown; black bristle present. Occiput red-brown, yellow along eye margins; occipital row with a large number of small pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.13 mm; 0.30 mm; 0.78 mm.

Thorax mesonotum pale fuscous with a mottled appearance from sites of attachment of dorsoventral flight muscles. Pleural areas pale fuscous, darker on sternopleuron and behind mesopleural stripe. Yellow markings as follows: humeral calli; notopleural calli; medium sized mesopleural stripe, reaching to anterior npl. bristle dorsally, continuing to sternopleuron as a large transverse spot, anterior margin slightly convex; upper hypopleural calli (posterior apices dark fuscous); anterior ⅔ lower hypopleural calli (remainder dark fuscous); a broad triangular marking with base on notopleural callus and running along anterior margin of mesonotal suture. Lateral and medial postsutural vittae absent. Postnotum dark fuscous. Scutellum yellow with a narrow fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. 1; mpl. 1; npl. 2; scp. 2 or 3; all bristles well developed and black.

Legs fulvous except fore and mid tibiae pale fuscous and hind tibiae fuscous; basal ½ of hind femora tending paler fulvous; mid tibiae each with an apical black spur.

Wings length 5.4 mm; costal cells dark fuscous; dense microtrichia covering both costal cells; remainder of wings colourless except dark fuscous subcostal cell, narrow dark fuscous costal band confluent with R_{2+3} and expanding beyond extremity of this vein to end between extremities of R_{4+5} and M, a broad dark fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe of medium development.

Abdomen oval; terga fused; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga uniformly red-brown. A pair of oval red-brown shining spots on tergum V. Posterior lobe of sursytlus long, sternum V with a slight concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

D. signatifrons is similar to *D. bellulus* Drew and Hancock in possessing elongate facial spots, broad

mesopleural stripe reaching anterior npl. bristle dorsally and a uniformly red-brown mesonotum. It differs from this species in having facial spots large and distinct, hind tibiae fuscous and costal band overlapping R_{2+3}.

KEY TO SPECIES OF SUBGENUS *DACUS*

1. Costal band confluent with M for entire length; humeral calli fuscous .... *absonifacies*
   Costal band not confluent with M for entire length; humeral calli yellow or mostly yellow 2
2(1). Scutellum with a fuscous triangle on dorsal surface; wing with a narrow fuscous transverse band across centre and a large fuscous spot across apex.... *alulapictus*
   Scutellum entirely yellow; wing not marked as above 3
3(2). Costal band narrow, confluent with or just overlapping R_{2+3} 4
   Costal band broad, confluent with or overlapping R_{4+5} 6
4(3). Facial spots absent; mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle; mesonotum rich chocolate brown with a central elliptical yellow spot posterior to mesonotal suture .... *newmani*
   Elongate facial spots present; mesopleural stripe broad and attaining anterior npl. bristle dorsally; mesonotum uniformly red-brown or dark brown 5
5(4). Facial spots small and narrow (occasionally absent); hind tibiae fulvous; costal band not overlapping R_{2+3} ..... *bellulus*
   Facial spots distinct and elongate, hind tibiae fulvous; costal band overlapping R_{2+3} ..... *signatifrons*
6(3). Medial postsutural vitta absent; costal band expanded beyond centre of wing to overlap M ..... *secamoneae*
   Medial postsutural vitta present; costal band of uniform width 7
7(6). Humeral calli entirely yellow; wing with membrane fuscous and costal band confluent with R_{4+5}; mesopleural stripe narrow, equal in width to notopleural callus; mesonotum dark fuscous; abdomen with a medial and 2 broad lateral longitudinal black bands joined along anterior margin of tergum III .. .. *alarifumidus*
   Humeral calli yellow except anterior ⅓ fuscous; wing membrane not generally fuscous; mesopleural stripe broad, extending to anterior npl. bristle; mesonotum red-brown; abdomen without black markings 8
8(7). Wing membrane colourless with costal band uniformly overlapping R_{4+5}; all femora fulvous with apices red-brown .... *badius*
   Wing membrane with pale fuscous tint and costal band confluent with R_{4+5}; all femora uniformly fulvous .... *concolor*

Subgenus **Didacus** Collart

Dacus (Didacus) aequalis Coquillett (Figs 434–436).

Dacus aequalis Coquillett, 1909: 794–5.
Chaetodacus aequalis: Tryon, 1927: 191–2.
Callantra aequalis: Perkins, 1934: 44; May, 1963: 40, 49.

MATERIAL EXAMINED

A large number of specimens in DPI (see DISTRIBUTION); types in NMNH.
LOCATION OF TYPES: Lectotype ♀ and paralectotype ♂ in NMNH.

DISTRIBUTION

Common along the eastern coast of Queensland and northern New South Wales, particularly associated with rainforests. Type locality, Tuggerah Lakes, New South Wales. Recently, 1 specimen was collected near Wilcannia, New South Wales, approximately 750 km from the nearest rainforest host area.

DIAGNOSIS

Large wasp-like species; facial spots large and elongate; humeral calli fuscous; notopleural calli yellow; mesonotum red-brown to fuscous with irregular blotched markings, triangular yellow markings along anterior margin of mesonotal suture, lateral and medial postsutural vittae absent, mesopleural stripe narrow equal in width to notopleural callus, scutellum yellow with a broad triangular fuscous basal band; wing with a very broad fuscous costal band (confluent with M) and anal streak, costal cells fuscous and covered with dense microtrichia; abdomen mostly fuscous with a large oval red-brown spot on centre of tergum V.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 2.0 mm. Frons narrowing slightly posteriorly, length 1.32 times breadth; fulvous with pale

fuscous around orbital bristles and on anteromedial hump, latter covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle black. Vertex pale fuscous. Face fulvous with large elongated black spots; length of face 0.68 mm. Genae fulvous, small brown subocular spot present; red-brown bristle present. Occiput red-brown, yellow along eye margins; occipital row with 6–7 weak pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with pale fuscous on apex and outer surface; a strong red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.28 mm; 0.45 mm; 1.15 mm.

Thorax mesonotum red-brown to fuscous with irregular blotched markings resulting from sites of attachment of dorsoventral flight muscles. Pleural areas pale fuscous except red-brown below humeral calli. Yellow markings as follows: notopleural calli; narrow mesopleural stripe, equal in width to notopleural callus dorsally, continuing to sternopleuron as a small transverse spot, anterior margin straight; anterior corner of upper hypopleural calli (remainder red-brown); anterior ⅔ lower hypopleural calli (remainder including broad ventral margins red-brown); a narrow triangular marking running along anterior margin of mesonotal suture with base on notopleural calli and apex at inner margin of suture. Lateral and medial postsutural vittae absent. Humeral calli fuscous. Postnotum red-brown. Scutellum yellow except for a broad triangular fuscous basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 2; bristles generally weak and fuscous.

Legs fore coxae fuscous, mid and hind coxae dark fuscous; femora fuscous to dark fuscous, tibiae fuscous, all tarsal segments fulvous; mid tibiae each with an apical black spur.

Wings length 8.1 mm; costal cell fuscous; dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint, except fuscous subcostal cell, very broad fuscous costal band confluent with M, broad fuscous anal streak which merges into pale fuscous at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate; terga fused; pecten present on tergum III. Tergum I and sterna I and II longer than wide. Tergum I fuscous; tergum II fuscous anterocentrally, fulvous across posterior margin and around lateral margins; terga III–V fuscous except for a narrow medial longitudinal pale fuscous band over anterior ⅔ of tergum V, the posterocentral area of tergum V red-brown changing to orange-brown around posterior margin. A pair of oval red-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

FEMALE: As for male except no dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak; no pecten present on abdominal tergum III.

Ovipositor basal segment red-brown, elongate and almost circular in transverse cross section. Ratio of length of oviscape to length of tergum V 1.63:1. Apex of piercer broadly rounded with 2 very short subapical bristles (Fig. 435). Spicules at distal end of middle segment with 1 very long and broad central dentation and 1 or 2 smaller lateral dentations (Fig. 436).

ATTRACTANT: Cue lure.

COMMENTS

D. aequalis is distinct from all other South Pacific *Didacus* in having the medial postsutural vitta absent and possessing a broad fuscous triangle on dorsal surface of scutellum and a broad costal band confluent with M for its entire length. In the original description, Coquillett listed the material studied as follows — "Tuggerah Lakes, near Gosford, New South Wales. Specimens of each sex collected by Inspector Hunter, June 25, 1907; bred from larvae in oranges". I have studied 2 specimens in NMNH. Because there does not appear to be a valid holotype designation (see comments for *B. facialis*), I designate the female labelled "Type No.11944 USNM" as lectotype and the male as paralectotype. One specimen in NSW may be a type but this is not certain. The host record must be regarded as doubtful as it has never been confirmed by subsequent recordings from any commercial fruits. W.W. Froggatt previously confused specimens reared from hosts (Drew, 1974a: 64–65).

Dacus (Didacus) dissimilis, n. sp.
(Fig. 437)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Oomsis Forestry Reserve, Lae–Bulolo road, attracted to cue lure, 22.vi.1980, R.A.I. Drew and D. Currey.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂ (cue lure), Oomsis Forestry Reserve, Lae–Bulolo road, 22.vi.1980, R.A.I. Drew and D. Currey; 1 ♂ (cue lure), Bubia, May–June 1971, J. Maiyel; 1 ♂ (Willison's lure), August 1971, J. Maiyel. Central Province: 1 ♂ (cue lure), Ninoa Estate, Sogeri Plateau, 28.ix–5.x.1973, Entomology Staff. Northern Province: 6 ♂♂, 4.x.1972, 2 ♂♂, 1.xi.1972, Pirive, Kokoda, E.S.C. Smith.

LOCATION OF TYPES: Holotype (T.10463) and 1 paratype

(T.10464) in QM; 2 paratypes in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 7 paratypes in DPI.

DISTRIBUTION

Known from the Morobe, Central and Northern Provinces, Papua New Guinea.

DIAGNOSIS

Medium sized species; face fulvous with small oval black spots; humeral and notopleural calli yellow; mesonotum red-brown with a mottled appearance, a broad triangular medial longitudinal postsutural vitta present, lateral postsutural vittae absent, mesopleural stripe of medium width (reaching midway between anterior npl. bristle and anterior margin of notopleural callus), a triangular yellow marking along anterior margin of mesonotal suture, scutellum yellow; wing with a broad dark fuscous costal band and anal streak, costal cells fuscous with microtrichia covering both cells; abdominal terga III–V orange-brown with broad medial and lateral longitudinal dull black bands over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.83 mm. Frons narrowing slightly posteriorly, length 1.32 times breadth; fulvous with no dark markings; anteromedial hump covered by a small number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fulvous. Ocellar triangle fuscous. Vertex fulvous. Face fulvous with small elongate-oval, black facial spots not reaching epistoma; length of face 0.6 mm. Genae fulvous, large fuscous subocular spot present; fuscous bristle present. Occiput fulvous, yellow along eye margins; occipital row with 1–4 well developed black bristles and a large number of smaller pale bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous except fuscous on apex and outer surface; a pale dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.35 mm; 1.13 mm.

Thorax mesonotum red-brown with a mottled appearance resulting from sites of attachment of the dorsoventral flight muscles. Pleural areas pale fuscous except red-brown below humeral calli. Yellow markings as follows: humeral calli; notopleural calli; mesopleural stripe of medium width reaching midway between anterior npl. bristle and anterior margin of notopleural callus dorsally, continuing to sternopleuron as a transverse spot, anterior margin slightly convex; a triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of suture; a broad triangular medial longitudinal postsutural vitta from level of upper pa. bristles to level of mesonotal suture; upper hypopleural calli (posterior apices fuscous); anterior ⅔ lower hypopleural calli (remainder fuscous). Lateral postsutural vittae absent. Postnotum pale fuscous. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 2 (inner pair absent and in 1 specimen there are 2 outer scp. on 1 side); all bristles well developed and black.

Legs fore coxae red-brown to fuscous, mid and hind coxae pale fuscous; all femora orange-brown tending pale fuscous on apical ⅓ of hind femora; fore and hind tibiae pale fuscous, mid tibiae orange-brown; all tarsi fulvous; mid tibiae each with an apical black spur; fore femora with a row of long dark setae on dorsal surface.

Wings length 6.6 mm; costal cells fuscous, dense microtrichia covering both costal cells; remainder of wings colourless except for dark fuscous subcostal cell, broad dark fuscous costal band confluent with R_{4+5} and overlapping this vein towards apex of wing, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate-oval, terga fused; pecten present on tergum III. Tergum I wider than long; sterna I and II slightly longer than wide. Tergum I dark fuscous; terga II–V orange-brown except for a broad medial longitudinal band which is dark fuscous on tergum II and black on terga III–V, fuscous around anterior and lateral margins of tergum II, broad lateral longitudinal dark fuscous to dull black bands over terga III–V. A pair of oval shining spots on tergum V. Posterior lobe of surstylus of medium length, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure; Willison's lure.

COMMENTS

D. dissimilis is similar to *D. maprikensis* in possessing a broad costal band confluent with R_{4+5} but differs from this species in having the abdomen uniformly orange-brown, the mesopleural stripe extending to the anterior npl. bristle above, and the entire wing membrane with a pale fuscous tint.

Dacus (Didacus) hardyi Drew
(Figs 438–440)

Dacus (*Didacus*) *hardyi* Drew, 1979: 74–6.

MATERIAL EXAMINED
A series of specimens (including paratypes) in DPI (see DISTRIBUTION).
LOCATION OF TYPE: Holotype ♂ (T.7788) in QM.

DISTRIBUTION
PREVIOUSLY RECORDED: The coastal areas of the Northern Territory (type locality, Fogg Dam).
NEW RECORDS: Torres Strait islands: Darnley, Stephens, Yorke (records from Plant Quarantine Survey).

DIAGNOSIS
Small species; large oval black facial spots; humeral and notopleural calli yellow; mesonotum red-brown without dark markings, mesopleural stripe reaching midway between anterior margin of notopleural callus and anterior npl. bristle, lateral postsutural vittae absent, a transverse rectangular yellow marking across posterior region of mesonotum, broad yellow triangle above notopleural calli and running along anterior margin of mesonotal suture, scutellum yellow; wing with a narrow dark fuscous costal band and narrow fuscous anal streak, costal cells fuscous, microtrichia covering second costal cell and outer ½ of first costal cell; abdominal terga III–V orange-brown darkening to red-brown laterally and with a narrow intermittent medial longitudinal fuscous band over all 5 terga.

DESCRIPTION
FEMALE: Ovipositor apex of piercer rounded at tip with 2 pairs of very short subapical bristles (Fig. 439). Spicules at distal end of middle segment with 1 large central dentation and 2 or 3 smaller lateral dentations (Fig. 440).
ATTRACTANT: Cue lure.

COMMENTS
D. hardyi was described adequately by Drew (1979). It is similar to *D. palmerensis* in possessing a narrow costal band not reaching R_{4+5} but differs from this species in the shape of the medial postsutural vitta.

Dacus (Didacus) maprikensis, n. sp.
(Fig. 441)

TYPE SPECIMENS
Holotype ♂, PAPUA NEW GUINEA, East Sepik Province: Maprik, Oct.–Dec. 1957, Malaria Control Section.
Paratypes, PAPUA NEW GUINEA, East Sepik Province: 2 ♂♂, Maprik, Oct.–Dec. 1957, Malaria Control Section.
LOCATION OF TYPES: Holotype (T.10465) in QM; 1 paratype in ANIC; 1 paratype in DPI.

DISTRIBUTION
Known only from Maprik, Papua New Guinea.

DIAGNOSIS
Medium sized species; face with a pair of very small oval pale fuscous spots; humeral and notopleural calli yellow; mesonotum red-brown, lateral postsutural vittae absent, medial postsutural vitta present, mesopleural stripe of medium width (reaching midway between anterior margin of notopleural callus and anterior npl. bristle), yellow triangle extending from notopleural callus along anterior margin of mesonotal suture, scutellum yellow; wing with a pale fuscous tint, broad fuscous costal band and anal streak, costal cells fuscous and covered with dense microtrichia; all abdominal terga uniformly orange-brown.

DESCRIPTION
MALE: Head generally fulvous. Vertical length 1.8 mm. Frons narrowing slightly posteriorly, length 1.43 times breadth; fulvous with, at most, pale fuscous around some orbital bristles and on anteromedial hump; latter covered by a small number of short dark setae; orbital bristles black: 1 s.or., 2 i.or. (in some specimens 1 pair of i.or. are reduced in size); lunule fulvous. Ocellar triangle black. Vertex fulvous. Face fulvous with small pale fuscous oval spots; length of face 0.58 mm. Genae fulvous, very pale brown subocular spot present; red-brown bristle present. Occiput fulvous, yellow along eye margins; occipital row with 2–5 dark bristles. Antennae with segments 1 and 2 fulvous, segment 3 fulvous with fuscous on apex and outer surface; a red-brown dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.25 mm; 0.38 mm; 1.10 mm.

Thorax mesonotum red-brown with a mottled appearance due to sites of attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; a triangle extending along anterior margin of mesonotal suture from notopleural callus; mesopleural stripe of medium width, extending midway between anterior margin of notopleural callus and anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; upper hypopleural calli (posterior apices red-brown); anterior ⅔ lower hypopleural calli (remainder red-brown); a medial longitudinal postsutural vitta broadly rounded posteriorly and narrowing to a point anteriorly to end at the level of the mesonotal suture. Lateral postsutural vittae absent. Postnotum red-brown. Scutellum yellow with a

narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 2; all bristles well developed and black.

Legs all segments entirely fulvous without dark markings; mid tibiae each with an apical black spur; fore femora with long pale setae on dorsal and ventral surfaces.

Wings length 6.9 mm; costal cells fuscous, dense microtrichia covering both costal cells; remainder of wings with a pale fuscous tint except for a fuscous subcostal cell, a broad fuscous costal band confluent with R_{2+3} and overlapping this vein at its extremity, a broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten present on tergum III. Tergum I and sterna I and II wider than long. All terga uniformly orange-brown without dark markings. A pair of oval orange-brown shining spots on tergum V. Posterior lobe of surstylus long, sternum V with posterior margin straight.

ATTRACTANT: No known record.

COMMENTS

D. maprikensis is similar to *D. dissimilis* in possessing the costal band confluent with R_{4+5} for its entire length but differs in having the abdominal terga uniformly orange-brown, mesopleural stripe extending to the anterior npl. bristle and the entire wing membrane covered in a pale fuscous tint.

Dacus (Didacus) palmerensis, n. sp.
(Fig. 442)

TYPE SPECIMEN

Holotype ♂, AUSTRALIA, north Queensland: Cape York Peninsula, Palmer River, attracted to cue lure, 1.xi.1978, I. Titmarsh.

LOCATION OF TYPE: Holotype (T.10466) in QM.

DISTRIBUTION

Known only from Palmer River, Queensland.

DIAGNOSIS

Small pale coloured species; medium sized elongate-oval facial spots present; humeral and notopleural calli yellow; mesonotum red-brown, lateral postsutural vittae absent, a broad triangular medial postsutural vitta present, broad mesopleural stripe reaching almost to anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells pale fuscous, microtrichia covering both costal cells; abdominal terga III–V fulvous except for 2 broad lateral longitudinal red-brown bands and a narrow medial longitudinal red-brown to dark fuscous band over all 3 terga.

DESCRIPTION

MALE: Head generally fulvous. Vertical length 1.4 mm. Frons of even width, length 1.55 times breadth; fulvous with fuscous around orbital bristles and on anteromedial hump, latter covered by a large number of short pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule pale fuscous. Ocellar triangle fulvous. Vertex fulvous. Face fulvous with medium sized elongate-oval black spots present; length of face 0.4 mm. Genae fulvous, fuscous subocular spot present; black bristles present. Occiput fulvous, yellow along eye margins; occipital row with 2–3 well developed red-brown bristles. Antennae with segments 1 and 2 fulvous, segment 3 missing; a weak fulvous dorsal bristle on segment 2; length of segments: 0.20 mm; 0.30 mm.

Thorax mesonotum red-brown with a mottled appearance resulting from attachment of dorsoventral flight muscles. Pleural areas red-brown without dark markings. Yellow markings as follows: humeral calli; notopleural calli; moderately broad mesopleural stripe extending almost to anterior npl. bristle dorsally, continuing to sternopleuron as a transverse spot, anterior margin straight; a triangular marking along anterior margin of each mesonotal suture, with base at notopleural callus and apex at inner margin of each suture; a medial longitudinal vitta in the shape of a broad triangular marking; upper hypopleural calli (posterior apices red-brown); anterior ¾ lower hypopleural calli (remainder red-brown). Lateral postsutural vittae absent. Postnotum red-brown. Scutellum yellow except for narrow red-brown basal band. Bristles: sc. 2; prsc. absent; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles weak and dark fuscous.

Legs fore coxae fulvous, mid and hind coxae red-brown; all other segments fulvous except apices of hind femora pale fuscous; mid tibiae each with an apical black spur.

Wings length 5.1 mm; costal cells pale fuscous, microtrichia covering both costal cells; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around $A_1 + CuA_2$; supernumerary lobe weak.

Abdomen elongate-oval; terga fused; pecten present on tergum III. Tergum I and sterna I and

II wider than long. Terga I and II red-brown except for 2 large transverse fulvous markings on posterior margin of tergum II and a medial longitudinal vitta which is dark red-brown on posterior ½ of tergum I and pale fuscous on tergum II; terga III–V fulvous except for 2 broad lateral longitudinal red-brown bands and a narrow medial longitudinal band which is dark red-brown to pale fuscous on tergum III, fuscous on tergum IV and dark fuscous on tergum V. A pair of oval fulvous shining spots on tergum V. Posterior lobe of surstylus long, sternum V with a slight concavity on posterior margin.

ATTRACTANT: Cue lure.

COMMENTS

D. palmerensis is similar to *D. hardyi* Drew in having a narrow costal band not reaching R_{4+5} but differs in possessing a medial postsutural vitta in the shape of a broad triangular yellow marking.

KEY TO SPECIES OF SUBGENUS *DIDACUS*

1. Lateral and medial postsutural vittae absent; scutellum yellow with a broad fuscous triangle on dorsal surface; costal band confluent with M for its entire length ..... *aequalis*
   Lateral postsutural vittae absent; medial postsutural vitta present; scutellum entirely yellow; costal band not attaining M 2
2(1). Costal band confluent with R_{4+5} for its entire length 3
   Costal band narrow, not attaining R_{4+5} except at apex of wing 4
3(2). Abdominal terga uniformly orange-brown; mesopleural stripe extending to anterior npl. bristle; entire wing membrane with pale fuscous tint ..... *maprikensis*
   Abdominal terga III–V with a black medial and broad dark fuscous to black lateral longitudinal bands; mesopleural stripe reaching midway between anterior margin of notopleural calli and anterior npl. bristles; wing membrane clear .... *dissimilis*
4(2). Medial postsutural vitta as a transverse rectangular marking across posterior region of mesonotum ..... *hardyi*
   Medial postsutural vitta as a broad triangular marking ..... *palmerensis*

Semicallantra, n. subgen.

Dacus (Semicallantra) aquilus, n. sp.
(Fig. 443)

TYPE SPECIMENS

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Mt Kaindi (1200 m), 11.vi.1981, A. Allison.

Paratypes, PAPUA NEW GUINEA, Morobe Province: 1 ♂, Mt Missim, 12.ii.1981; 4 ♂♂, Mt Missim (950 m), 20.viii.1981; 1 ♂, Mt Missim (950 m), 28.v.1981; 1 ♂, Wau Ecology Institute, 28.xii.1981. All collected at cue lure by A. Allison.

LOCATION OF TYPES: Holotype (T.10467) in QM; 1 paratype in ANIC; 1 paratype in BMNH; 1 paratype in DPI(PNG); 4 paratypes in DPI.

DISTRIBUTION

Known only from Mt Missim and Mt Kaindi, Papua New Guinea.

DIAGNOSIS

Medium sized species; facial spots very large elongate-oval; humeral calli yellow (anterior and ventral margins dark fuscous); notopleural calli yellow (basal ½ black); mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe of medium width reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and broad fuscous anal streak, costal cells with a very pale fulvous tint, microtrichia covering outer ½ of second costal cell only; abdominal terga I–V black with a narrow dark fuscous pattern across posterior margin of tergum V and extending anteriorly along either side of a narrow medial longitudinal black band.

DESCRIPTION

MALE: Head generally red-brown. Vertical length 1.65 mm. Frons of even width, length 1.48 times breadth; red-brown with fuscous around s.or. bristles and on anteromedial hump, latter covered by a large number of small pale setae; orbital bristles black: 1 s.or., 2 i.or.; lunule red-brown. Ocellar triangle black. Vertex fuscous. Face red-brown with very large elongate-oval black spots filling antennal furrows; length of face 0.53 mm. Genae red-brown, black subocular spot present; black bristle present. Occiput black, red-brown along eye margins; occipital row with 3–6 well developed black bristles. Antennae with segments 1 and 2 red-brown, segment 3 fuscous except red-brown along ventral margin; a strong black dorsal bristle on segment 2; arista black (red-brown basally); length of segments: 0.30 mm; 0.50 mm; 0.93 mm.

Thorax mesonotum and pleural areas black with no pale markings. Yellow markings as follows: humeral calli (anterior and ventral margins dark fuscous); apical ½ of notopleural calli (basal ½ black); medium sized mesopleural stripe reaching anterior npl. bristle dorsally, not reaching sternopleuron below, anterior margin straight; upper hypopleural calli (dorsal margin and posterior apices black); anterior 5/9 lower hypopleural calli (remainder including broad ventral margin black); 2 broad parallel sided lateral postsutural vittae ending behind upper pa. bristles. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs all coxae dark fuscous; all femora black; fore and mid tibiae fuscous, hind tibiae dark fuscous; all tarsal segments fulvous; rows of long black setae on dorsal surfaces of fore femora; mid tibiae each with an apical black spur.

Wings length 6.4 mm; costal cells with a very pale fulvous tint, microtrichia covering outer ½ of second costal cell only; remainder of wings colourless except fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending just beyond extremity of R_{4+5}, broad fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I wider than long; sterna I and II as long as wide. Terga I–V black except for a narrow dark fuscous band along posterior margin of tergum V and extending anteriorly along either side of a narrow medial longitudinal black band on this tergum. A pair of oval black shining spots on tergum V. Posterior lobe of surstylus of medium development, sternum V with a deep concavity on posterior margin.
ATTRACTANT: Cue lure.

COMMENTS

D. aquilus is similar to *D. nigriculus* in having lateral postsutural vittae present and the medial postsutural vitta absent but differs in possessing humeral calli yellow (except anterior ¼ dark fuscous), notopleural calli with apical ½ yellow (basal ½ black) and wing membrane colourless.

Dacus (Semicallantra) memnonius, n. sp.
(Fig. 444)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Central District: Hombrom Bluff, attracted to methyl eugenol, 24.xi.1973, J. Stibick.
LOCATION OF TYPE: Holotype (T.10468) in QM.

DISTRIBUTION

Known only from Hombrom Bluff, Papua New Guinea.

DIAGNOSIS

Medium sized species; face dark fuscous with large elongate black spots; humeral calli black; notopleural calli yellow dorsally (black ventrally); mesonotum black, lateral and medial postsutural vittae absent, mesopleural stripe broad reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells with pale fuscous tint, microtrichia in outer ½ second costal cell only; all abdominal terga black except for a narrow fulvous band along posterior margin of tergum V.

DESCRIPTION

MALE: Head generally pale fuscous. Vertical length 1.78 mm. Frons narrowing slightly posteriorly, length 1.43 times breadth; pale fuscous with dark fuscous to black on anterior ⅓; anteromedial hump covered by a small number of short dark setae; orbital bristles black; 1 s.or., 2 i.or. (1 posterior i.or. bristle absent); lunule fulvous. Ocellar triangle black. Vertex fuscous. Face dark fuscous wth large elongate black facial spots, running along antennal furrows from antennal sockets to end just before epistoma; length of face 0.58 mm. Genae fuscous, small black subocular spot present; black bristle present. Occiput black laterally, fuscous centrally and along eye margins; occipital row with a large number of well developed black bristles. Antennae with segment 1 fulvous, segment 2 fuscous, segment 3 dark fuscous; a black dorsal bristle on segment 2; arista black (fulvous basally); length of segments: 0.33 mm; 0.51 mm; 0.98 mm.

Thorax mesonotum and pleural areas black. Yellow markings as follows: dorsal ½ of notopleural calli (remainder black); broad mesopleural stripe reaching anterior npl. bristle dorsally, narrowing sharply ventrally, anterior margin straight; upper hypopleural calli (posterior apices black); anterodorsal spot on lower hypopleural calli (remainder black). Lateral and medial postsutural vittae absent. Humeral calli black dorsally, dark fuscous ventrally. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 4; all bristles well developed and black.

Legs coxae dark fuscous; femora black; tibiae dark fuscous; tarsi fulvous; mid tibiae each with an apical black spur; fore femora with rows of long black setae on dorsal and ventral surfaces.

Wings length 6.7 mm; costal cells with pale fuscous tint, microtrichia in outer ½ of second costal cell; remainder of wings colourless except for fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and ending between extremities of R_{4+5} and M, narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe weak.

Abdomen elongate, clavate and petiolate, terga fused but with overlap along sutures (except between terga I and II); pecten present on tergum III; tergum I long and narrow; sterna I and II longer than wide. All terga black except for a narrow transverse fulvous band along posterior margin of tergum V. A pair of oval shining spots on tergum V. Posterior lobe of surstylus of medium length, sternum V with a deep concavity on posterior margin.

ATTRACTANT: Methyl eugenol.

COMMENTS

D. memnonius differs from the other species of South Pacific *Semicallantra* in having lateral and medial postsutural vittae absent.

Dacus (Semicallantra) nigriculus, n. sp. (Fig. 445)

TYPE SPECIMEN

Holotype ♂, PAPUA NEW GUINEA, Morobe Province: Robbies Creek, Stony logging area, Bulolo, collected under leaf of *Musa* sp., 29.vi.1979, H. Roberts.

LOCATION OF TYPE: Holotype (T.10469) in QM.

DISTRIBUTION

Known only from the Bulolo area, Papua New Guinea.

DIAGNOSIS

Medium sized species; face dark fulvous with very large black spots covering antennal furrows; humeral calli dark fuscous; notopleural calli yellow; mesonotum black, lateral postsutural vittae present, medial postsutural vitta absent, mesopleural stripe broad reaching anterior npl. bristle, scutellum yellow; wing with a narrow fuscous costal band and anal streak, costal cells with a pale fuscous tint, microtrichia in outer ½ of second costal cell only; abdomen black except dark fuscous on posterior of tergum V.

DESCRIPTION

MALE: Head generally dark fulvous. Vertical length 1.68 mm. Frons narrowing slightly posteriorly, length 1.37 times breadth; dark fulvous except fuscous around orbital bristles and on anteromedial hump; latter covered by small dark setae; orbital bristles black: 1 s.or., 2 i.or.; lunule fuscous. Ocellar triangle black. Vertex fuscous. Face dark fulvous with very large elongate black spots covering the antennal furrows; length of face 0.53 mm. Genae dark fulvous, large dark fuscous subocular spot present; black bristle present. Occiput dark fuscous, dark fulvous along eye margins; occipital row with 6–7 well developed black bristles. Antennae with segment 1 fulvous basally, fuscous apically, segment 2 fuscous, segment 3 dark fuscous; a small black dorsal bristle on segment 2; arista black (dark fulvous basally); length of segments: 0.30 mm; 0.43 mm; 0.95 mm.

Thorax mesonotum and pleural areas black. Yellow markings as follows: notopleural calli; mesopleural stripe broad, reaching anterior npl. bristle dorsally, not continuing to sternopleuron, anterior margin straight; 2 lateral postsutural vittae, narrowing anteriorly and broadly rounded posteriorly to end behind the upper pa. bristles; upper hypopleural calli (posterior apices black); anterior 3/5 lower hypopleural calli (remainder including broad ventral margin black). Humeral calli dark fuscous. Postnotum black. Scutellum yellow except for narrow black basal band. Bristles: sc. 2; prsc. 2; pa. 2; sa. absent; mpl. 1; npl. 2; scp. 6; all bristles well developed and black.

Legs all coxae dark fuscous; fore femora dark fuscous, mid and hind femora black; fore and mid tibiae dark fuscous, hind tibiae black; all tarsal segments fulvous; mid tibiae each with an apical black spur; fore femora with a row of long dark setae on dorsal surface.

Wings length 6.4 mm; costal cells with pale fuscous tint, microtrichia in outer ½ of second costal cell only; remainder of wings with a pale fuscous tint, dark fuscous subcostal cell, narrow fuscous costal band overlapping R_{2+3} and lacking a distinct margin between R_{2+3} and R_{4+5}, a narrow fuscous anal streak ending at wing margin; dense aggregation of microtrichia around A_1 + CuA_2; supernumerary lobe of medium development.

Abdomen elongate-oval; terga free; pecten present on tergum III. Tergum I wider than long; sterna I and II slightly longer than wide. Terga I–IV black; tergum V black along anterior margin, remainder dark fuscous. A pair of oval shining spots on tergum V. Posterior lobe of surstylus

short, sternum V with a deep concavity on posterior margin.
ATTRACTANT: No known record.

COMMENTS
D. nigriculus is similar to *D. aquilus* in having lateral postsutural vittae present and the medial postsutural vitta absent but differs in possessing humeral calli dark fuscous, notopleural calli entirely yellow and wing membrane with a pale fuscous tint.

KEY TO SPECIES OF SUBGENUS *SEMICALLANTRA*

1. Lateral and medial postsutural vittae absent ..... *memnonius*
   Lateral postsutural vittae present; medial postsutural vitta absent 2
2(1). Humeral calli dark fuscous; notopleural calli entirely yellow; wing membrane with pale fuscous tint .....*nigriculus*
   Humeral calli yellow except anterior ¼ dark fuscous; notopleural calli with apical ½ yellow and basal ½ black; wing membrane colourless .....*aquilus*

Genus **Paracallantra** Hendel

Paracallantra vespiformis Hendel

Paracallantra vespiformis Hendel, 1927b: 60–1; Drew, 1972a: 20; Drew, 1974a: 98.
Dacus (*Paracallantra*) *vespiformis*: Hardy, 1955b: 434.

MATERIAL EXAMINED
None.
LOCATION OF TYPE: The holotype ♂ was placed in the Hamburg Museum, Germany and lost when this Museum was destroyed by fire in 1943.

DISTRIBUTION
New Britain (type locality).

ATTRACTANT: No known record.

COMMENTS
The definition of this species is unclear. *Dacus* (*Callantra*) *axanus* (Hering) is common in New Britain and I believe it possible that Hendel had a specimen of this species which he described as *Paracallantra vespiformis*.

BIOLOGY

In this section the biology of the subfamily Dacinae is discussed and particularly aspects which may influence species distribution and speciation.

HOST PLANTS
In Table 1 host records are presented for fruit fly species within Australasia and Oceania. Consequently, only a small number of hosts are given for the introduced *B. cucurbitae* which infests a wide range of plants in South East Asia. Fruit fly species are listed in alphabetical order within subgenera of the genera *Bactrocera* and *Dacus*. The hosts have been compiled from those of May (1953, 1957a, 1960), Allwood and Angeles (1979), Drew (1978, 1982) and new records from recent field work. It was necessary to revise published records in order to update the botanical taxonomy and amend errors in plant and fruit fly identifications. A complete host list for fruit flies in the Northern Territory is to be published separately (Smith et al., in press).

Some fruits previously reported as hosts of *B. tryoni*, viz. strawberries, grapes and lemons, are rarely infested. Additionally, oviposition is common in avocados and passionfruit although larval development is rare. *B. bryoniae* has been reared from commercial fruits only in Papua New Guinea.

Some species have been classified as having minor pest status on the basis of single or rare occurrences (May, 1963). These records have not been confirmed subsequently and the following fly species are therefore not considered to have any economic importance: *B. breviaculeus*, *B. cacuminata*, *B. halfordiae*, *B. mayi*, *B. mutabilis* and *D. aequalis*. The record of *D. aequalis* is almost certainly in error (see discussion under comments on that species). *B. breviaculeus*, *B. halfordiae*, *B. mayi* and *B. mutabilis* are of general red-brown colouration and teneral host reared specimens would look superficially like *B. tryoni*. Therefore, previous records upon which these species were considered economic may have been based on incorrect identifications.

May (1953) recorded *Zeugodacus synnephes* (Hendel) in *Bryonopsis laciniosa*. Neither the fly nor the plant occur in Australia and the association most likely was of *B. chorista* in *Diplocyclos palmatus*.

Table 1. Host records of fruit flies occurring in the Australasian and Oceanian regions.

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Afrodacus) jarvisi	Anacardiaceae	*Semecarpus australiensis*	*Mangifera indica* (mango)	
	Barringtoniaceae	*Planchonia careya*		
	Chrysobalanaceae	*Parinari corymbosum*		
	Combretaceae	*Terminalia catappa*; *Terminalia melanocarpa*		
	Ebenaceae		*Diospyros kaki* (persimmon)	
	Meliaceae	*Aglaia sapindina*		
	Musaceae		*Musa* sp. (banana)	
	Myrtaceae	*Syzygium armstrongii*; *Syzygium cormiflorum*; *Syzygium rubiginosum*; *Syzygium rubrimolle*; *Syzygium suborbiculare*	*Psidium cattleianum* (cherry guava); *Psidium guajava* (guava)	
	Oleaceae	*Notalaea* sp.		
	Punicaceae		*Punica granatum* (pomegranate)	
	Rosaceae		*Cydonia oblonga* (quince); *Prunus armeniaca* (apricot); *Prunus persica* (peach); *Pyrus communis* (pear)	
	Sapotaceae	*Planchonella* sp.		
B. (Austrodacus) cucumis	Caricaceae		*Carica papaya* (papaya)	
	Cucurbitaceae	*Diplocyclos palmatus*; *Momordica charantia*	*Cucumis melo* (rockmelon); *Cucumis sativus* (cucumber); *Cucurbita pepo* (marrow, pumpkin, squash);	

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Austrodacus) cucumis (continued)			*Luffa cylindrica* (vegetable sponge); *Trichosanthes anguina* (guada bean)	
	Euphorbiaceae	*Glochidion harveyanum*		
	Solanaceae		*Lycopersicon lycopersicum* (tomato)	
B. (Bactrocera) alyxiae	Apocynaceae	*Alyxia spicata*		
B. (Bactrocera) aquilonis	Arecaceae (Palmae)	*Livistona humilis*		
	Chrysobalanaceae	*Maranthes corymbosa*		
	Combretaceae	*Terminalia erythrocarpa*; *Terminalia ferdinandiana*; *Terminalia grandiflora*		
	Elaeocarpaceae	*Elaeocarpus grandis*		
	Meliaceae	*Aglaia eleagnoidea*		
	Myrtaceae	*Acmena hemilampra*; *Cleistocalyx operculatus*; *Syzygium armstrongii*; *Syzygium claviflorum*; *Syzygium forte*; *Syzygium operculatum*; *Syzygium suborbiculare*	*Psidium guajava* (guava)	
	Rosaceae		*Prunus persica* (peach)	
	Rutaceae	*Glycosmis pentaphylla*; *Glycosmis trifoliata*; *Micromelem minutum*	*Citrus paradisi* (grapefruit); *Citrus* sp.	
B. (Bactrocera) bancroftii	Moraceae	*Cudrania cochinchinensis*		
B. (Bactrocera) barringtoniae	Barringtoniaceae	*Barringtonia calyptrata*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Guttiferae	*Garcinia warrenii*		
B. (Bactrocera) breviaculeus	Euphorbiaceae	*Glochidion ferdinandii*; *Glochidion harveyanum*		
B. (Bactrocera) bryoniae	Cucurbitaceae	*Diplocyclos palmatus*; *Mukia maderaspatana*; *Zehneria cunninghamii*		
	Musaceae		*Musa* sp. (banana)	
	Passifloraceae	*Passiflora foetida*; *Passiflora suberosa*		
	Solanaceae		*Capsicum frutescens* (capsicum)	
	Strychnaceae	*Strychnos lucida*		
B. (Bactrocera) bullata	Guttiferae	*Garcinia* sp.		
B. (Bactrocera) cacuminata	Elaeocarpaceae	*Elaeocarpus* sp.		
	Meliaceae	*Disoxylum* sp.		
	Solanaceae	*Solanum erianthum*; *Solanum mauritianum*		
B. (Bactrocera) curvipennis	Rutaceae		*Citrus* sp.	
B. (Bactrocera) dapsiles	Solanaceae	*Solanum mauritianum*		
B. (Bactrocera) diospyri	Ebenaceae	*Diospyros maritima*		
B. (Bactrocera) distincta	Sapotaceae	*Burckella richii*	*Chrysophyllum cainito* (star apple)	
B. (Bactrocera) endiandrae	Annonaceae	*Cananga odorata*		
	Chrysobalanaceae	*Maranthes corymbosa*		
	Lauraceae	*Beilschmiedia obtusifolia*; *Cryptocarya erythroxylon*; *Litsea*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
		leefeana; *Endiandra cowleyana*; *Endiandra discolor*; *Endiandra muelleri*		
B. (*Bactrocera*) *eximia*	Combretaceae	*Terminalia brassii* (ex stem)		
B. (*Bactrocera*) *facialis*	Anacardiaceae		*Mangifera indica* (mango)	
	Myrtaceae		*Psidium guajava* (guava)	
	Rosaceae		*Prunus persica* (peach)	
	Rutaceae		*Citrus* sp.	
	Solanaceae		*Capsicum frutescens* (capsicum); *Lycopersicon lycopersicum* (tomato)	
B. (*Bactrocera*) *fagraea*	Myrtaceae	*Syzygium* sp. (nr. *suborbiculare*)		
	Potaliaceae	*Fagraea gracilipes*		
B. (*Bactrocera*) *frauenfeldi*	Anacardiaceae		*Mangifera indica* (mango)	
	Combretaceae	*Terminalia catappa*		
	Moraceae		*Artocarpus altilis* (breadfruit)	
	Myrtaceae	*Syzygium branderhorstii*; *Syzygium malaccense*	*Psidium guajava* (guava)	
	Sapotaceae	*Manilkara kauki*		
B. (*Bactrocera*) *halfordiae*	Annonaceae	*Rauwenhoffia leichhardtii*		
	Cunoniaceae	*Schizomeria ovata*		
	Moraceae	*Ficus racemosa*		
	Myrtaceae	*Syzygium corynanthum*; *Syzygium crebrinerve*		*Syzygium uniflora* (*brazilian* cherry);

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Bactrocera) halfordiae (continued)				*Feijoa sellowiana* (feijoa)
	Rosaceae		*Eriobotrya japonica* (loquat)	
	Rutaceae	*Acronychia laevis*; *Acronychia pubescens*; *Halfordia kendack*	*Citrus paradisi* (grapefruit); *Citrus reticulata* (mandarin); *Citrus sinensis* (orange); *Fortunella japonica* (kumquat)	
	Sapotaceae	*Niemeyera chartacea*; *Planchonella australis*		
	Smilacaceae	*Smilax australis*		
	Thymelaeaceae	*Phaleria chermsideana*		
B. (Bactrocera) kirki	Anacardiaceae		*Mangifera indica* (mango)	
	Combretaceae	*Terminalia catappa*		
	Myrtaceae		*Psidium guajava* (guava)	
	Rosaceae		*Prunus persica* (peach)	
	Solanaceae		*Capsicum frutescens* (capsicum)	
B. (Bactrocera) kraussi	Annonaceae	*Cananga odorata*		
	Apocynaceae			*Thevetia peruviana* (yellow oleander)
	Cunoniaceae	*Schizomeria whitei*		
	Euphorbiaceae	*Fontainea picrosperma*		
	Flacourtiaceae	*Baileyoxylon lanceolatum*		
	Icacinaceae	*Irvingbaileya australis*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Lauraceae	*Endiandra compressa*; *Endiandra discolor*; *Endiandra palmerstonii*		
	Myrtaceae	*Acmena graveolens*; *Rhodomyrtus macrocarpa*; *Syzygium australe*; *Syzygium branderhorstii*; *Syzygium cormiflorum*; *Syzygium luehmanni*; *Syzygium rubrimolle*; *Syzygium suborbiculare*; *Syzygium tierneyanum*		
	Oleaceae Rutaceae	*Notolaea* sp. *Acronychia acidula*; *Acronychia vestita*; *Halfordia scleroxyla*		
	Sapindaceae	*Arytera* sp.; *Castanospora alphandii*		
	Thymelaeaceae	*Phaleria clerodendron*		
B. (Bactrocera) laticaudus	Combretaceae	*Terminalia muelleri*		
	Euphorbiaceae	*Glochidion ferdinandii*		
	Sapotaceae	*Planchonella obovata*		
B. (Bactrocera) luteola	Rubiaceae	*Guettarda speciosa*		
B. (Bactrocera) manskii	Ebenaceae	*Diospyros* sp.		
	Strychnaceae	*Strychnos colubrina*		
B. (Bactrocera) mayi	Combretaceae	*Terminalia muelleri*		
	Rosaceae		*Prunus armeniaca* (apricot)	

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Sapotaceae	*Planchonella australis*; *Planchonella obovata*; *Planchonella pohlmaniana*		
B. (*Bactrocera*) *melanotus*	Anacardiaceae		*Mangifera indica* (mango)	
	Myrtaceae		*Psidium guajava* (guava)	
	Rutaceae		*Citrus* sp.	
B. (*Bactrocera*) *melas*	Arecaceae		*Phoenix dactylifera* (date palm)	
	Moraceae		*Ficus carica* (fig)	
	Myrtaceae		*Psidium guajava* (guava)	
	Passifloraceae	*Passiflora subpeltata*		
	Rosaceae		*Eriobotrya japonica* (loquat); *Malus sylvestris* (apple); *Prunus domestica* (plum); *Prunus persica* (peach); *Pyrus communis* (pear)	
	Rutaceae		*Citrus paradisi* (grapefruit); *Citrus sinensis* (orange); *Fortunella japonica* (kumquat)	
B. (*Bactrocera*) *mendosa*	Sapotaceae	*Pouteria sericea*		
B. (*Bactrocera*) *moluccensis*	Caesalpiniaceae	*Inocarpus fagiferus*		
B. (*Bactrocera*) *musae*	Capparidaceae	*Capparis lucida*		
	Caricaceae		*Carica papaya* (papaya)	
	Musaceae	*Musa banksii*	*Musa acuminata* and *Musa paradisiaca* (commercial banana)	

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Myrtaceae	*Syzygium bamagense*	*Psidium guajava* (guava)	
B. (Bactrocera) mutabilis	Rutaceae		*Fortunella japonica* (kumquat)	
B. (Bactrocera) neohumeralis	Anacardiaceae		*Mangifera indica* (mango)	*Spondias cytherea* (hog plum)
	Annonaceae	*Cananga odorata*	*Annona squamosa* (custard apple)	
	Arecaceae (Palmae)		*Phoenix dactylifera* (date palm)	
	Capparidaceae	*Capparis lucida*		
	Celastraceae	*Cassine australis*		
	Combretaceae	*Terminalia catappa*; *Terminalia melanocarpa*		
	Euphorbiaceae	*Drypetes australasica*		
	Lauraceae	*Cryptocarya erythroxylon*; *Endiandra compressa*; *Endiandra cowleyana*		
	Moraceae		*Morus nigra* (black mulberry)	
	Myrtaceae	*Rhodomyrtus macrocarpa*; *Syzygium australe*; *Syzygium tierneyanum*	*Psidium cattleianum* (cherry guava); *Psidium guajava* (guava)	*Feijoa sellowiana* (feijoa); *Syzygium uniflora* (brazilian cherry)
	Oleaceae	*Notalaea* sp.		
	Passifloraceae	*Passiflora suberosa*; *Passiflora subpeltata*		
	Naucleaceae	*Nauclea orientalis*		
	Rosaceae		*Eriobotrya japonica* (loquat); *Fragaria* sp. (strawberry);	

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Bactrocera) neohumeralis (continued)			*Malus sylvestris* (apple); *Prunus armeniaca* (apricot); *Prunus domestica* (plum); *Prunus persica* (peach); *Pyrus communis* (pear)	
	Rubiaceae		*Coffea arabica* (coffee)	
	Rutaceae	*Casimiroa edulis*; *Clausena brevistyla*	*Citrus maxima* (pomelo); *Citrus limon* (lemon); *Citrus paradisi* (grapefruit); *Citrus reticulata* (mandarin); *Citrus sinensis* (orange); *Fortunella japonica* (kumquat)	
	Sapindaceae	*Ganophyllum falcatum*		
	Sapotaceae	*Niemeyera chartacea*; *Planchonella obovata*		
	Solanaceae	*Solanum laciniatum*; *Solanum seaforthianum*	*Cyphomandra betacea* (tree tomato); *Lycopersicon lycopersicum* (tomato)	
	Vitaceae		*Vitis labruscana* (isabella grape)	
B. (Bactrocera) nigrovittata	Lauraceae	*Endiandra* sp.		
	Solanaceae	*Solanum torvum*		
B. (Bactrocera) obliqua	Myrtaceae	*Syzygium malaccense*		
B. (Bactrocera) opiliae	Opiliaceae	*Opilia amentacea*		
B. (Bactrocera) pallida	Naucleaceae	*Nauclea orientalis*; *Sarcocephalus coadunatus*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Bactrocera) passiflorae	Anacardiaceae		*Mangifera indica* (mango)	
	Passifloraceae		*Passiflora edulis* (passionfruit); *Passiflora quadrangularis* (granadilla)	
	Rutaceae		*Citrus* sp.	
B. (Bactrocera) phaleriae	Thymelaeaceae	*Phaleria blumei* var. *latifolia*		
B. (Bactrocera) psidii	Anacardiaceae		*Mangifera indica* (mango)	
	Myrtaceae		*Psidium cattleianum* (cherry guava); *Psidium guajava* (guava)	
	Passifloraceae		*Passiflora quadrangularis* (granadilla)	
	Rutaceae		*Citrus* sp.	
B. (Bactrocera) pulchra	Sapotaceae	*Planchonella* sp.		
B. (Bactrocera) tenuifascia	Sapotaceae	*Planchonella pohlmanniana*		
B. (Bactrocera) terminaliae	Combretaceae	*Terminalia complanata*		
	Lauraceae	*Endiandra* sp.		
B. (Bactrocera) tinomiscii	Menispermaceae	*Chlaenandra ovata*; *Tinomiscium phytocrenoides*		
	Xanthophyllaceae	*Xanthophyllum* sp.		
B. (Bactrocera) trivialis	Myrtaceae		*Psidium guajava* (guava)	
	Rosaceae		*Prunus persica* (peach)	
	Rutaceae		*Citrus paradisi* (grapefruit)	
	Solanaceae		*Capsicum frutescens* (capsicum)	
B. (Bactrocera) tryoni	Anacardiaceae	*Pleiogynium timorense*	*Anacardium occidentale* (cashew); *Mangifera indica* (mango)	*Spondias cytherea* (hog plum)

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Bactrocera) tryoni (continued)	Annonaceae	*Cananga odorata; Polyalthia nitidissima; Rauwenhoffia leichhardtii*	*Annona reticulata* (bullock's heart); *Annona squamosa* (custard apple)	
	Apocynaceae	*Alyxia ruscifolia; Carissa ovata; Ochrosia elliptica*		
	Arecaceae (Palmae)		*Phoenix dactylifera* (date palm)	
	Cactaceae			*Opuntia ficus-indica* (indian fig)
	Capparidaceae	*Capparis lucida; Capparis mitchellii; Capparis nobilis*		
	Caricaceae		*Carica papaya* (papaya)	
	Celastraceae	*Cassine australis*		
	Combretaceae	*Terminalia catappa; Terminalia melanocarpa; Terminalia muelleri*		
	Cunoniaceae	*Schizomeria ovata*		
	Davidsoniaceae	*Davidsonia pruriens*		
	Ebenaceae	*Diospyros australis*	*Diospyros kaki* (persimmon)	
	Euphorbiaceae	*Drypetes australasica; Glochidion ferdinandii*		
	Flacourtiaceae			*Dovyalis caffra* (kei apple); *Flacourtia jangomas*
	Juglandaceae		*Juglans regia* (walnut)	
	Lauraceae	*Beilschmiedia obtusifolia;*	*Persea americana*	

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
		Cryptocarya erythroxylon; *Endiandra compressa*; *Endiandra cowleyana*; *Endiandra discolor*	(avacado)	
	Meliaceae	*Aglaia sapindina*; *Owenia venosa*		
	Moraceae	*Cudrania cochinchinensis*; *Ficus macrophylla*; *Ficus racemosa*	*Ficus carica* (fig); *Morus alba* (white mulberry); *Morus nigra* (black mulberry)	
	Musaceae		*Musa acuminata* (dwarf banana)	
	Myrtaceae	*Acmena graveolens*; *Acmena smithii*; *Rhodamnia sessiliflora*; *Syzygium australe*; *Syzygium cormiflorum*; *Syzygium corynanthum*; *Syzygium kuranda*; *Syzygium rubrimolle*; *Syzygium suborbiculare*	*Psidium cattleianum* (cherry guava); *Psidium guajava* (guava)	*Feijoa sellowiana* (feijoa); *Syzygium jambos*; *Syzygium uniflora* (brazilian cherry)
	Naucleaceae	*Nauclea orientalis*		
	Oleaceae	*Notelaea longifolia*	*Olea europaea* (olive)	
	Oxalidaceae		*Averrhoa carambola* (carambola)	
	Passifloraceae	*Passiflora aurantia*; *Passiflora subpeltata*	*Passiflora edulis* (passionfruit); *Passiflora quadrangularis* (granadilla)	
	Punicaceae		*Punica granatum* (pomegranate)	
	Rhamnaceae	*Rhamnella vitiensis*; *Ziziphus mauritiana*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
B. (Bactrocera) tryoni (continued)	Rosaceae		*Cydonia oblonga* (quince); *Eriobotrya japonica* (loquat); *Malus sylvestris* (apple); *Prunus armeniaca* (apricot); *Prunus avium* (cherry); *Prunus domestica* (plum); *Prunus persica* (peach); *Prunus persica* var. *nectarina* (nectarine); *Pyrus communis* (pear); *Rubus fruticosus* (blackberry); *Rubus ursinus* (loganberry)	*Prunus cerasifera* (ornamental plum)
	Rubiaceae		*Coffea arabica* (coffee)	
	Rutaceae	*Acronychia acidula*; *Acronychia* sp. (aff. *laevis*); *Eremocitrus glauca*	*Casimiroa edulis* (white sapote); *Citrus limon* (lemon); *Citrus maxima* (pomelo); *Citrus medica* (citron); *Citrus paradisi* (grapefruit); *Citrus reticulata* (mandarin); *Citrus sinensis* (orange); *Fortunella japonica* (kumquat)	*Aegle marmelos* (bael fruit)
	Sapindaceae	*Castanospora alphandii*; *Ganophyllum falcatum*		
	Sapotaceae	*Amorphospermum antilogum*; *Mimusops elengi*; *Niemeyera chartacea*; *Planchonella australis*; *Planchonella pohlmaniana*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Siphonodontaceae	*Siphonodon australis*		
	Smilacaceae	*Rhipogonum papuanum*		
	Solanaceae	*Solanum laciniatum*; *Solanum mauritianum*; *Solanum seaforthianum*	*Capsicum frutescens* (capsicum); *Lycopersicon lycopersicum* (tomato); *Physalis peruviana* (cape gooseberry)	
	Vitaceae	*Cissus* sp.	*Vitis labruscana* (isabella grape); *Vitis vinifera* (grape)	
B. (Bactrocera) umbrosa	Moraceae		*Artocarpus spp.* (jackfruit)	
B. (Diplodacus) signatifera	Barringtoniaceae	*Barringtonia calyptrata*		
	Capparidaceae	*Capparis lucida*		
B. (Gymnodacus) calophylli	Guttiferae	*Calophyllum inophyllum*		
B. (Gymnodacus) hastigerina	Anacardiaceae	*Spondias* sp.		
B. (Hemisurstylus) melanoscutata	Guttiferae		*Garcinia xanthochymus*	
B. (Hemizeugodacus) aglaiae	Meliaceae	*Aglaia ferruginea*; *Aglaia sapindina*		
	Sapindaceae	*Ganophyllum falcatum*		
B. (Hemizeugodacus) aurea	Alangiaceae	*Alangium villosum* subsp. *tomentosum*		
B. (Javadacus) aberrans	Lauraceae	*Cinnamomum oliveri*; *Cinnamomum virens*; *Litsea leefeana*; *Litsea reticulata*		
B. (Melanodacus) nigra	Icacinaceae	*Gomphandra australiana*		
	Lauraceae	*Cryptocarya* sp.		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Oleaceae	*Olea paniculata*		
	Symplocaceae	*Symplocos thwaitesii*		
B. (Notodacus) xanthodes	Bromeliaceae		*Ananas comosus* (pineapple)	
	Barringtoniaceae	*Barringtonia edulis*		
	Caricaceae		*Carica papaya* (papaya)	
	Cucurbitaceae		*Citrullus lanatus* (watermelon)	
	Myrtaceae		*Psidium guajava* (guava)	
	Passifloraceae		*Passiflora quadrangularis* (granadilla)	
	Rutaceae		*Citrus* sp.	
	Solanaceae		*Lycopersicon lycopersicum* (tomato)	
B. (Paradacus) decipiens	Cucurbitaceae		*Cucurbita pepo* (pumpkin)	
B. (Paratridacus) atrisetosa	Cucurbitaceae		*Citrullus lanatus* (watermelon); *Cucumis sativus* (cucumber); *Cucurbita pepo* (pumpkin, squash)	
	Meliaceae	*Aglaia sapindina*		
	Solanaceae		*Lycopersicon lycopersicum* (tomato)	
B. (Paratridacus) expandens	Guttiferae	*Garcinia gibbsiae*	*Garcinia dulcis*; *Garcinia xanthochymus*	
B. (Polistomimetes) decurtans	Rhizophoraceae	*Carallia brachiata*		
B. (Polistomimetes) murrayi	Anacardiaceae	*Semecarpus australiensis*		

Fruit Fly Species	Plant Family	Wild Host	Commercial Host	Ornamental Host
	Moraceae	*Ficus* sp.		
B. (Polistomimetes) visenda	Guttiferae	*Garcinia gibbsiae*; *Garcinia warrenii*		
B. (Zeugodacus) chorista	Cucurbitaceae	*Diplocyclos palmatus*		
B. (Zeugodacus) cucurbitae	Cucurbitaceae	*Momordica charantia*	*Cucumis melo* (rockmelon); *Cucumis sativus* (cucumber); *Cucurbita pepo* (marrow)	
B. (Zeugodacus) trichota	Cucurbitaceae	Native cucurbit species (May 1962a)		
D. (Callantra) axanus	Cucurbitaceae		*Trichosanthes anguina* (guada bean)	
D. (Callantra) petioliforma	Cucurbitaceae		*Trichosanthes anguina* (guada bean)	
*D. (Callantra) smieroides**	Cucurbitaceae	*Luffa acutangula*		
D. (Callantra) solomonensis			*Cucumis sativus* (cucumber); *Cucurbita pepo* (pumpkin)	
D. (Dacus) absonifacies	Asclepiadaceae	*Marsdenia rostrata* (pupae develop within the fruit)		
D. (Dacus) secamoneae	Asclepiadaceae	*Secamone elliptica*		
D. (Didacus) aequalis	Asclepiadaceae	*Marsdenia rostrata* (pupae develop within the fruit)		
D. (Didacus) hardyi	Asclepiadaceae	*Cynanchum* sp.		

* *D. smieroides* does not occur in the region covered by this monograph but is included because of morphological and host relationships to other species.

The South Pacific Dacinae have been recorded from endemic fruits belonging to 46 families (Table 2). This list does not include introduced host plants. Only species in the genus *Dacus* (fused abdominal terga species) have been recorded from Asclepiadaceae. The other recorded hosts of this genus belong to the Cucurbitaceae. These 2 plant families (plus Passifloraceae) contain the majority of hosts of most African Dacinae (Munro, 1984; Hancock, 1986) and these also belong to genus *Dacus*. The Asclepiadaceae are mostly tropical in distribution and are concentrated in Africa while the Cucurbitaceae are abundant throughout the tropics (Willis, 1960).

Forty-five plant families (other than Asclepiadaceae) contain the recorded hosts of the genus *Bactrocera* (free abdominal terga species). These plants occur primarily in the tropical and subtropical rainforests. Close to the equator such forests grow from sea level to an altitude of ca. 2400 m. There is a change in distribution of plant species with altitude but no associated change in the distribution of dacine species except for a few that have been collected only at higher altitudes in Papua New Guinea.

In Africa, the tribe Ceratitini occupies soft fleshy fruits similar to those that are occupied by the Dacinae in the South Pacific and Asian regions. This fleshy fruit niche is occupied by the genera *Rhagoletis* and *Anastrepha* in the southern Nearctic and Neotropical regions.

The major pest species such as *B. tryoni* and *B. neohumeralis* have a broad forest host range. It is apparent in Australia that this characteristic enabled these species to spread into cultivated fruits introduced by European settlers.

The major natural enemies of the dacine species in the endemic rainforest habitat are the fruit feeding vertebrate animals (Drew, 1987a). There is a large number of canopy and ground dwelling fruit feeders that devour considerable quantities of fruit and cause up to 70 percent reduction in fly populations. The hymenopterous parasites also suffer the same fate and exercise only a small influence in reducing fly populations. It appears that such parasites are not significant mortality factors in the life system of fruit flies in their endemic habitats.

Table 2. Fruit fly species reared from endemic fruits in Australasia and Oceania.

ALANGIACEAE	*B. aurea*
ANACARDIACEAE	*B. hastigerina*
	B. jarvisi
	B. murrayi
	B. tryoni
ANNONACEAE	*B. endiandrae*
	B. halfordiae
	B. kraussi
	B. neohumeralis
	B. tryoni
APOCYNACEAE	*B. alyxiae*
	B. tryoni
ARECACEAE	*B. aquilonis*
ASCLEPIADACEAE	*D. absonifacies*
	D. aequalis
	D. hardyi
	D. secamoneae
BARRINGTONIACEAE	*B. barringtoniae*
	B. jarvisi
	B. signatifera
	B. xanthodes
CAESALPINIACEAE	*B. moluccensis*
CAPPARIDACEAE	*B. musae*
	B. neohumeralis
	B. signatifera
	B. tryoni
CELASTRACEAE	*B. neohumeralis*
	B. tryoni
CHRYSOBALANACEAE	*B. aquilonis*
	B. endiandrae
	B. jarvisi
COMBRETACEAE	*B. aquilonis*
	B. eximia
	B. frauenfeldi
	B. jarvisi
	B. kirki
	B. laticaudus
	B. mayi
	B. neohumeralis
	B. terminaliae
	B. tryoni
CUCURBITACEAE	*B. bryoniae*
	B. chorista
	B. cucumis
	B. cucurbitae
	B. trichota
	B. atrisetosa
	D. axanus
	D. petioliforma
CUNONIACEAE	*B. halfordiae*
	B. kraussi
	B. tryoni

DAVIDSONIACEAE	*B. tryoni*
EBENACEAE	*B. diospyri*
	B. manskii
	B. tryoni
ELAEOCARPACEAE	*B. aquilonis*
	B. cacuminata
EUPHORBIACEAE	*B. breviaculeus*
	B. cucumis
	B. kraussi
	B. laticaudus
	B. neohumeralis
	B. tryoni
FLACOURTIACEAE	*B. kraussi*
GUTTIFERAE	*B. barringtoniae*
	B. bullata
	B. calophylli
	B. expandens
	B. melanoscutata
	B. visenda
ICACINACEAE	*B. kraussi*
	B. nigra
LAURACEAE	*B. aberrans*
	B. endiandrae
	B. kraussi
	B. neohumeralis
	B. nigra
	B. nigrovittata
	B. terminaliae
	B. tryoni
MELIACEAE	*B. aglaiae*
	B. aquilonis
	B. atrisetosa
	B. cacuminata
	B. jarvisi
	B. tryoni
MENISPERMACEAE	*B. tinomiscii*
MORACEAE	*B. bancroftii*
	B. halfordiae
	B. murrayi
	B. tryoni
	B. umbrosa
MUSACEAE	*B. musae*
MYRTACEAE	*B. aquilonis*
	B. fagraea
	B. frauenfeldi
	B. halfordiae
	B. jarvisi
	B. kraussi
	B. musae
	B. neohumeralis
	B. obliqua
	B. tryoni
NAUCLEACEAE	*B. neohumeralis*
	B. pallida
	B. tryoni
OLEACEAE	*B. jarvisi*
	B. kraussi
	B. neohumeralis
	B. nigra
	B. tryoni
OPILIACEAE	*B. opiliae*
PASSIFLORACEAE	*B. bryoniae*
	B. melas
	B. neohumeralis
	B. tryoni
POTALIACEAE	*B. fagraea*
RHAMNACEAE	*B. tryoni*
RHIZOPHORACEAE	*B. decurtans*
RUBIACEAE	*B. luteola*
RUTACEAE	*B. aquilonis*
	B. halfordiae
	B. kraussi
	B. neohumeralis
	B. tryoni
SAPINDACEAE	*B. aglaiae*
	B. kraussi
	B. neohumeralis
	B. tryoni
SAPOTACEAE	*B. distincta*
	B. frauenfeldi
	B. halfordiae
	B. jarvisi
	B. laticaudus
	B. mayi
	B. mendosa
	B. neohumeralis
	B. pulchra
	B. tenuifascia
	B. tryoni
SIPHONODONTACEAE	*B. tryoni*
SMILACACEAE	*B. halfordiae*
	B. tryoni
SOLANACEAE	*B. cacuminata*
	B. dapsiles
	B. neohumeralis
	B. nigrovittata
	B. tryoni
STRYCHNACEAE	*B. bryoniae*

	B. manskii
SYMPLOCACEAE	*B. nigra*
THYMELAEACEAE	*B. halfordiae*
	B. kraussi
	B. phaleriae
VITACEAE	*B. tryoni*
XANTHOPHYLLACEAE	*B. tinomiscii*

ADULT BEHAVIOUR

The host plant is the focal point of activity of fruit flies, and the relationship of the flies to their host involves host seeking, adult feeding, egg development, mating behaviour and oviposition.

The adults feed within the host tree on certain bacteria which supply nutrients for development to sexual maturity (Drew et al., 1983; Courtice and Drew, 1984). The first flies to arrive in the host tree when fruit become susceptible to oviposition are primarily immature females and sexually mature males (Drew and Lloyd, 1987). The flies introduce bacteria of the family Enterobacteriaceae onto the fruit surfaces. Within 7–14 days most fruits have a heavy growth of "fruit fly type" bacteria. The nutrient supply for such bacteria colonisation is provided by leachates, defined as chemicals (inorganic and organic) that occur within a plant and which exude onto the plant surface (Tukey, 1971). Leaching is prominent on soft fleshy fruits when they begin to ripen and is heavy under conditions of wetting during light rain, dew and cloud mist (Tukey, 1971). In tropical and subtropical regions there are usually 2 distinct seasons, a warm wet season and a cool dry season. During the dry there is a build up of soluble nitrogen in the soil which then becomes available to the plant in the wet season, increasing the soluble nitrogen concentration in the sap (Courtice and Drew, 1984; White, 1984). Such increase in nitrogen flow is significant in causing an increase in survival and abundance of phytophagous insects (White, 1984). The nitrogen flow from the soil is important in increasing the nitrogen in the leachates (Courtice and Drew, 1984) which in turn benefits bacteria colonisation of the fruit surfaces. Thus, the increased leaching and bacterial growth during a warm wet season may have the effect of concentrating nitrogen on the plant surface and influencing dacine activity.

Egg development and mating occur within the host tree (Drew and Lloyd, 1987). Protein food is an essential prerequisite to both activities, further emphasising that the flies are feeding within the host plant. Studies on feeding in a mulberry tree in Brisbane (Drew et al., 1983) have shown that females contain different crop contents (in colour and bacteria content) from males and that females feed on the fruit surfaces. The males do not feed upon the fruit surfaces and have different nutritional requirements (Drew, 1987b).

Considering that immature females and mature males are the stages mostly attracted to host trees, that each sex has different feeding sites and nutritional requirements, that females feed on the host fruit surfaces and mating occurs in the host trees (Drew, 1987b), it is possible that the host tree stimuli that attract the flies to the tree are food attractants to the female and sex attractants to the male. These stimuli could be both visual and olfactory, however, visual stimuli would seem insignificant in the endemic rainforest habitat where flies must locate host fruit scattered randomly throughout a dense forest canopy. On the other hand, the Dacinae are known to respond to various odours, e.g., a range of male lures (Drew, 1974b; Drew and Hooper, 1981), ammonia (Bateman and Morton, 1981) and certain bacterial emissions (Keiser and Wakabayashi, 1981; Drew, unpub. data). It seems that host odours are significant in attracting flies to the plants, and because the flies arrive when the fruit reaches a particular stage, host fruit odours may be particularly significant. Chemicals such as 2-butanone (the most attractive part of the cue lure molecule) have been recorded from fresh fruit (Nursten, 1970) and are emitted by some "fruit fly type" bacteria growing on proteinaceous substrates (Drew, 1987b).

The exact site of origin of plant chemicals that attract flies to hosts is unknown. However, the possibility exists that some attractants are produced by bacteria growing on fruit surfaces. It is also possible that the biological significance of the male fruit fly attractants is in these host plant odours attracting sexually mature males into the host plants to ensure mating success (Drew, 1987b).

Host plant odours are long distance attractants drawing the immature females and mature males into the trees. Following that, the short distance male pheromones are involved in mating behaviour. Observations on *B. tryoni* have shown that males position themselves under leaves at dusk, push their wings over the anal area using the hind legs and then vibrate the wings, apparently dispersing pheromone from the rectal sac. This procedure is repeated many times and the male often turns around in a circle observing females that are attracted to adjacent leaves. Eventually the male either mates with 1 of the females or, if no females are attracted within 30–60 minutes, departs to another leaf. This combination of host plant

odours and male pheromones would fall into the category of Specific-Mate Recognition Systems (SMRS) proposed by Paterson (1985) as essential in drawing the sexes together as the central basis of an alternative view of species — the Recognition Concept.

The long-accepted theory of genetic species, due to Dobzhansky and Mayr, espouses the view that reproductive isolating mechanisms develop within two or more parts of an originally interbreeding population. These "isolating mechanisms" then act as a barrier to gene flow thus resulting in the evolution of separate species. Although this isolation theory has been called the biological species concept, most discussions on the topic ignore basic biology and concentrate on genetic aspects. While genetic changes are essential in speciation, it is probable that an understanding of the biology of organisms will throw greater light on the processes of natural selection. For example, one could expect that a change in the reproductive behaviour of a portion of an existing species is a necessary precursor to the development of another species. Under the biological species concept, reproductive behaviour is viewed as ethological isolation, ignoring the obvious fact that this behaviour clearly relates to the achieving of intraspecific fertilization. It is a relational concept in which 2 isolated populations have, at some stage, shared a common reproductive behaviour. Consequently, such speciation could only have occurred in sympatry.

Bush (1974) proposed a genetic model for speciation based on host recognition. However, the majority of the Dacinae are single host species and the host plant is the significant rendezvous and mating site. For speciation, therefore, mate recognition is the primary biological advantage of host recognition. There are also other mate recognition systems that exist within the host plant. For example, 2 *dorsalis* complex species in Malaysia mate within the same host but never interbreed (Drew, unpubl. data). Each species possesses a markedly different male pheromone that is released at dusk during courtship. With such species, host recognition is not alone sufficient and specific-mate recognition factors must be employed. Bush's views have recently come under critical reassessment (Futuyma and Mayer, 1980; Paterson, 1981; Jaenike, 1981).

The more that biological factors associated with reproduction in fruit flies are understood, the clearer becomes the Recognition Concept of Species proposed by Paterson (1985). In the dacine sibling species that we have studied, no reproductive isolating mechanism exists or, where one appears to exist, it is environmentally dependent and easily destroyed. For example, there are documented cases of hybridisation of species such as *B. neohumeralis* and *B. tryoni* in the laboratory and disturbed environments. It is difficult to imagine that speciation could have such a tenuous basis. In contrast, mate recognition within the host plant is very secure in restricting gene flow and reproductive isolation is probably a by-product.

Speciation in the Dacinae is more easily understood in the development of a new fertilization system (or mating population) closely integrated with a host. The prolific speciation in tropical rainforest plants, the endemic habitat of the Dacinae, has provided unlimited opportunity for accompanying speciation in these flies. Each plant species provides a potential niche into which flies can adapt and develop fertilization systems prior to the development of a new species.

Another difference of the Recognition Concept of Species is that it is not a relational concept as it involves speciation in allopatry. Sympatric speciation faces many genetical difficulties as has been demonstrated by Futuyma and Mayer (1980), Paterson (1981) and Jaenike (1981). Defining species in terms of fertilization systems which have evolved to bring about fertilization offers a new and effective way of viewing dacine reproductive behaviour.

The role of SMRS on speciation within the Dacinae is an area deserving research. It is possible that as a population adapts to the odours emitted by a new host plant and its fruit, to which it has been confined in allopatry, it diverges into a species. This would mean that speciation is due to adaptation of responses to particular host plant odours. For example, *B. musae* and *B. tinomiscii* are 2 sympatric sibling species in Papua New Guinea, identifiable only by scanning electron microscopy of the ovipositor. Each species has a different host fruit and the ovipositor is adapted accordingly. Host plant odours are probably central to specific-mate recognition in the development and maintenance of these species. Indeed, the many closely related species described in the 20 species complexes in this monograph are best explained on the basis of responses to specific hosts and host odours. In the Dacinae, members of a species share a common Fertilization System within the normal habitat (host plant) and therefore the habitat is an essential part of the speciation system.

The information described above reflects the importance of biological data to taxonomic studies

and how a knowledge of host plants can be valuable in defining sibling species of Dacinae.

GEOGRAPHIC DISTRIBUTION

The Dacinae are distributed throughout the tropics and subtropics of the world. Munro (1984) and Hancock (1985) recorded 182 species in Africa while 290 species are recorded in this monograph, covering the South Pacific area from Papua New Guinea and Australia, east to the Society Islands. It is estimated that the Asian and South East Asian fauna will comprise approximately 200 species. Except for *B. oleae*, the only species in the Mediterranean region, the subfamily is restricted to regions of alternating cool dry and warm wet seasons.

The distribution of species is closely linked to that of their host plants. In Africa, most species occur in open woodland (or savannah) with only a few species (those placed in subgenus *Dacus*) occurring in rainforests (Hancock, 1986). This habitat contains the major hosts, Asclepiadaceae and Cucurbitaceae. In Asia, South East Asia and the South Pacific, most species occur in the rainforest habitat where they breed in the soft fleshy fruits of many plant families. Within such areas, some species are restricted, due to the limited distribution of a particular host. For example, *B. halfordiae* occurs in the eastern area of Australia from south-east Queensland to Sydney, breeding in *Planchonella australis* in the higher altitude forests.

Within Australia, the Dacinae occur in 2 geographically isolated zones, viz., the northwestern zone (comprising the northern parts of Western Australia and the Northern Territory) and the northeastern zone (the eastern coastline from Cape York in Queensland to East Gippsland in the south). There are some species that occur in both zones and others that are endemic to one zone. Because of the economic importance of the Dacinae, the species recorded from each Australian zone are listed in Table 3.

Table 3. Species of Dacinae recorded from 2 geographically isolated zones in Australia.

Northwestern Zone

Genus *Bactrocera*	Genus *Dacus*
B. allwoodi	*D. axanus*
B. aquilonis	*D. bellulus*
B. bryoniae	*D. hardyi*
B. cucumis	*D. newmani*
B. decurtans	*D. secamoneae*
B. diospyri	
B. jarvisi	
B. mendosa	
B. opiliae	
B. pallida	
B. parafrauenfeldi	
B. signatifera	
B. tenuifascia	

Northeastern Zone

Genus *Bactrocera*

B. aberrans	*B. kraussi*
B. abscondita	*B. laticaudus*
B. aeroginosa	*B. manskii*
B. aglaiae	*B. mayi*
B. alyxiae	*B. melanothoracica*
B. amplexiseta	*B. melas*
B. antigone	*B. mendosa*
B. aurantiaca	*B. murrayi*
B. aurea	*B. musae*
B. bancroftii	*B. mutabilis*
B. barringtoniae	*B. neohumeralis*
B. batemani	*B. nigra*
B. bidentata	*B. notatagena*
B. breviaculeus	*B. pallida*
B. brunnea	*B. peninsularis*
B. bryoniae	*B. perkinsi*
B. cacuminata	*B. phaleriae*
B. calophylli	*B. pulchra*
B. chorista	*B. quadrata*
B. cucumis	*B. robiginosa*
B. decurtans	*B. romigae*
B. endiandrae	*B. rufescens*
B. erubescentis	*B. rufofuscula*
B. exigua	*B. russeola*
B. expandens	*B. salamander*
B. fagraea	*B. signatifera*
B. fallacis	*B. silvicola*
B. frauenfeldi	*B. strigata*
B. fuliginus	*B. strigifinis*
B. halfordiae	*B. tigrina*
B. hispidula	*B. tryoni*
B. humilis	*B. unirufa*
B. jarvisi	*B. visenda*

Genus *Dacus*

D. absonifacies	*D. palmerensis*
D. aequalis	*D. petioliforma*
D. axanus	*D. pusillus*
D. bellulus	*D. secamoneae*
D. concolor	*D. signatifrons*
D. newmani	

Eleven species are common to both areas, 7 are endemic to the northwestern and 66 endemic to the northeastern zone. Some are closely related, indicating that speciation has occurred between the 2 areas now isolated by a large arid/semiarid land mass, which runs from the Gulf of Carpentaria to the southern and western coastlines of the continent. Species pairs exhibiting such relationships are *B. aquilonis–B. tryoni*, *B. decurtans–B. murrayi*, *B. opiliae–B. endiandrae*, *B. parafrauenfeldi–B. frauenfeldi*, *B. tenuifascia–B. mayi*.

In addition, *B. diospyri* in the northwestern zone is closely related to *B. exspoliata* in Papua New Guinea, while a large number of species in the northeastern zone either occur or are closely related to species, in Papua New Guinea.

Attractants

A large number of Dacinae have been attracted to 1 of the male attractants (cue lure, methyl eugenol). Each species responded to only 1 lure while some did not respond to any.

In the region from Asia to the South Pacific, dacine species respond to both cue lure and methyl eugenol. In Africa, species of Dacinae are attracted to cue lure but not to methyl eugenol. In that region, the methyl eugenol responding species belong to the tribe Ceratitini (subfamily Ceratitinae), which also occupy the soft fleshy fruits of the type utilised by the Dacinae in Asia, South East Asia and the South Pacific. This also supports the thesis that the male lures have their origins in host plant odours.

In the division of the Dacinae into 2 genera, viz., *Dacus* (fused abdominal terga species typified by the African fauna) and *Bactrocera* (free abdominal terga species), the lure responses are significant. Species of *Dacus* (except *D. memnonius* and *D. pusillus*) respond only to cue lure while *Bactrocera* species respond to either cue lure or methyl eugenol. Some subgenera of *Bactrocera* do not contain any species that respond to lures, viz., *Austrodacus*, *Diplodacus*, *Heminotodacus*, *Hemiparatridacus*, *Hemisurstylus*, *Hemizeugodacus*, *Melandacus*, *Queenslandacus*.

DEVELOPMENT OF THE ECONOMIC FRUIT FLY PROBLEM IN AUSTRALIA

European settlement began in Australia, in the area now known as Sydney, in 1788. Since that time, major changes have been made to the environment of endemic Australian animals and plants. This, in turn, has caused significant changes in the distribution and abundance of many endemic insect species. Significantly, some species have become serious pests of introduced food crops. Several species of fruit fly fall into this category, the most important of which is the Queensland fruit fly (*B. tryoni*). The historical development of the fruit fly problem in Australia becomes primarily a study of the evolution of *B. tryoni* as a pest species along the eastern coastline.

From the first years of settlement, extensive plant introductions took place. A large range of vegetable and fruit plants were well established by the turn of the 19th century (Wentworth, 1819). Although some crops were suffering insect problems, the fruit trees known today as major fruit fly hosts, e.g. peaches, plums, apricots, mulberry, apples and oranges, had no recorded fruit losses due to insect attack (Wentworth, 1819). Indeed, in describing the Colonial garden, Wentworth noted that peaches, apricots, nectarines, oranges, grapes, pears, plums and melons grew to maturity in very great abundance and that peaches were the most abundant of all. There were enough peach varieties to allow fruiting from November to March and fruit production was so plentiful that it was used for pig food, while peach cider was produced in great quantities. This indicates that in the Sydney area, from settlement to 1819, no fruit fly problems were experienced.

The earliest record of fruit fly damage in south-east Queensland was at Toowoomba in 1853 (Tryon, 1889). Tryon records that the fly "has been known as a pest on the Darling Downs ever since fruit has been grown there". A village was first built at the location now known as Toowoomba in 1849 and this settlement declared a town in 1860. It would appear, therefore, that fruit fly was a problem in that area as soon as the first fruit trees were bearing. Tryon also reports that at Toowoomba in 1869 "not only were the stone fruits destroyed by the fruit fly, but even the guavas also". Jarvis (1925) recorded damage to deciduous crops in Brisbane as early as 1864. Although the Moreton Bay settlement (now known as Brisbane) began in 1824, the climate of the area is not conducive to the growing of good deciduous fruit crops, in contrast to the more temperate climate of Toowoomba. It is possible, therefore, that the fruit fly did not make the same impact in the Brisbane area although it must have been present.

The earliest record of fruit fly in New South Wales is provided by Farwell (1973), quoting Edward Ogilvie reporting in his diary in mid-February 1853 "I made the agreeable discovery that the maggot, which has hitherto confined its ravages to the peaches and apples, has now found out that grapes will also suit its taste". Ogilvie lived on the

Clarence River and from this we can assume that the fly was active in north-east New South Wales prior to 1853. Tryon (1889) recorded that fruit fly grubs were noticed in peaches as early as 1853 at Kiama, south from Sydney. Tryon also reported a Mr. MacStay, an experienced horticulturist, stating that "the fruit growing in the gardens in the district of Sydney was not worth gathering, owing to the extent to which it would be infested by the fruit fly maggot", when much rain was about. This record must have been prior to 1889. Froggatt (1909) noted that fruit fly was a pest in New South Wales as early as 1852.

Birch (1965) suggested that *B. tryoni* underwent genetic change by hybridising with *B. neohumeralis* and consequently moved south from Queensland to invade Sydney in 1895 and East Gippsland (Victoria) in 1947. This chronology is not supported by the data given above.

The earliest known Dacinae collected in Australia are 2 specimens of *B. halfordiae* in the Macleay collection, University of Sydney. These were collected in the Sydney area, sometime between 1830 and 1850. An important wild host of this species, *Schizomeria ovata*, is endemic to the Sydney region. *B. halfordiae* has never been recorded from peaches and has a temperate distribution, ranging from Sydney to south-east Queensland and in the northern limits it occurs mostly at higher altitudes. There is little doubt that *B. halfordiae* was the only endemic Dacinae along the central and southern New South Wales coastline before European settlement. Even as late as Froggatt (1910), this species was being incorrectly called *B. tryoni* in the Sydney area, although the latter species was described by Froggatt (1897). A large series of specimens labelled "Narara, 4.2.1910, from White Ash berries", in the N.S.W. collection, are *B. halfordiae* and incorrectly identified as *B. tryoni*.

The early records of fruit fly problems in commercial fruits in south-east Queensland and coastal New South Wales could only be due to either *B. tryoni* or *B. neohumeralis*, or both. These species coexist in some of the same endemic rainforest fruits which occur throughout eastern Queensland and north-east New South Wales (e.g. *Drypetes australasica* [Muell. Arg.] Pax and K. Hoffman) and so there is no reason to assume that introduced fruit cultivation has brought them together to hybridise as stated by Birch (1965). The theory that such hybridisation was important in producing a more cold tolerant *B. tryoni* which hastened its southern spread is most unlikely. *B. neohumeralis* appears more tropical, having colonised the northern tropical lands such as Papua New Guinea and the Torres Strait islands where *B. tryoni* does not exist. From Cape York to south-east Queensland, both species occur in equal numbers in cue lure trap catches and often in fruit infestations. It has also been demonstrated by Gee (1969) that each species has an entirely different daily mating period and Meats (1976) has shown that *B. tryoni* has a natural ability to survive low temperatures.

It appears that *B. tryoni* and *B. neohumeralis* are endemic in the tropical and subtropical rainforests of the eastern coastal areas of Queensland and northern New South Wales and that *B. tryoni* extended its southern limit to the Sydney area sometime between the period recorded by Wentworth (1819) and the early 1850's recorded by Tryon (1889).

Between 1820 and 1840, European settlements were established along the coastline. This involved major clearing of forests and the growing of introduced commercial fruit plants, especially stone fruits such as peaches. In Queensland and north-east New South Wales, the clearing of lowland rainforests (the endemic habitat of the flies) and the establishment of introduced fruits in the cleared areas provided a more abundant supply of larval food without the natural population reducing mechanisms. The chief mechanisms in the endemic habitat of the fly are the fruit feeding vertebrate animals (Drew, 1987a). Consequently, the populations of *B. tryoni* and *B. neohumeralis* were able to increase unchecked and, in the case of *B. tryoni*, expand southwards as larval food plants became available. As noted under Biology, these same plants are important adult feeding sites also. As long as climatic conditions permit an adequate supply of larval and adult food, in the absence of biocontrol systems, populations of fruit fly species which have potential to exploit commercial fruits will expand in both distribution and abundance.

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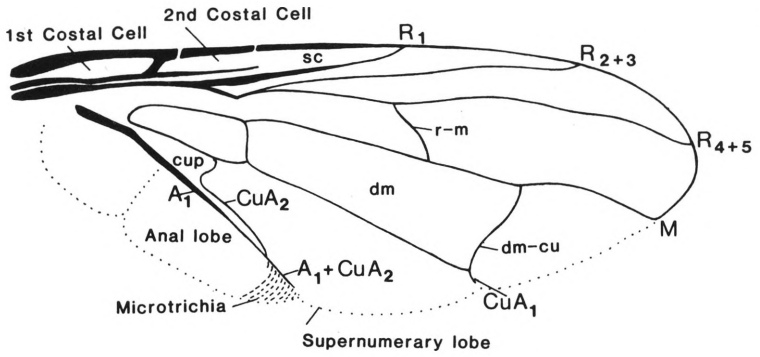


FIG. 1. Terminology used for Dacinae wing venation and cells —

veins
A1, branch of anal vein
CuA1, CuA2, anterior branches of cubitus
dm-cu, discal medial-cubital crossvein
M, media
R1, anterior branch of radius
R2+3, R4+5, combined posterior branches of radius
r-m, radial-medial

cells
cup, posterior cubital
dm, discal medial
sc, subcostal

2

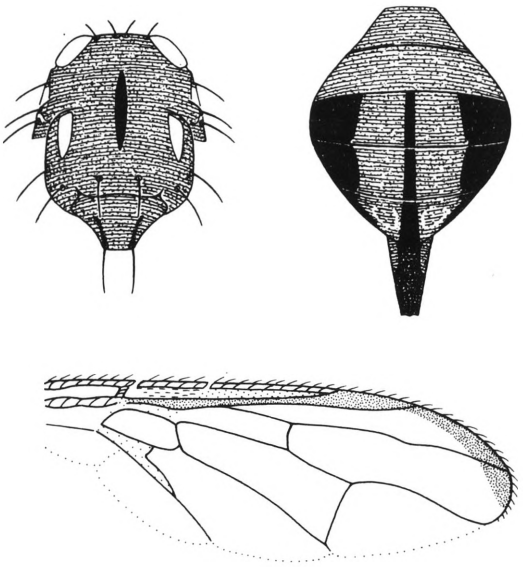
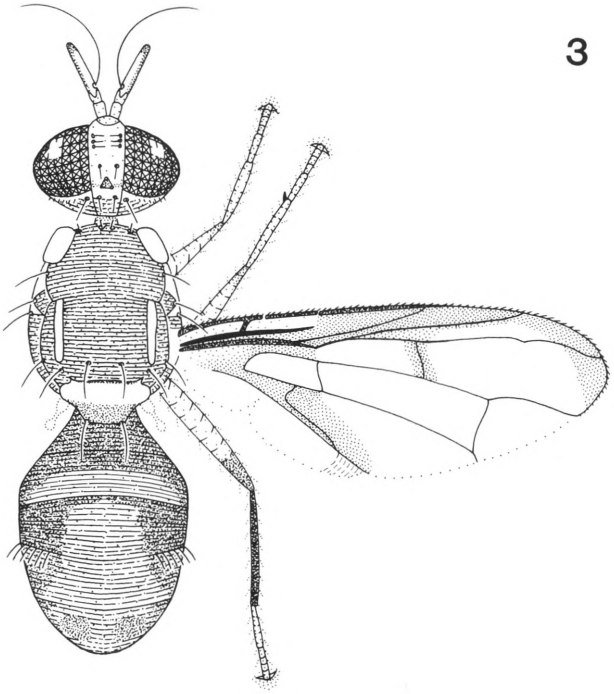
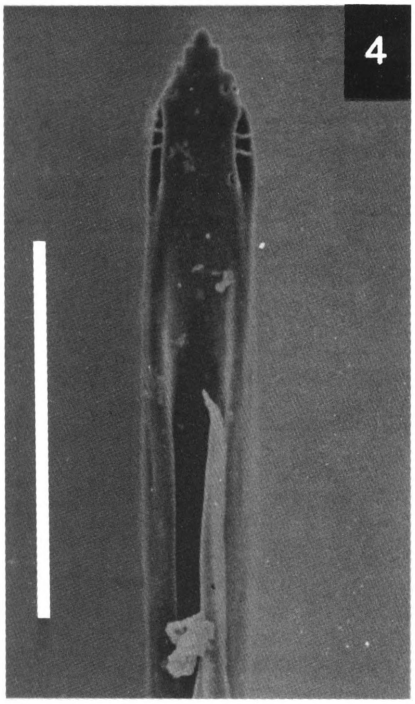
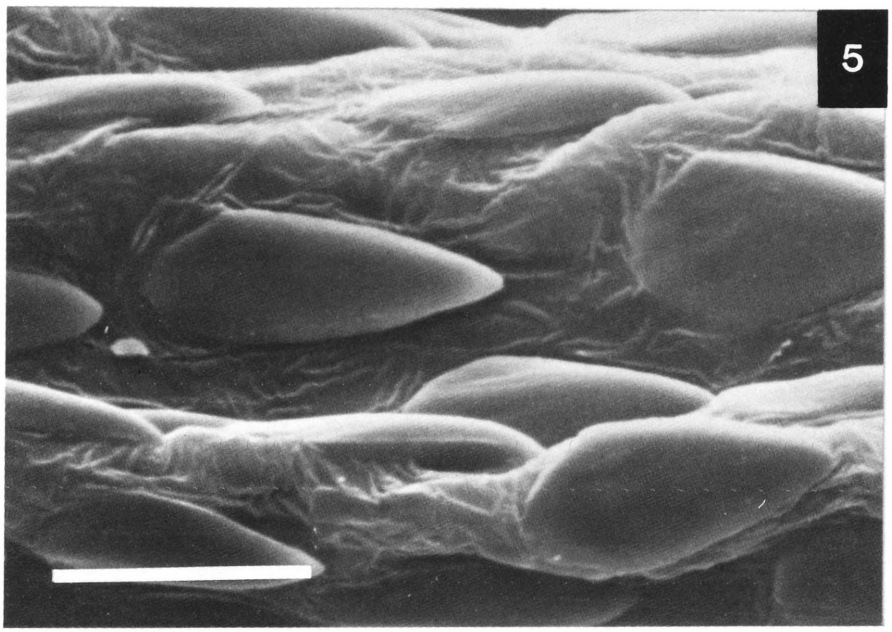


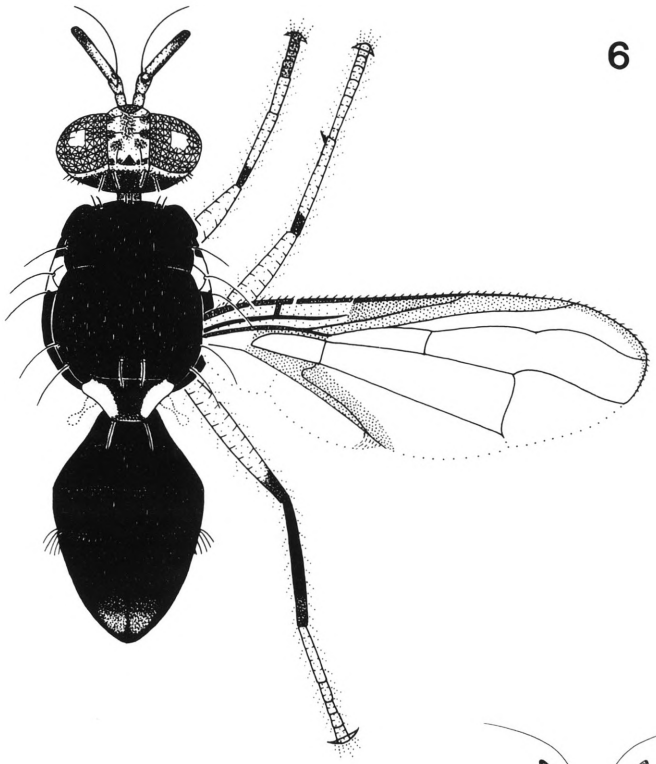
FIG. 2. *Bactrocera* (*Afrodacus*) *aenigmatica* (Malloch), (x13).







FIGS 3–5. *Bactrocera* (*Afrodacus*) *brunnea* (Perkins and May): 3, adult male (x10); 4, apex of aculeus (scale 0.1 mm); 5, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



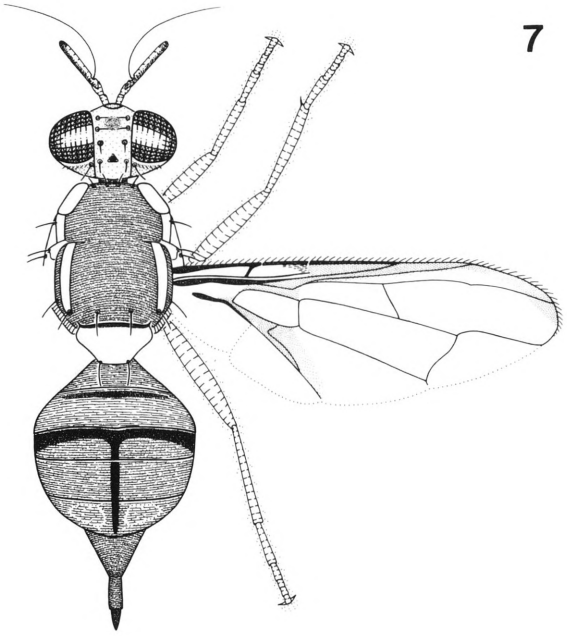
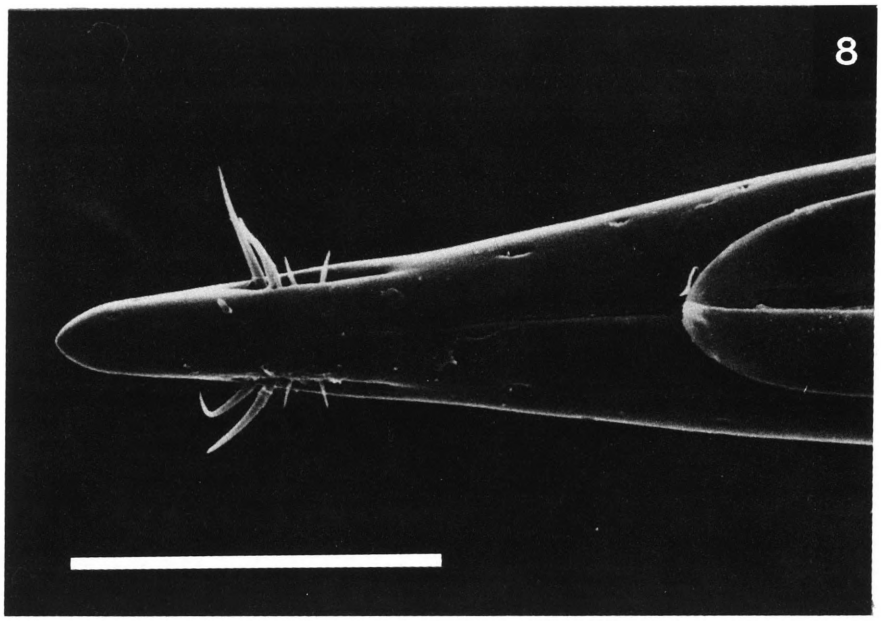
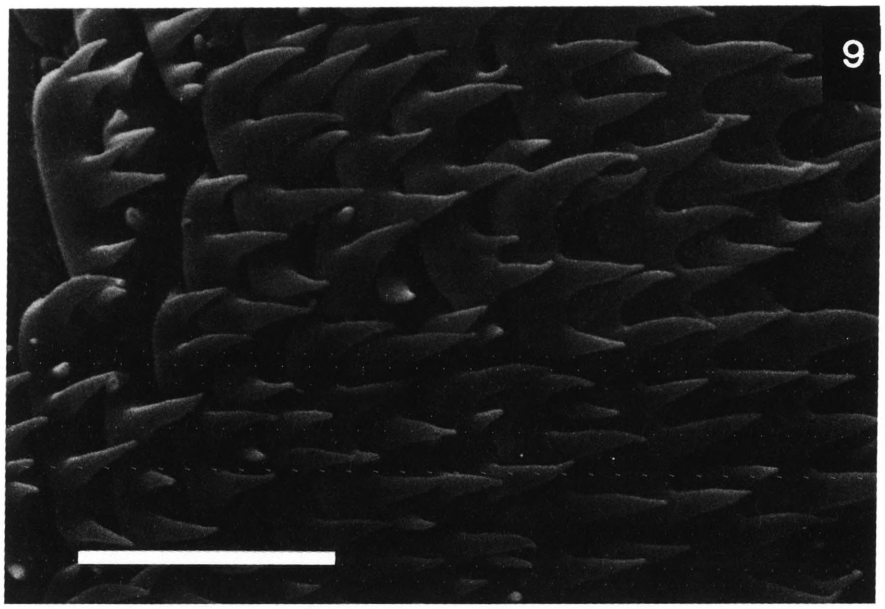


FIG. 6. *Bactrocera* (*Afrodacus*) *hypomelaina* n. sp., adult male (x9). FIG. 7. *Bactrocera* (*Afrodacus*) *jarvisi* (Tryon), adult female (x9).





FIGS 8–9. *Bactrocera* (*Afrodacus*) *jarvisi* (Tryon): 8, apex of aculeus (scale 0.1 mm); 9, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

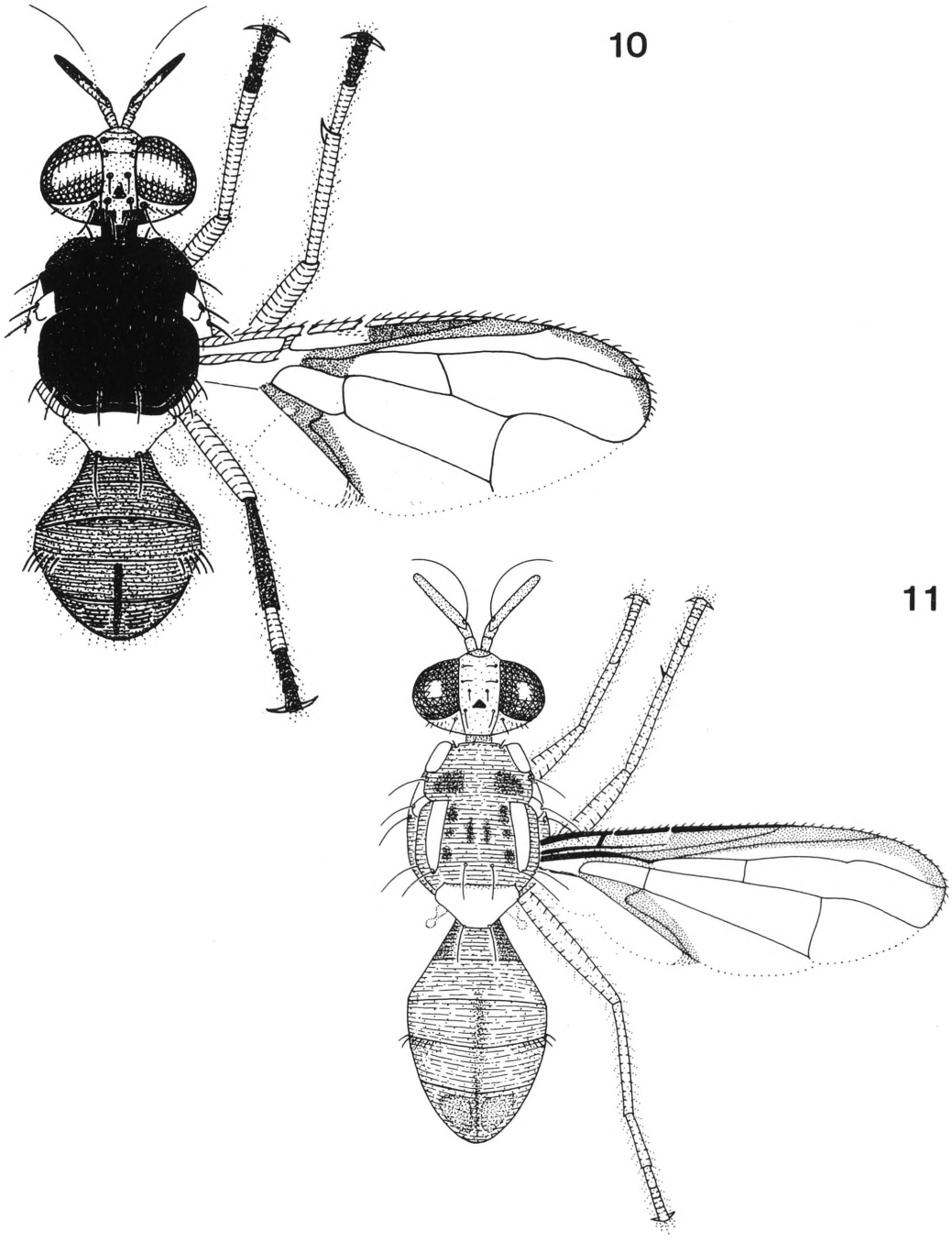
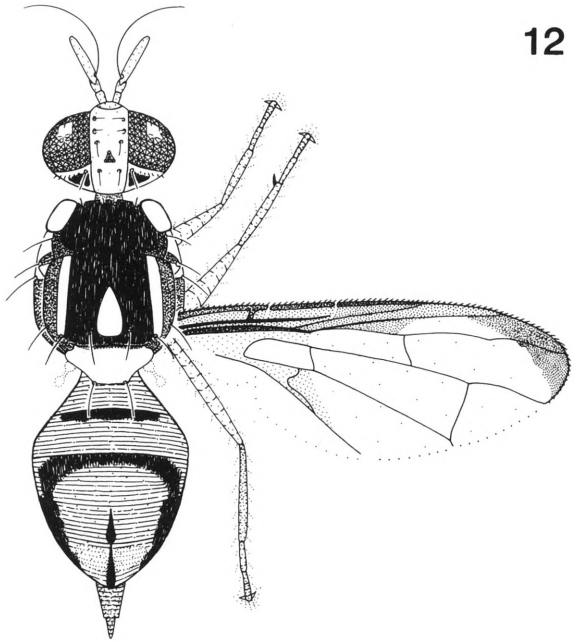
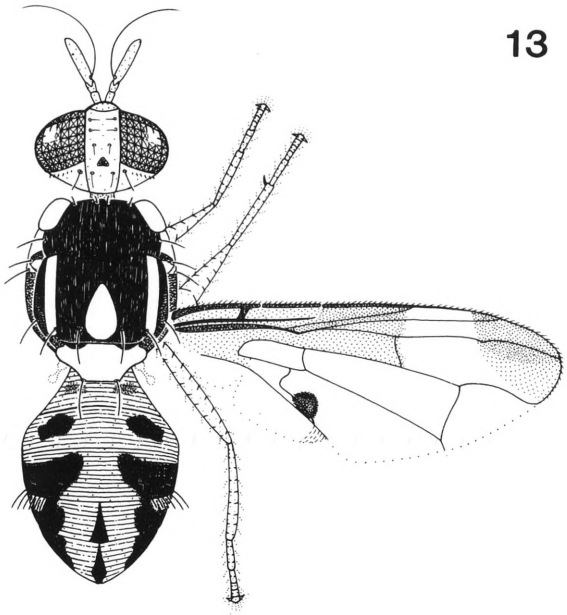
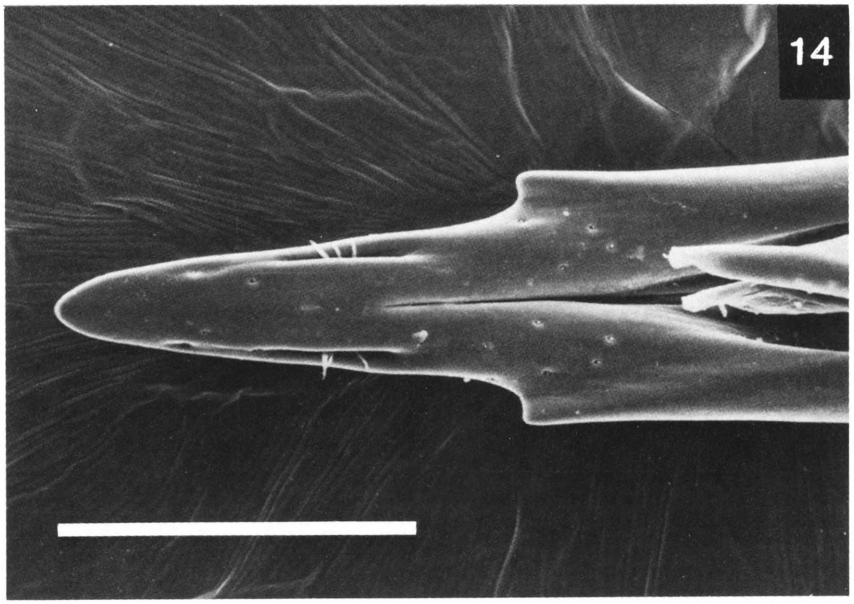


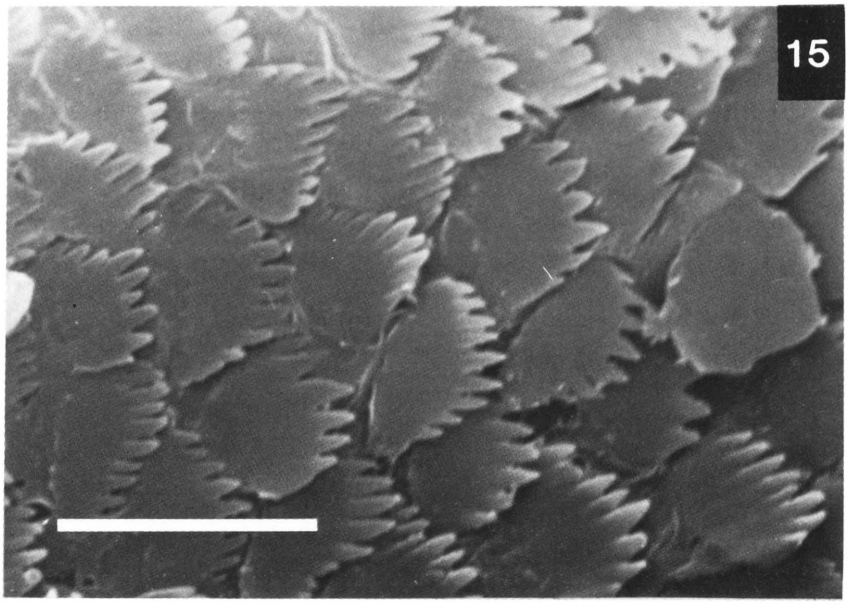
FIG. 10. *Bactrocera* (*Afrodacus*) *minuta* (Drew), adult male (x16). FIG. 11. *Bactrocera* (*Afrodacus*) *ochracea* n. sp., adult male (x11).



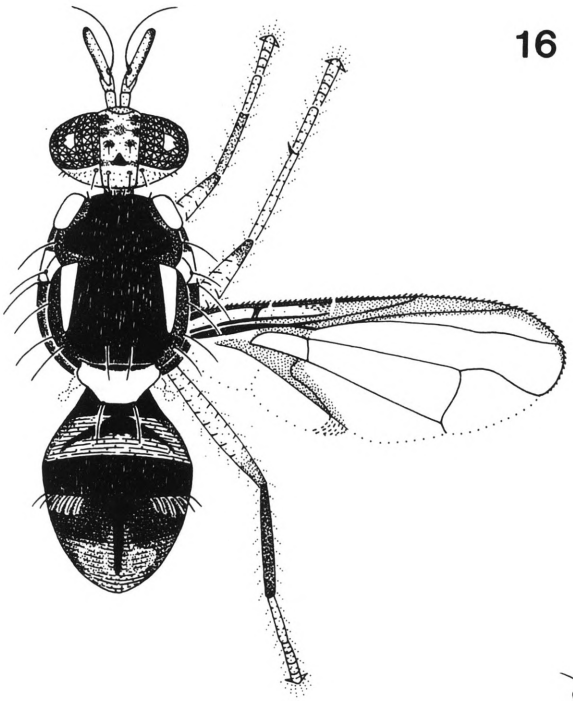


FIGS 12–13. *Bactrocera* (*Afrodacus*) *tigrina* (May): 12, adult female (x12); 13, adult male (x14).





FIGS 14–15. *Bactrocera* (*Afrodacus*) *tigrina* (May): 14, apex of aculeus (scale 0.1 mm); 15, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



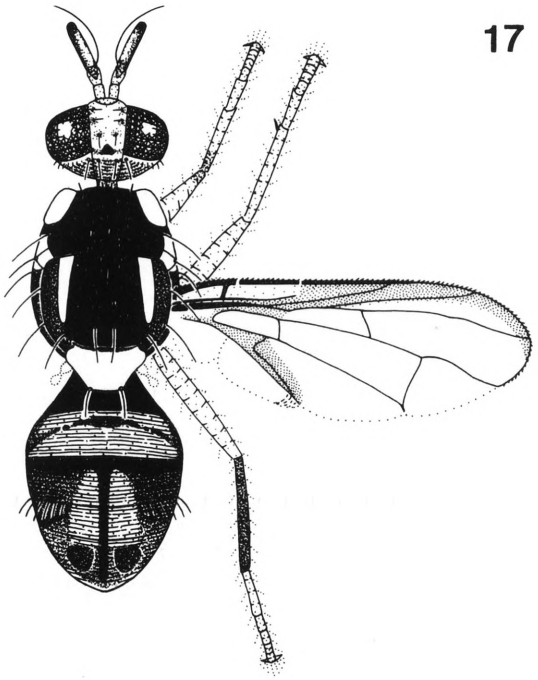


FIG. 16. *Bactrocera* (*Bactrocera*) *aemula* n. sp., adult male (x8). FIG. 17. *Bactrocera* (*Bactrocera*) *consectorata* n. sp., adult male (x7).

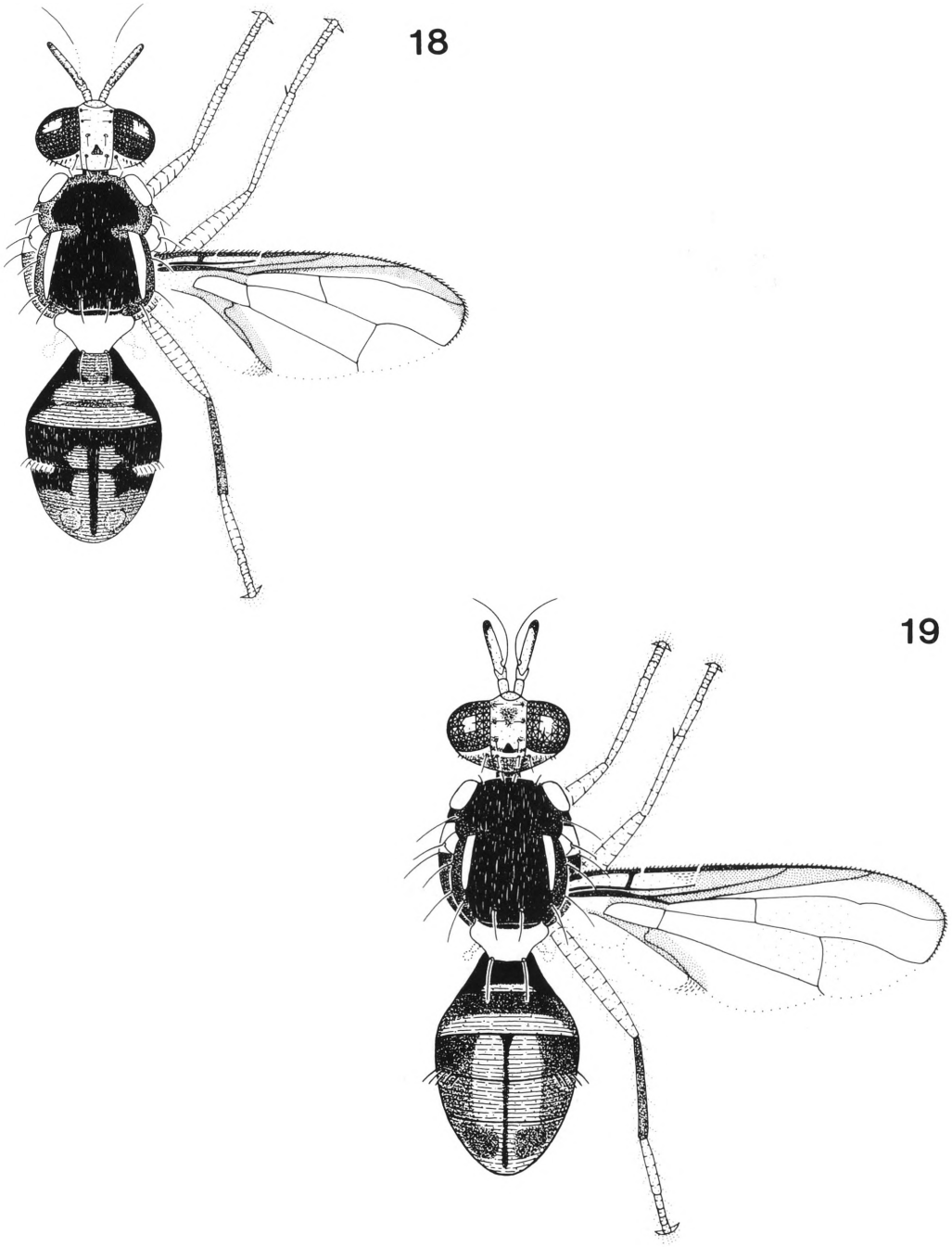
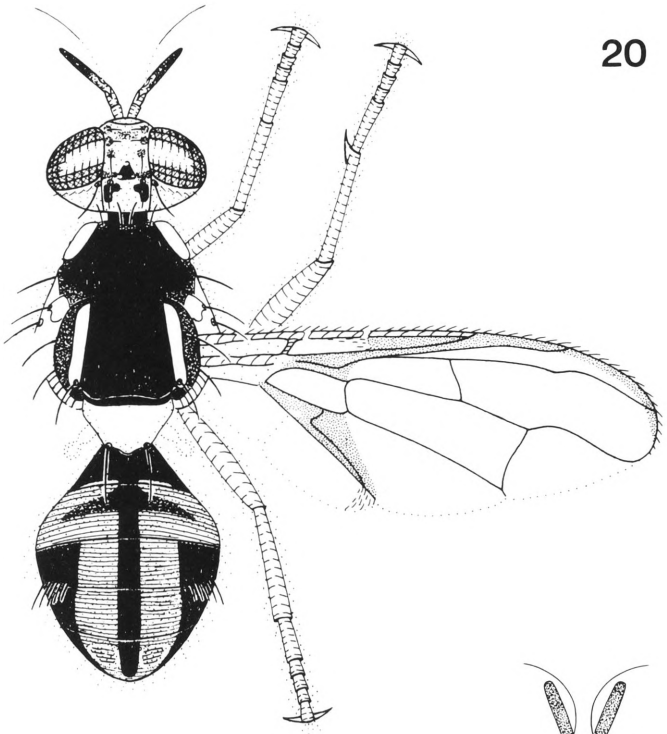


FIG. 18. *Bactrocera* (*Bactrocera*) *fuliginus* (Drew and Hancock), adult male (x9). FIG. 19. *Bactrocera* (*Bactrocera*) *inconstans* n. sp., adult male (x10).



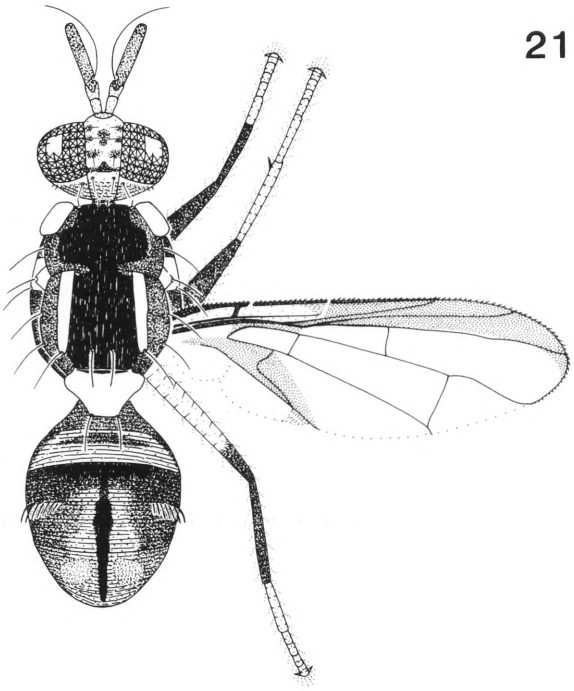
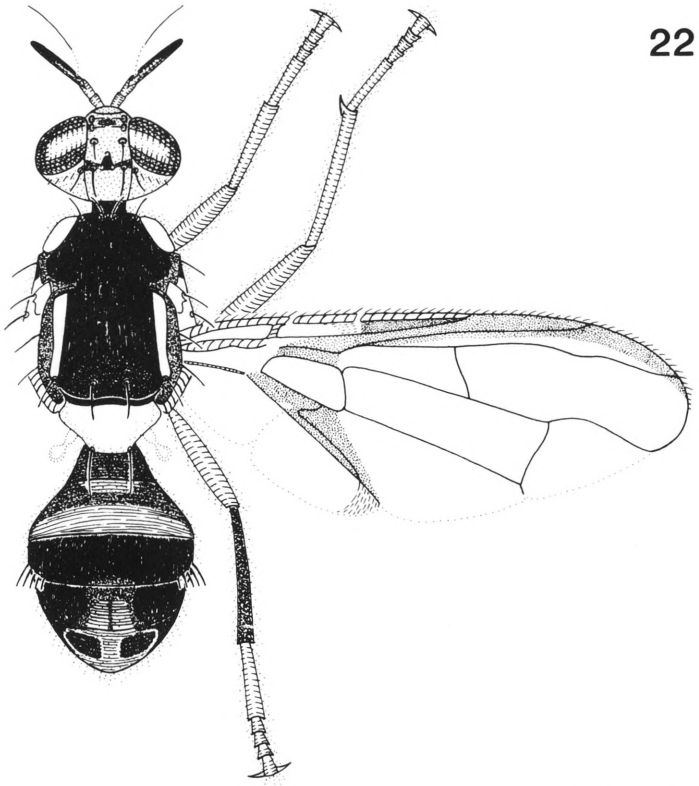
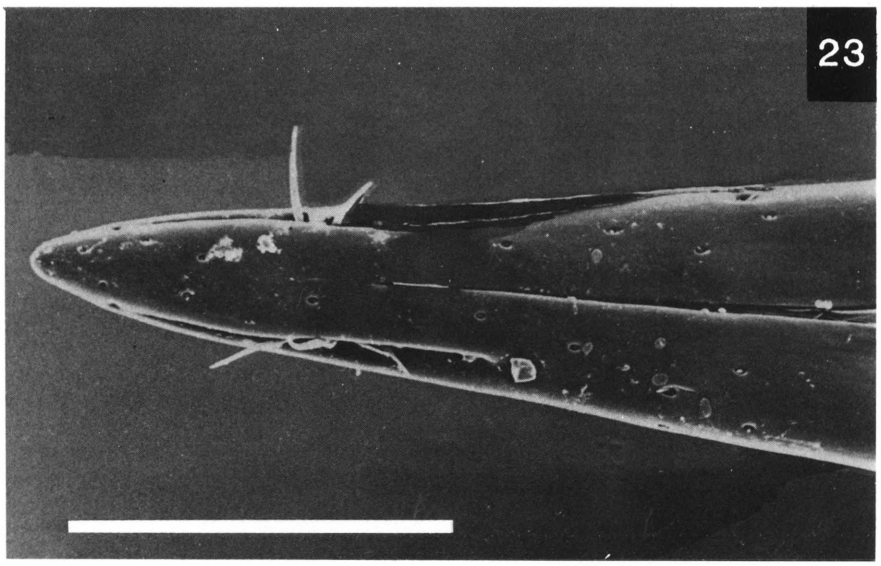
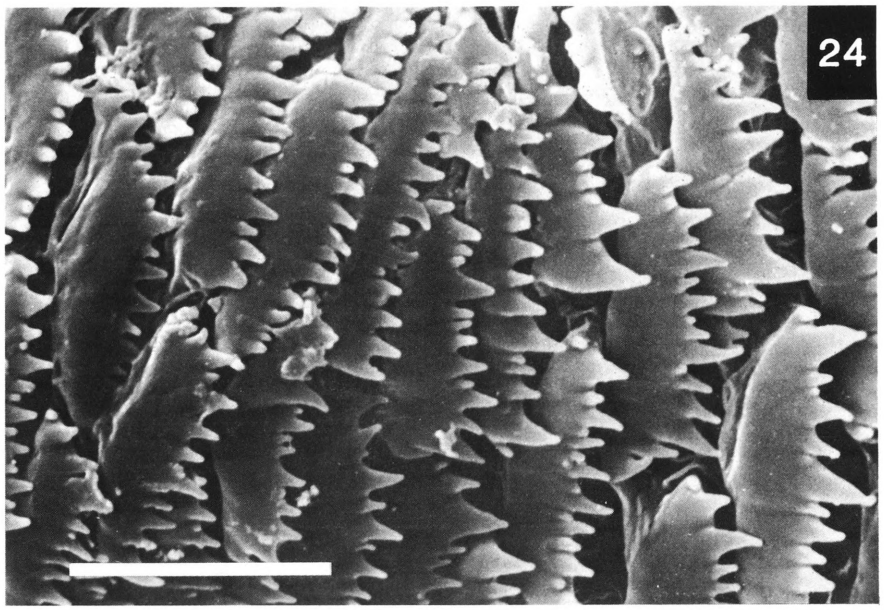


FIG. 20. *Bactrocera* (*Bactrocera*) *indecora* (Drew), adult male (x10). FIG. 21. *Bactrocera* (*Bactrocera*) *laticosta* n. sp., adult male (x8).





FIGS 22–23. *Bactrocera* (*Bactrocera*) *trivialis* (Drew): 22, adult male (x11); 23, apex of aculeus (scale 0.1 mm).



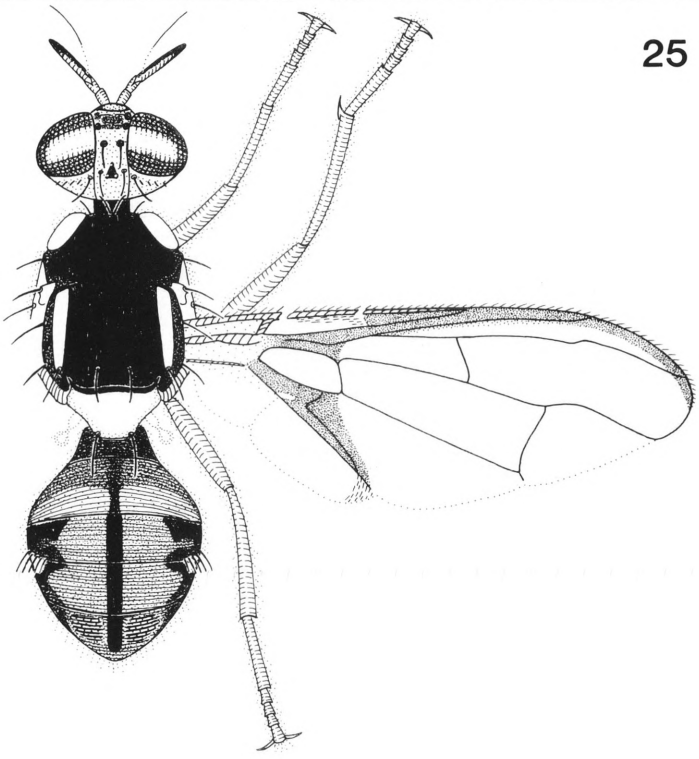
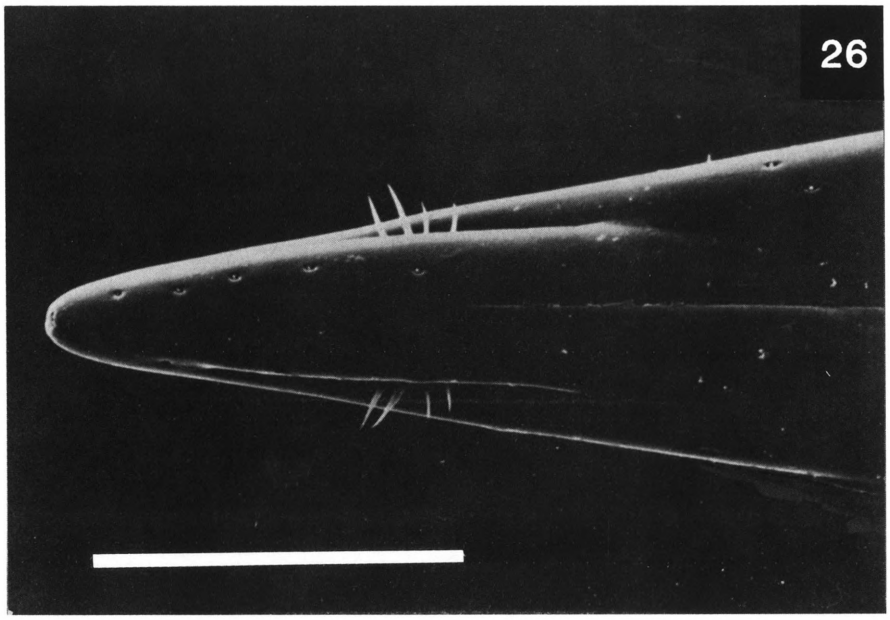
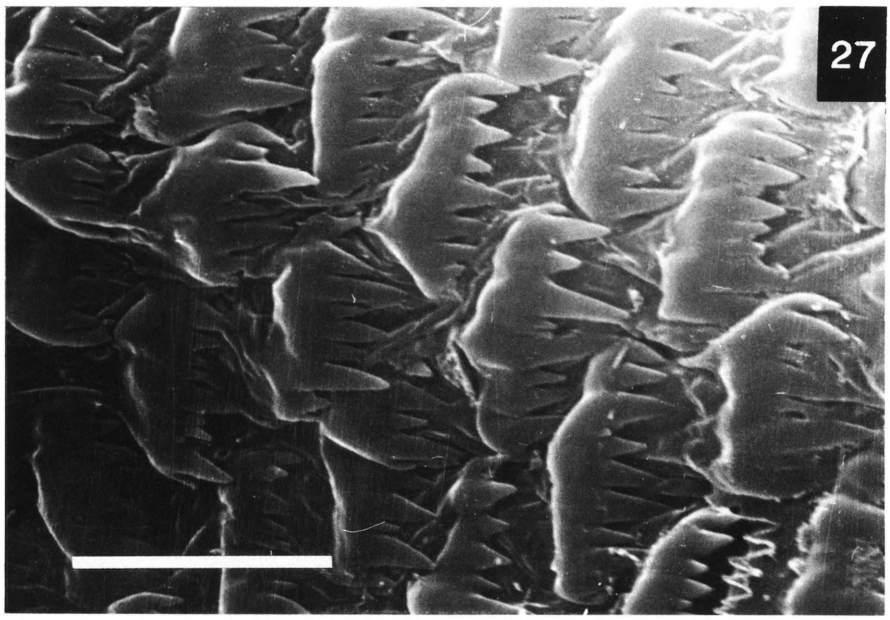
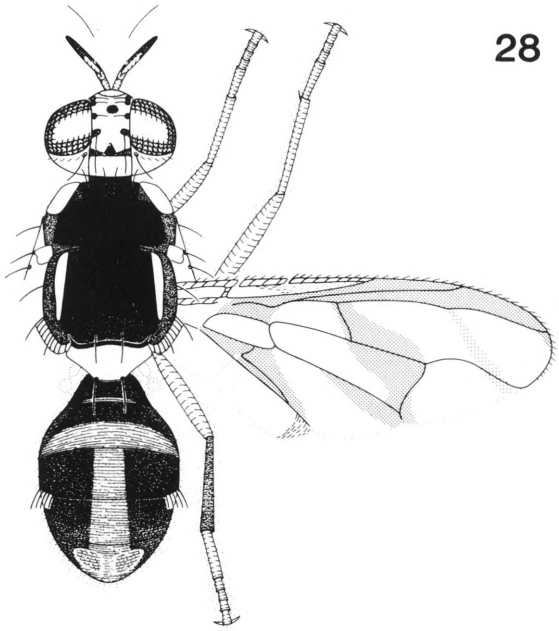


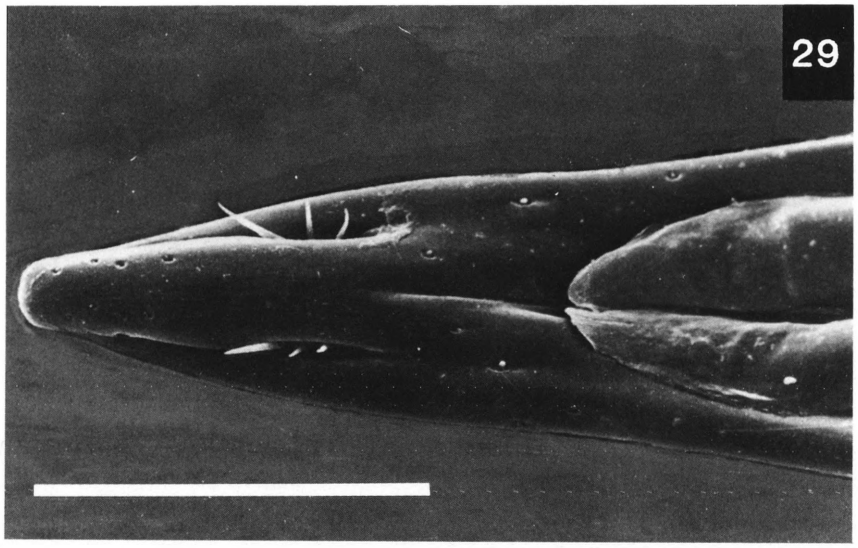
FIG. 24. *Bactrocera* (*Bactrocera*) *trivialis* (Drew), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 25. *Bactrocera* (*Bactrocera*) *vulgaris* (Drew), adult male (x11).



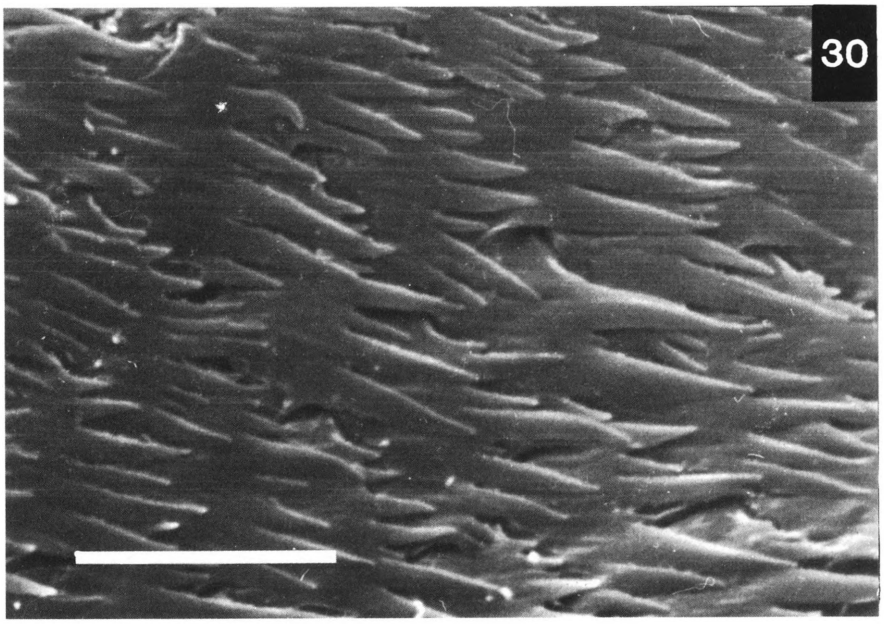


FIGS 26–27. *Bactrocera* (*Bactrocera*) *vulgaris* (Drew): 26, apex of aculeus (scale 0.1mm); 27, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 28–29. *Bactrocera* (*Bactrocera*) *alyxiae* (May): 28, adult male (x9); 29, apex of aculeus (scale 0.1 mm).



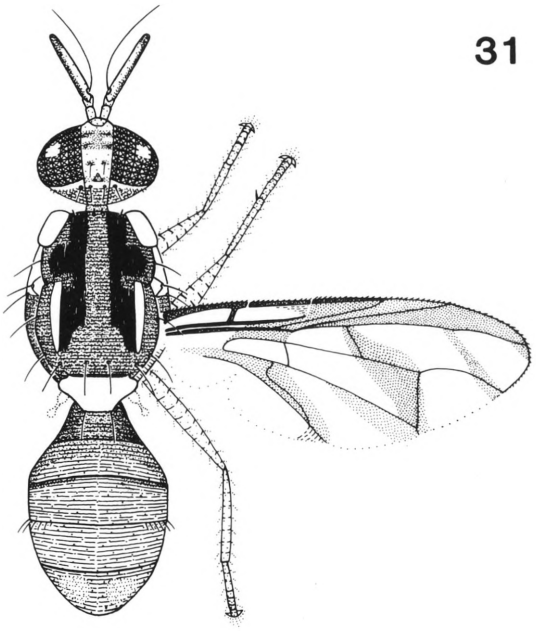
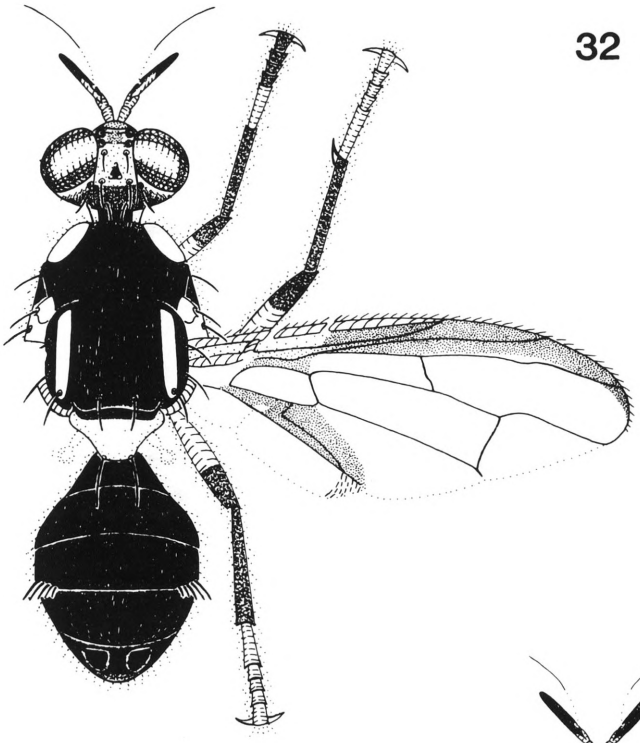


FIG. 30. *Bactrocera* (*Bactrocera*) *alyxiae* (May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 31. *Bactrocera* (*Bactrocera*) *repanda* n. sp., adult male (x9).



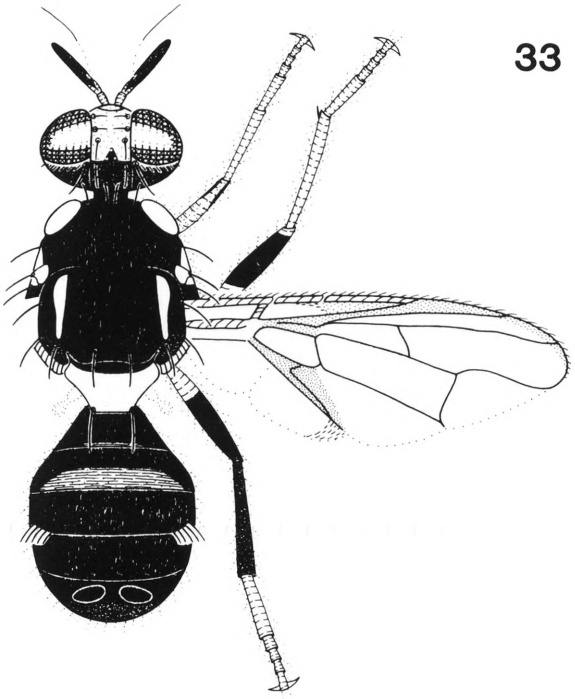
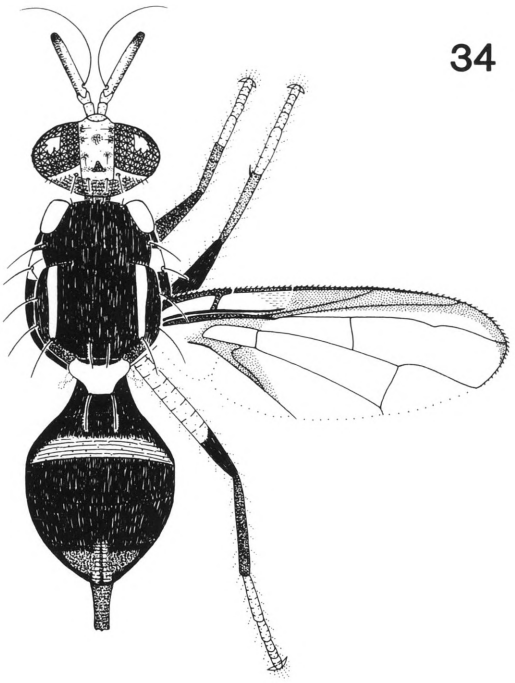
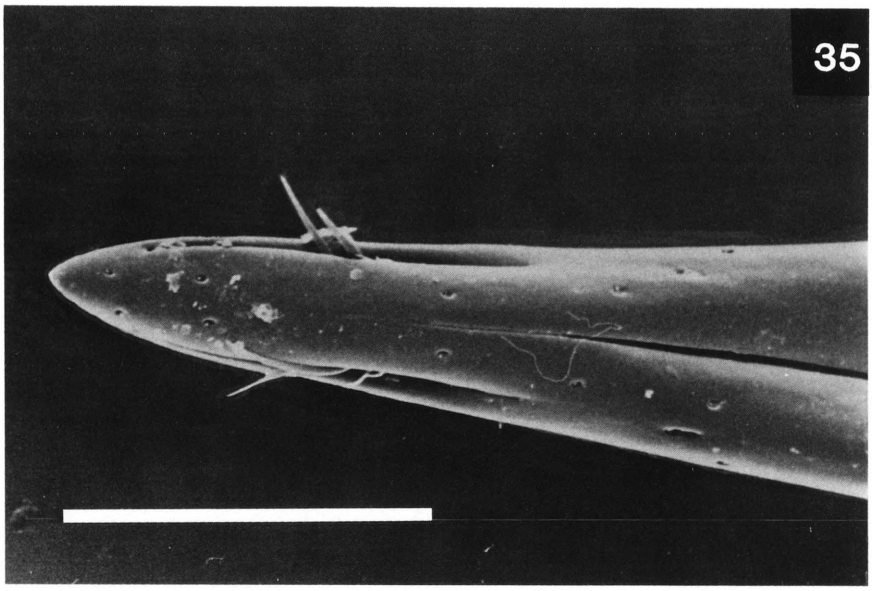
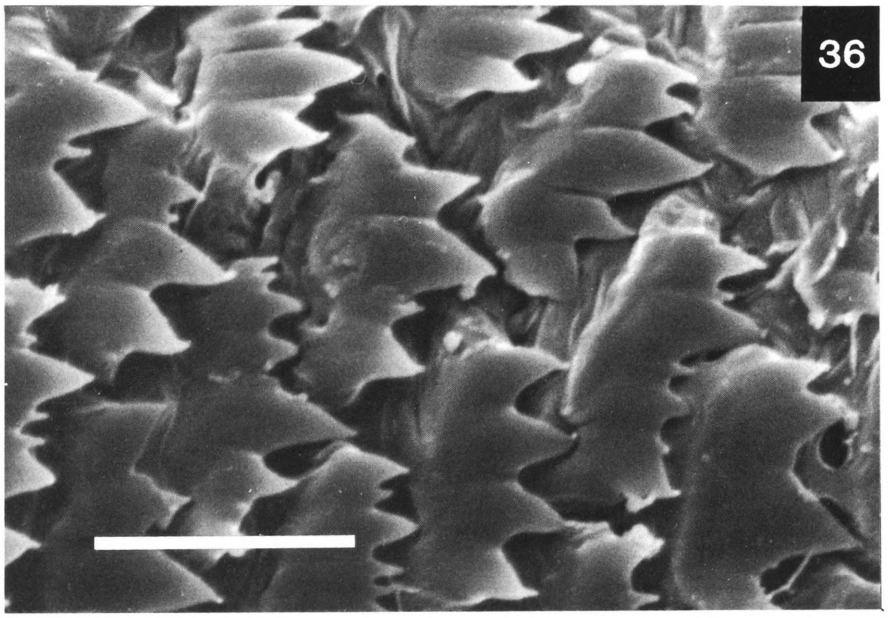


FIG. 32. *Bactrocera* (*Bactrocera*) *anthracina* (Drew), adult male (x9). FIG. 33. *Bactrocera* (*Bactrocera*) *aterrima* (Drew), adult male (x8).





FIGS 34–35. *Bactrocera* (*Bactrocera*) *terminaliae* n. sp.: 34, adult female (x8); 35, apex of aculeus (scale 0.1 mm).



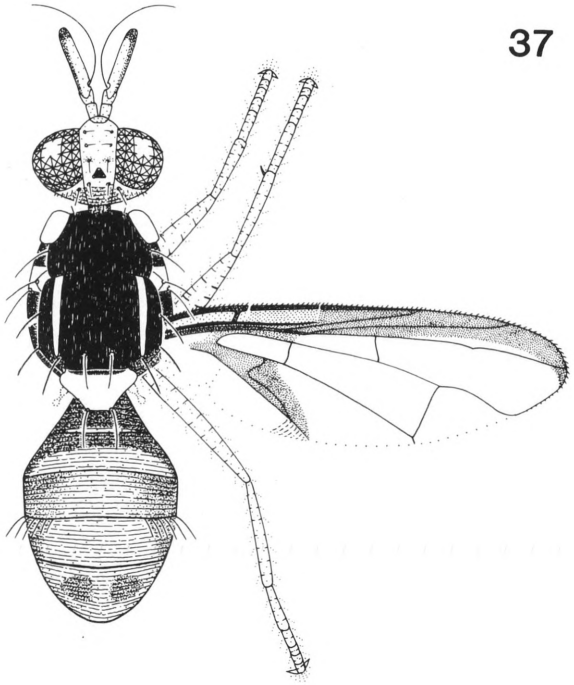
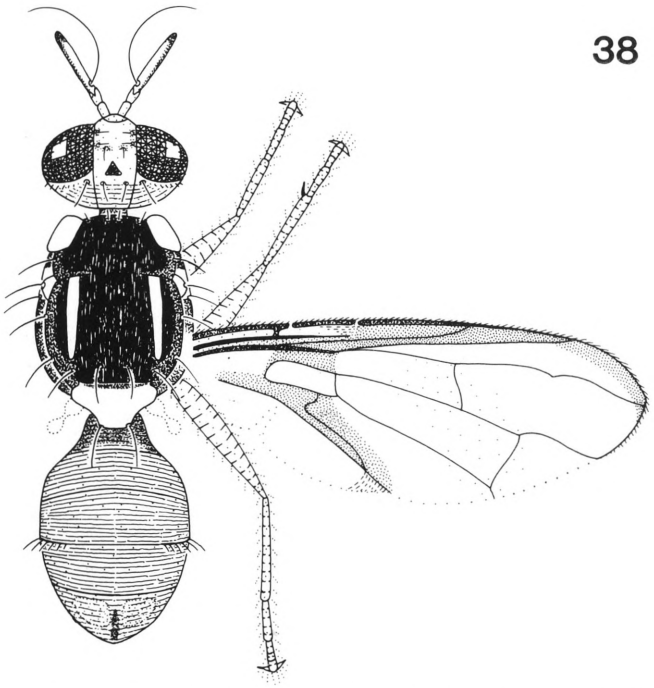
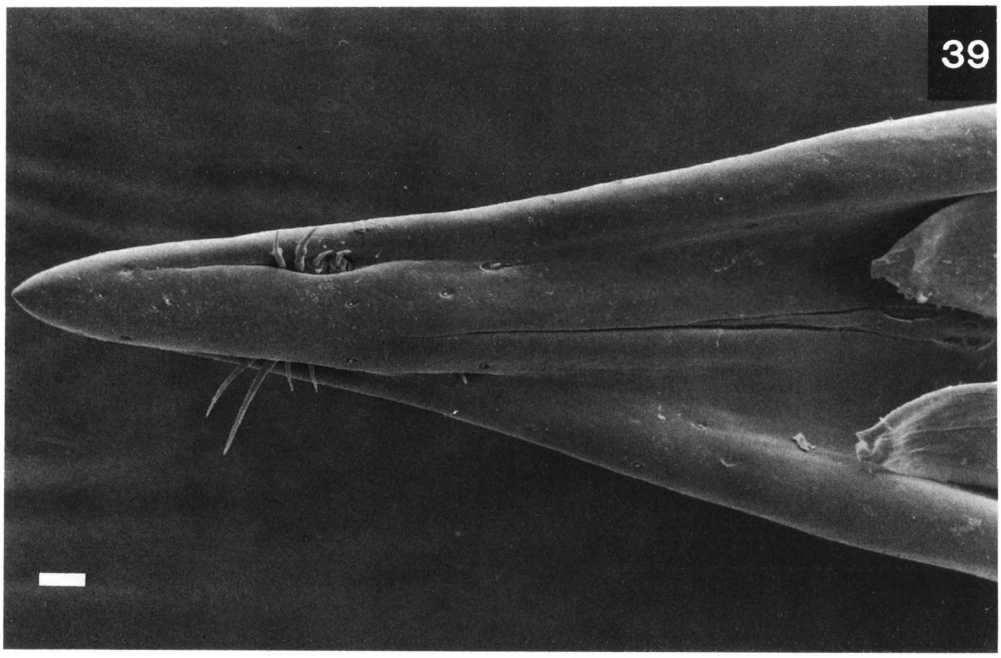
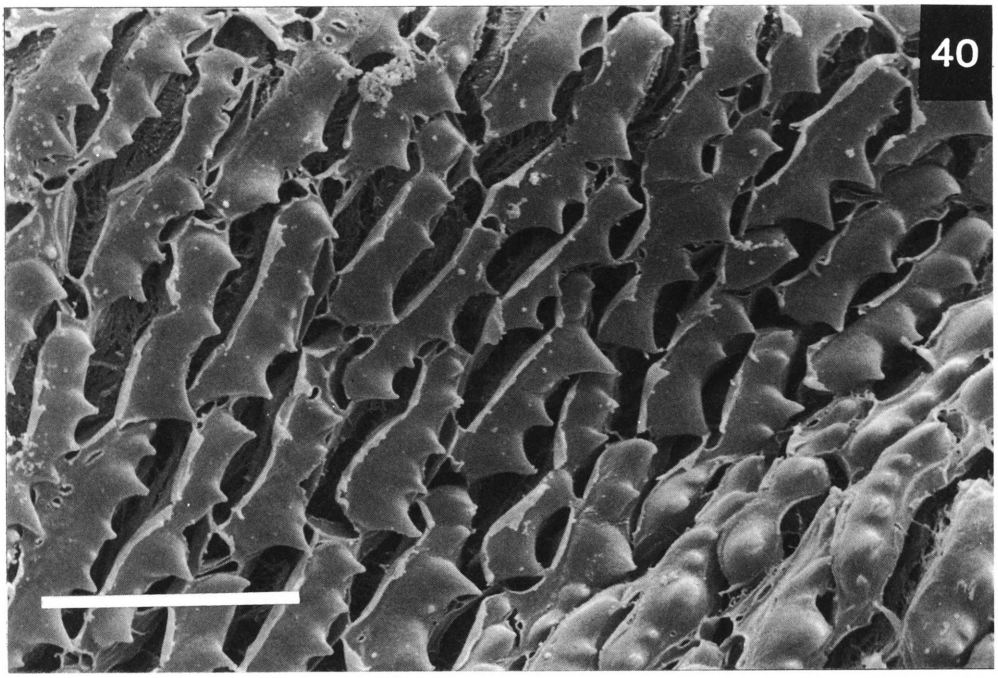


FIG. 36. *Bactrocera* (*Bactrocera*) *terminaliae* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 37. *Bactrocera* (*Bactrocera*) *assita* n. sp., adult male (x10).





FIGS 38–39. *Bactrocera* (*Bactrocera*) *brevistriata* (Drew): 38, adult male (x10); 39, apex of aculeus (scale 0.01 mm).



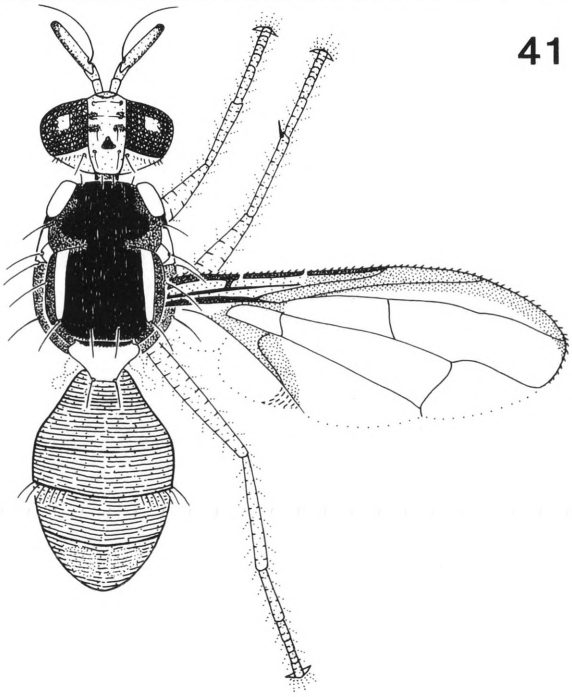
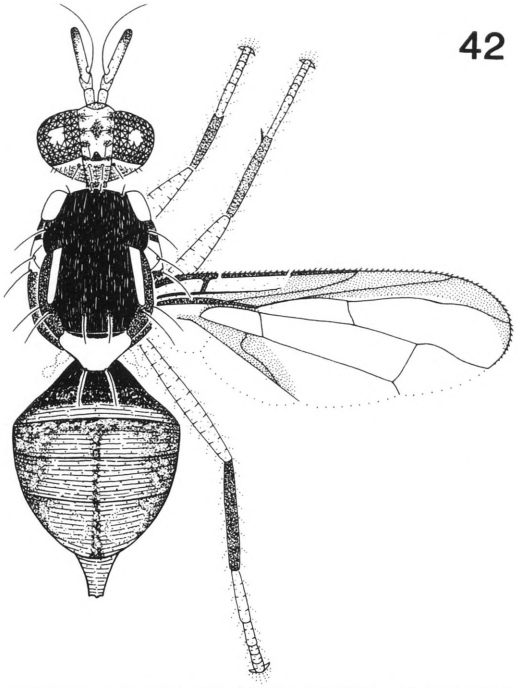
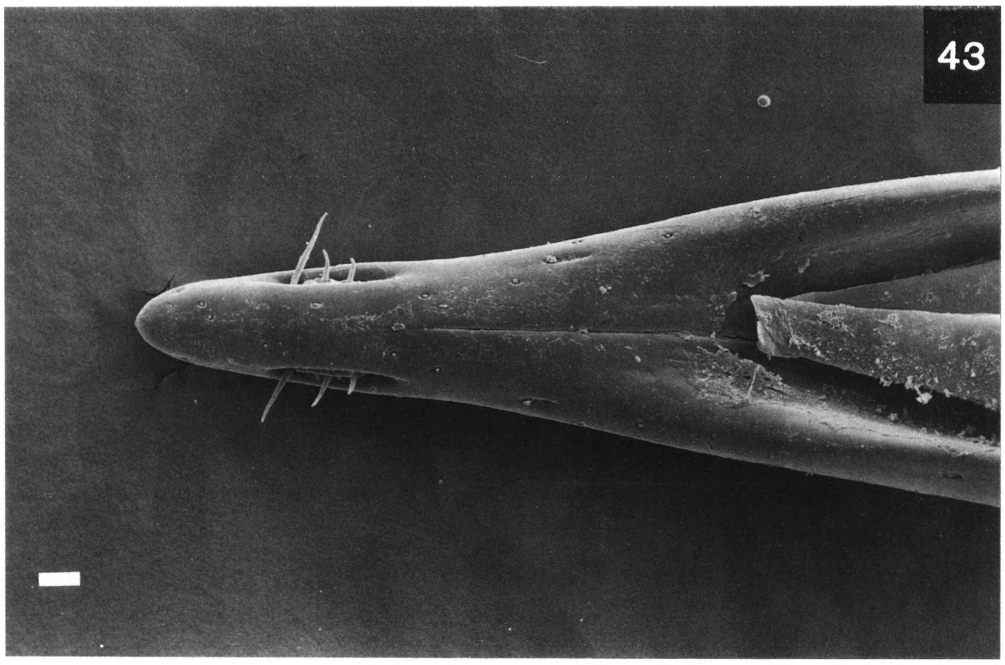
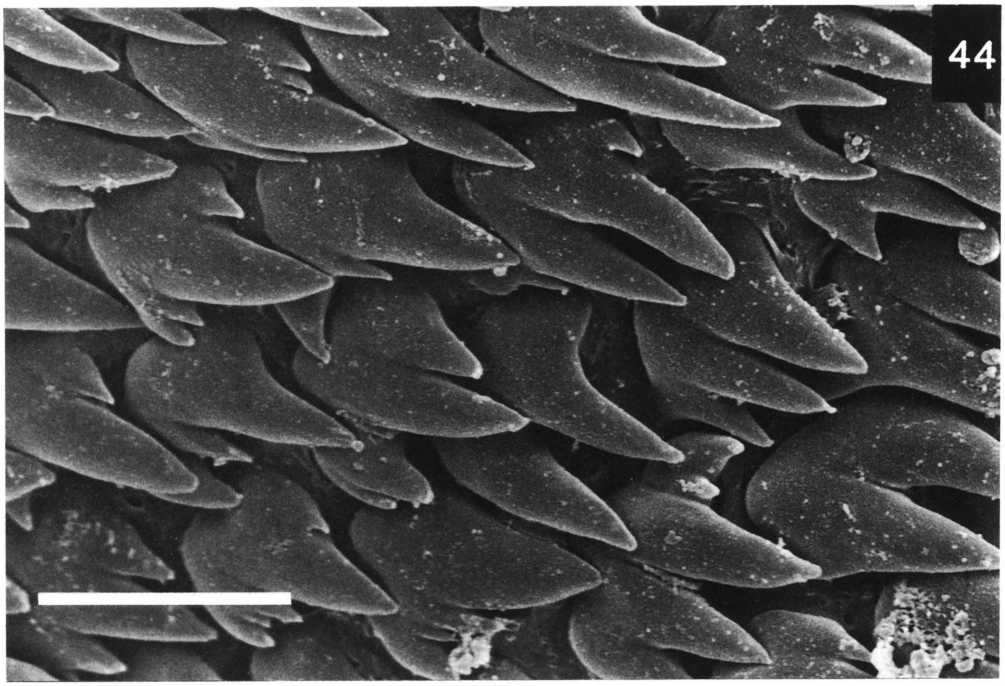


FIG. 40. *Bactrocera* (*Bactrocera*) *brevistriata* (Drew), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 41. *Bactrocera* (*Bactrocera*) *circamusae* n. sp., adult male (x8).





FIGS 42–43. *Bactrocera* (*Bactrocera*) *commina* n. sp.: 42, adult female (x10); 43, apex of aculeus (scale 0.01 mm).



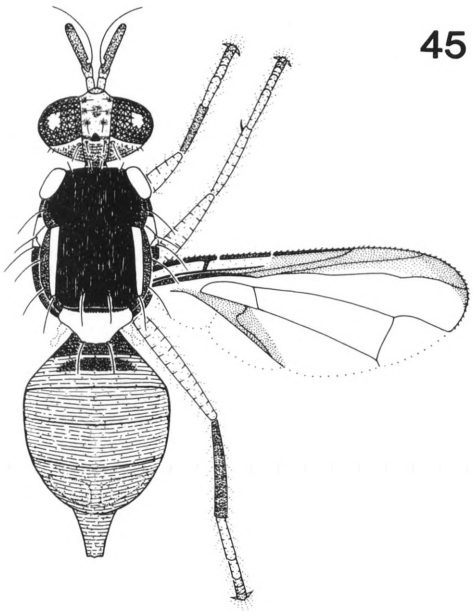
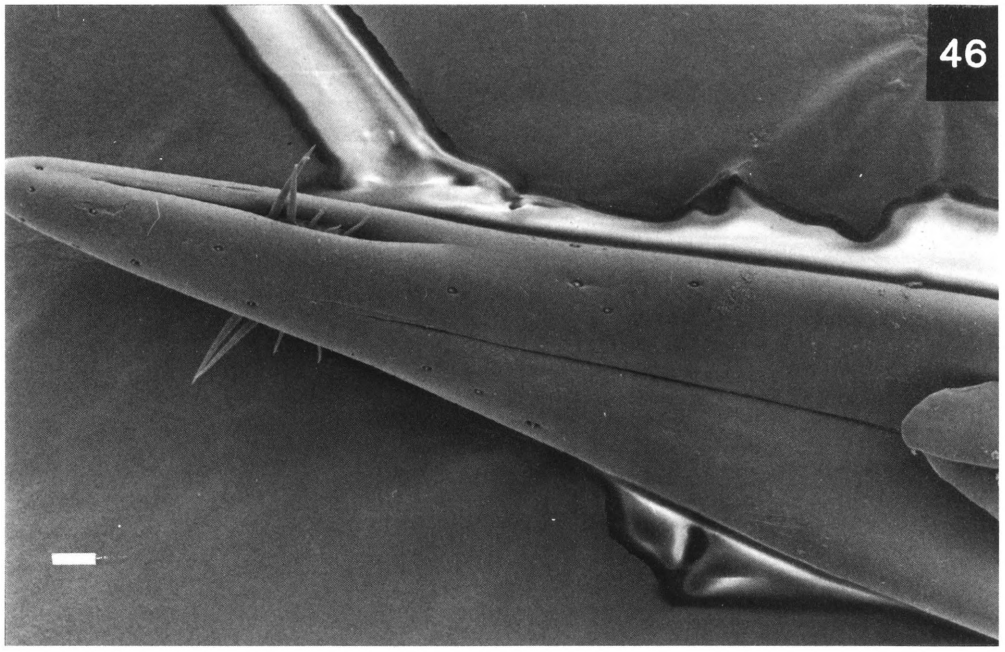
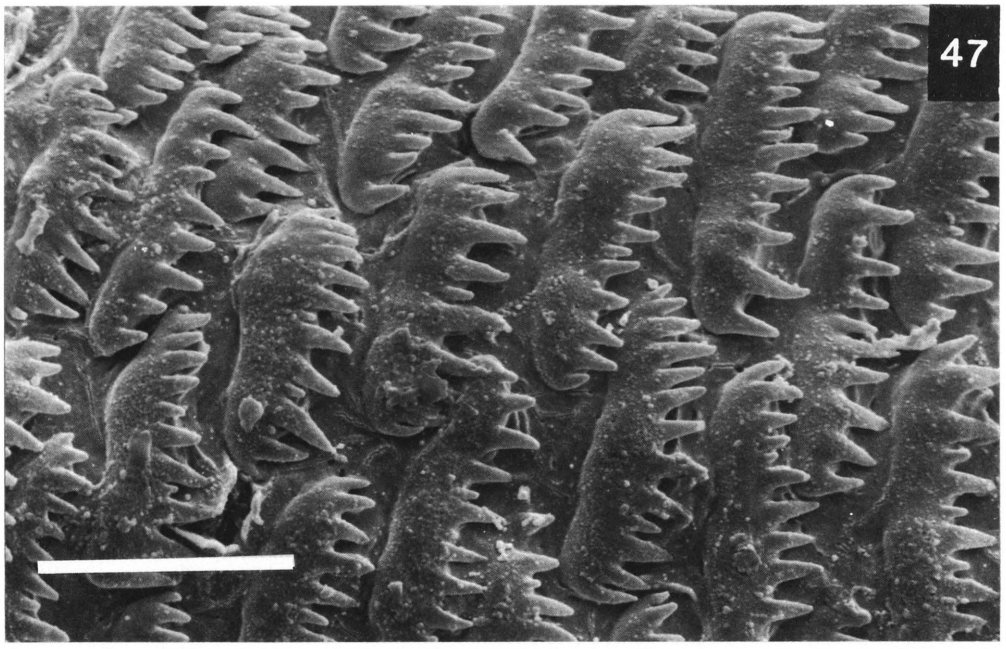
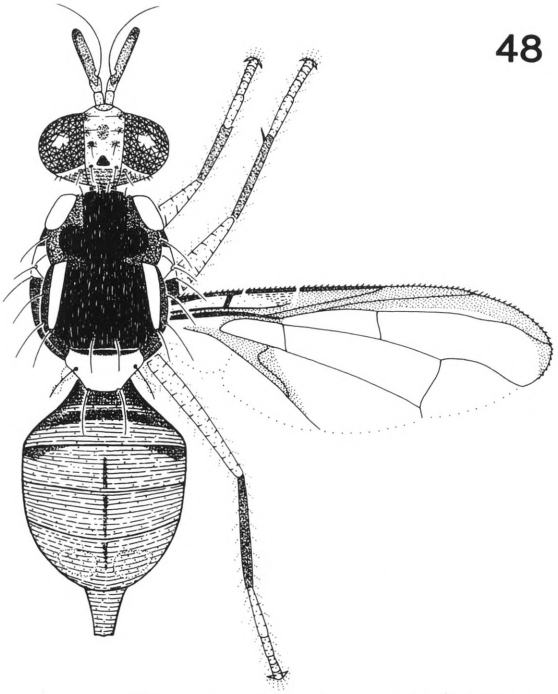


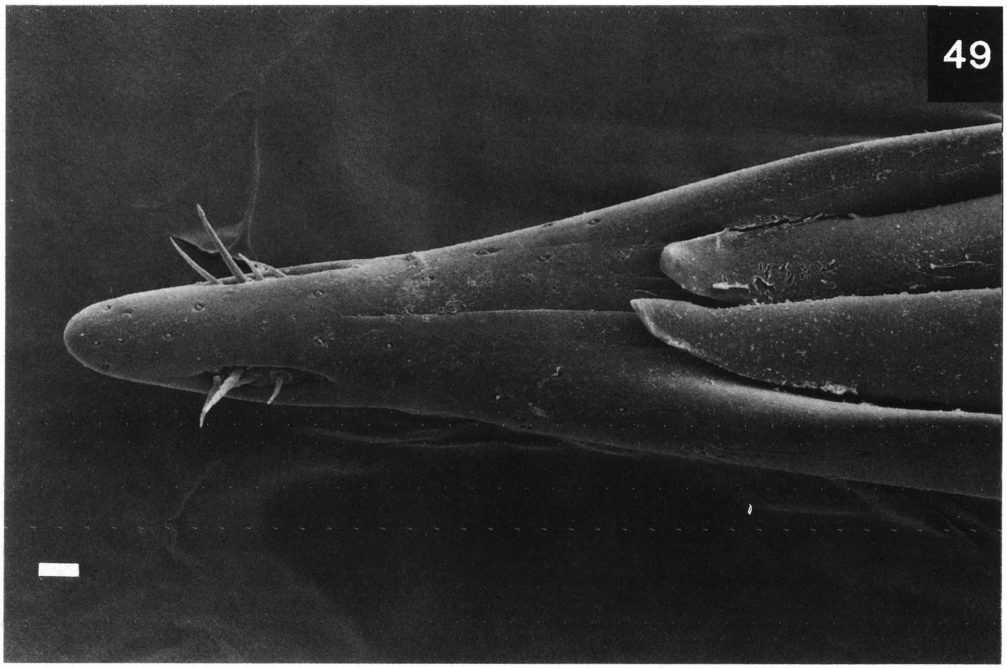
FIG. 44. *Bactrocera* (*Bactrocera*) *commina* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 45. *Bactrocera* (*Bactrocera*) *contermina* n. sp., adult female (x7).



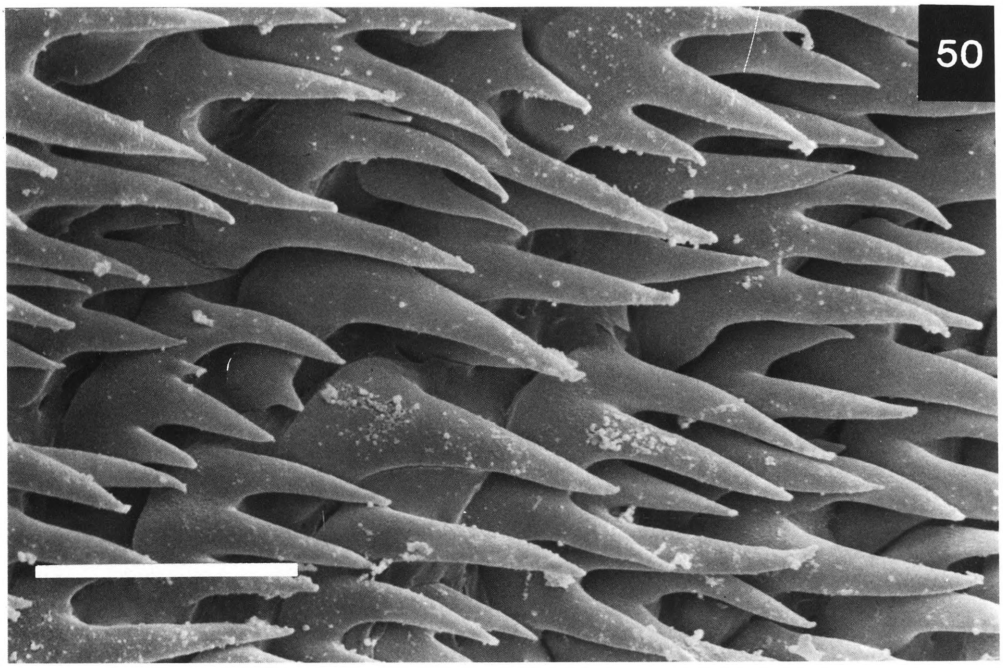


FIGS 46–47. *Bactrocera* (*Bactrocera*) *contermina* n. sp.: 46, apex of aculeus (scale 0.01 mm); 47, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 48–49. *Bactrocera* (*Bactrocera*) *contigua* n. sp.: 48, adult female (x7); 49, apex of aculeus (scale 0.01 mm).



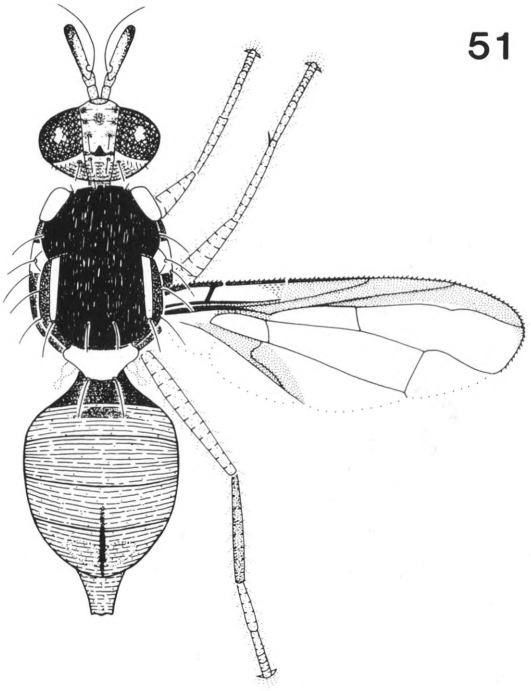
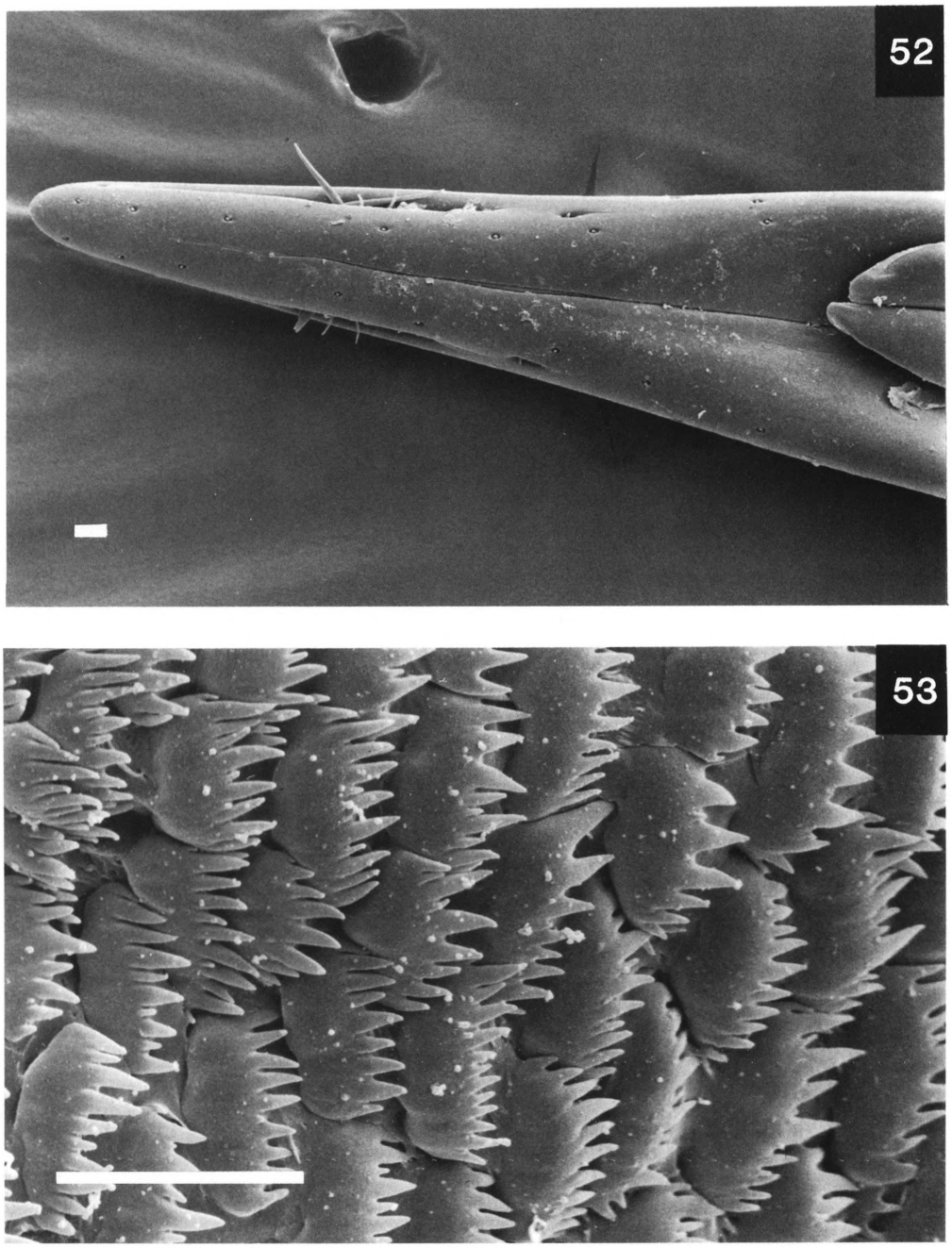
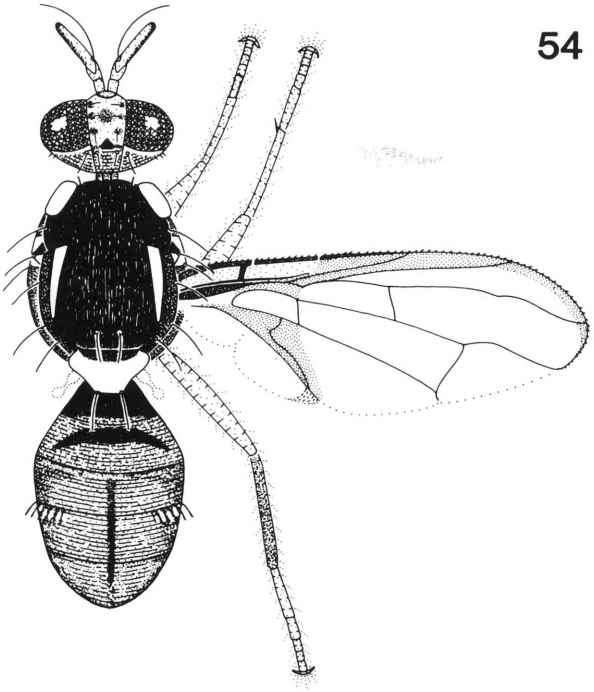


FIG. 50. *Bactrocera* (*Bactrocera*) *contigua* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 51. *Bactrocera* (*Bactrocera*) *finitima* n. sp., adult female (x7).



FIGS 52–53. *Bactrocera* (*Bactrocera*) *finitima* n. sp.: 52, apex of aculeus (scale 0.01 mm); 53, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



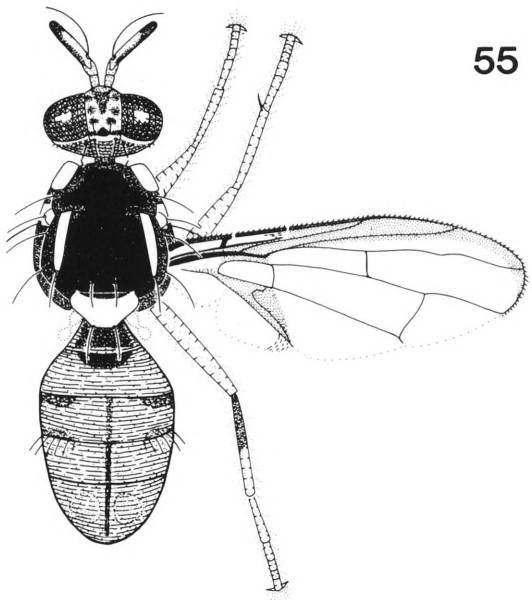
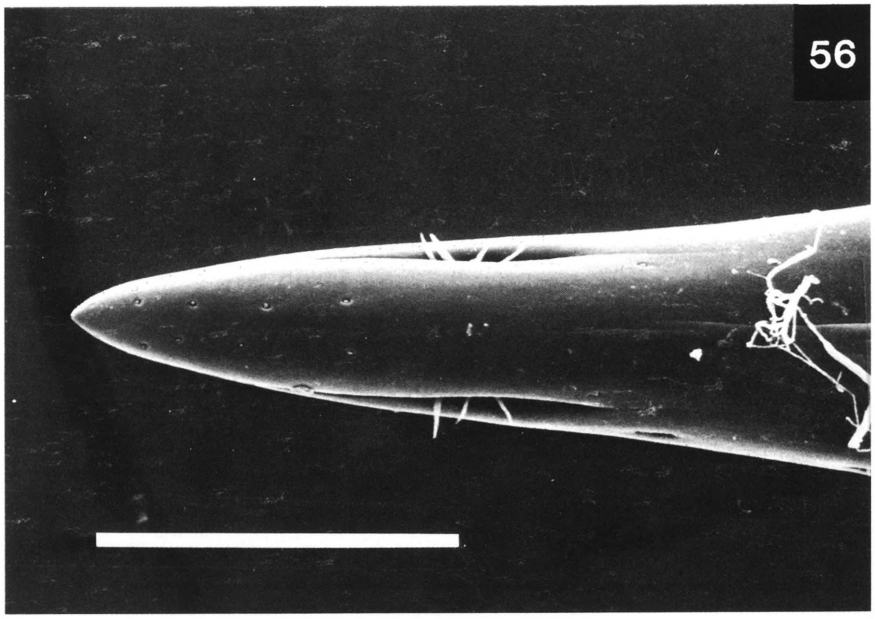
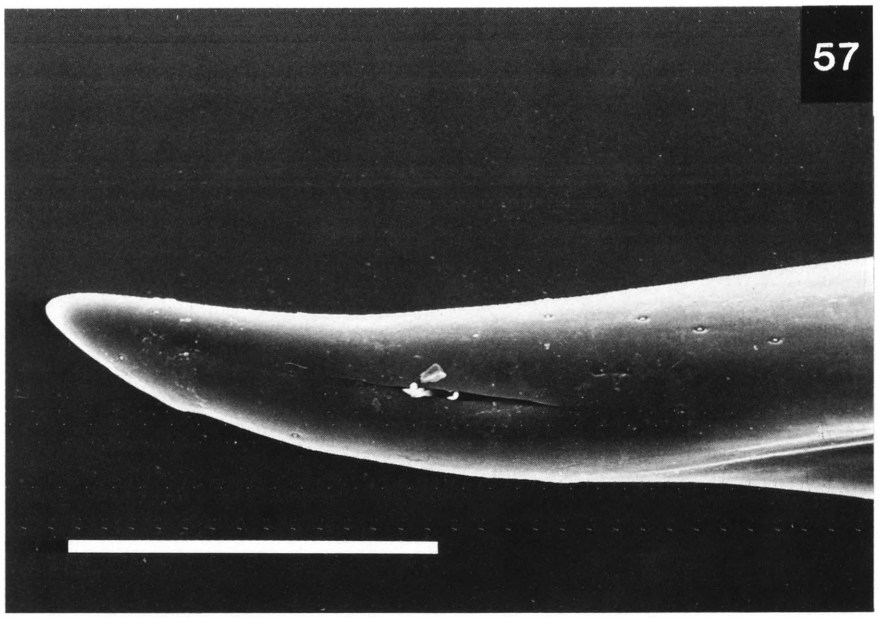
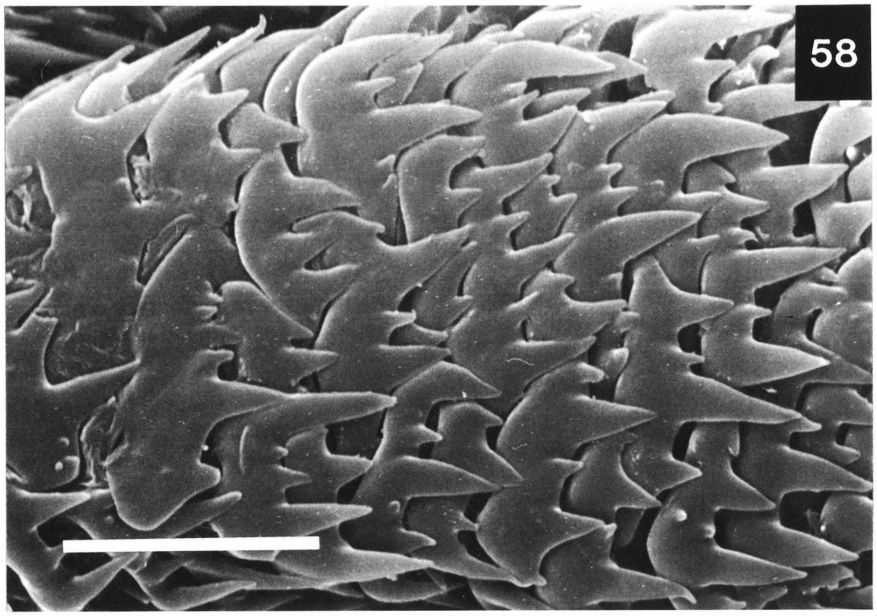


FIG. 54. *Bactrocera* (*Bactrocera*) *robertsi* n. sp., adult male (x8). FIG. 55. *Bactrocera* (*Bactrocera*) *tinomiscii* n. sp., adult male (x7).





FIGS 56–57. *Bactrocera* (*Bactrocera*) *tinomiscii* n. sp.: 56, apex of aculeus dorsal view (scale 0.1 mm); 57, apex of aculeus lateral view (scale 0.1 mm).



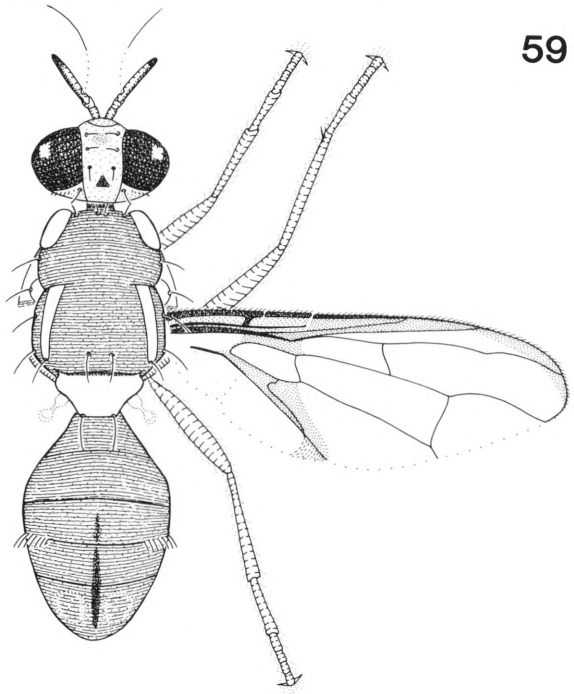
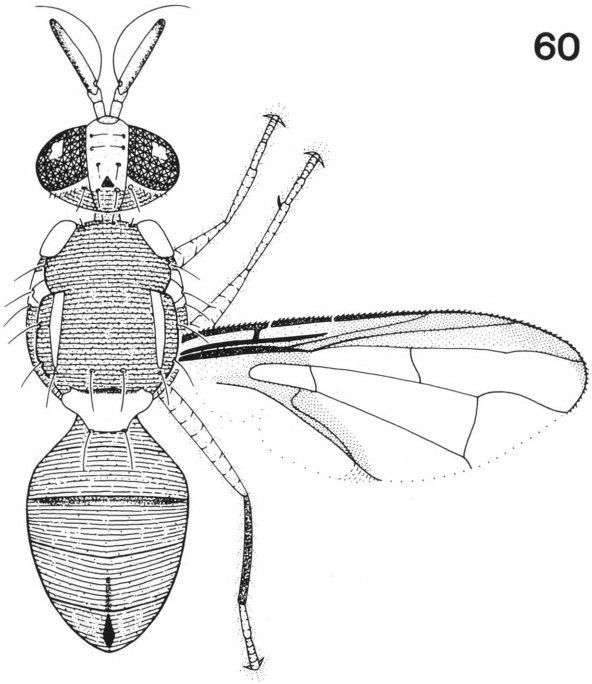
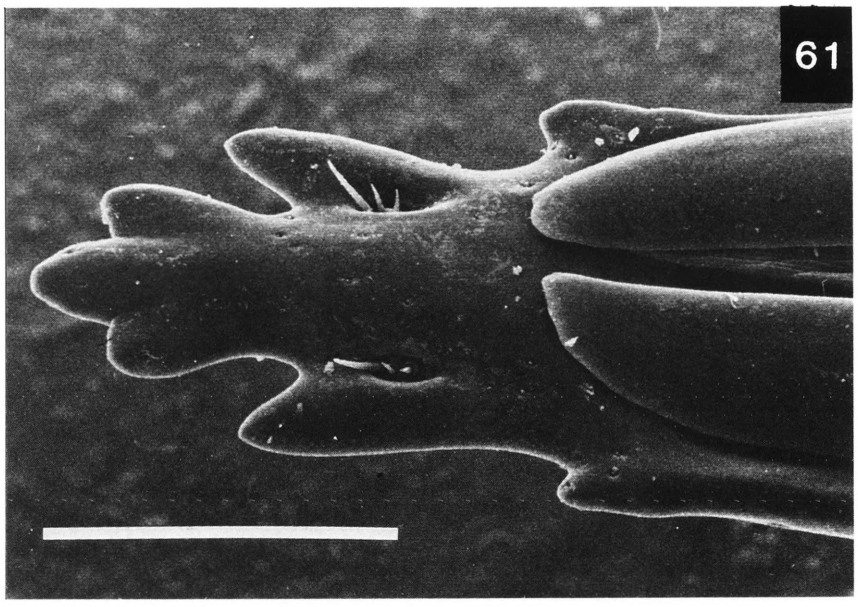
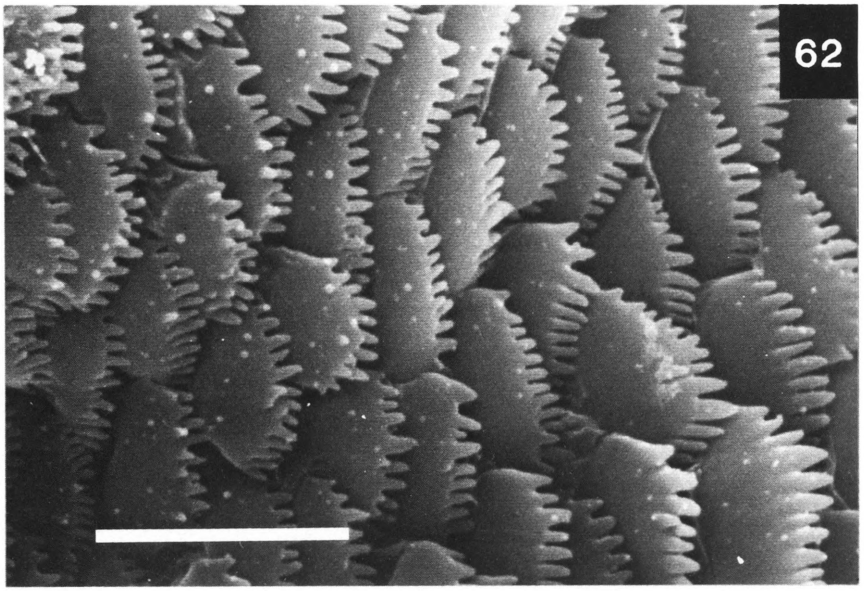


FIG. 58. *Bactrocera* (*Bactrocera*) *tinomiscii* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 59. *Bactrocera* (*Bactrocera*) *aeroginosa* (Drew and Hancock), adult male (x9).





FIGS 60–61. *Bactrocera* (*Bactrocera*) *bidentata* (May): 60, adult male (x9); 61, apex of aculeus (scale 0.1 mm).



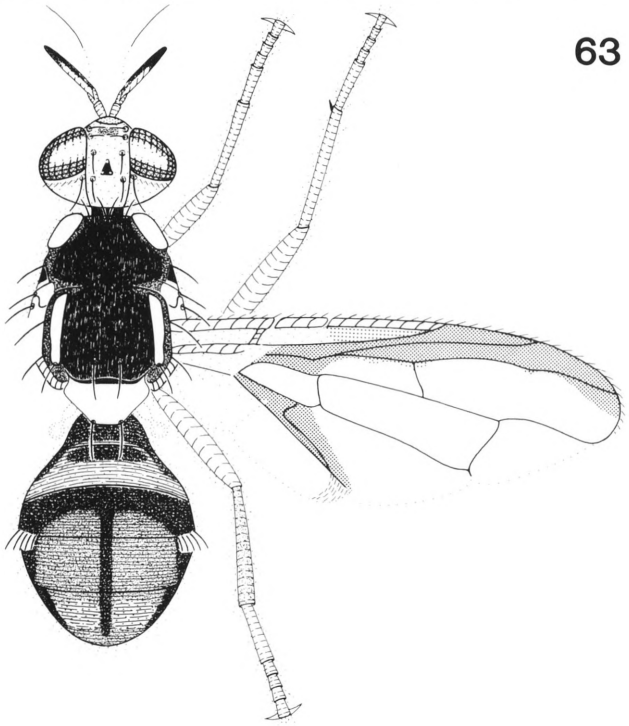
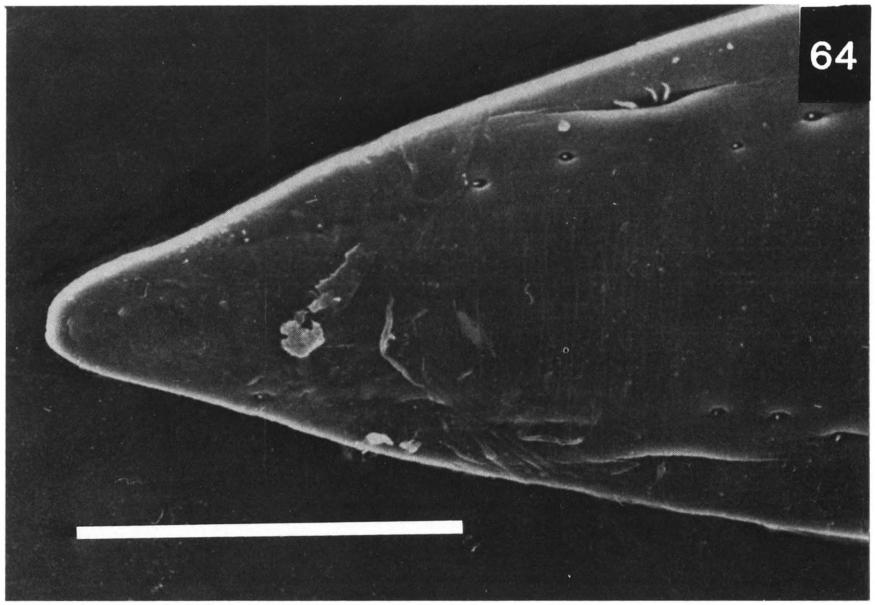
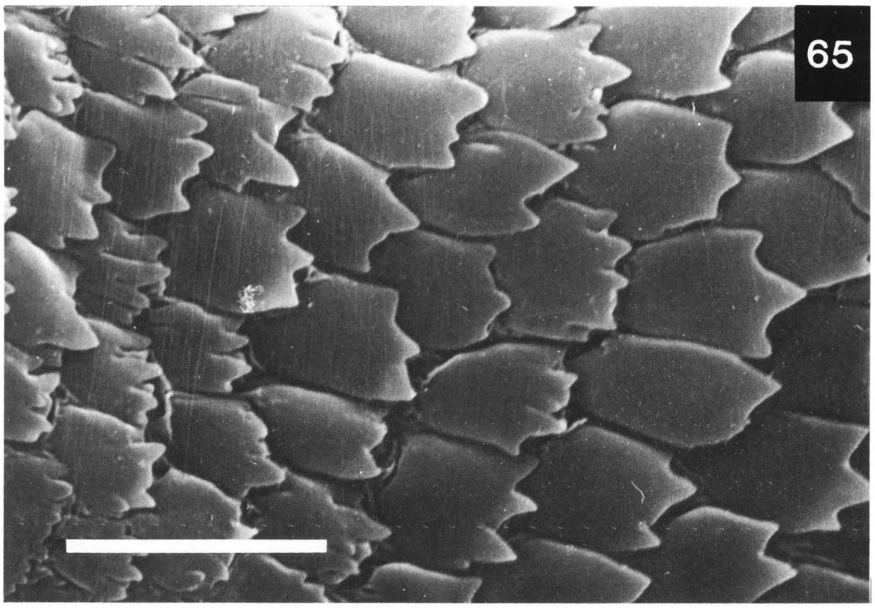
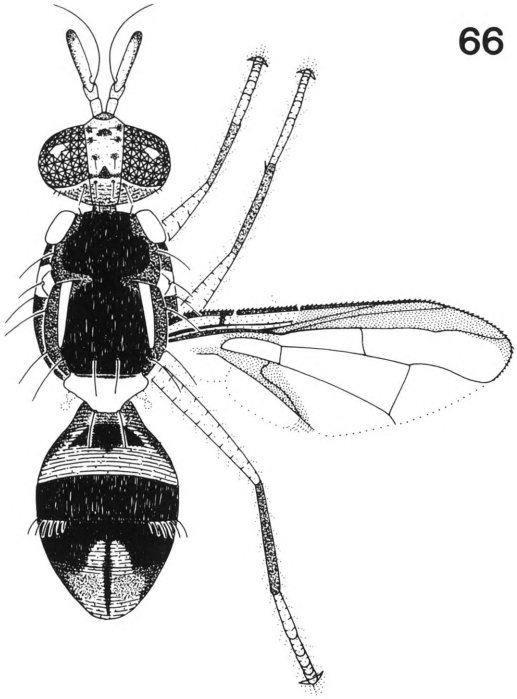


FIG. 62. *Bactrocera* (*Bactrocera*) *bidentata* (May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 63. *Bactrocera* (*Bactrocera*) *bryoniae* (Tryon), adult male (x9).





FIGS 64–65. *Bactrocera* (*Bactrocera*) *bryoniae* (Tryon): 64, apex of aculeus (scale 0.1 mm); 65, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



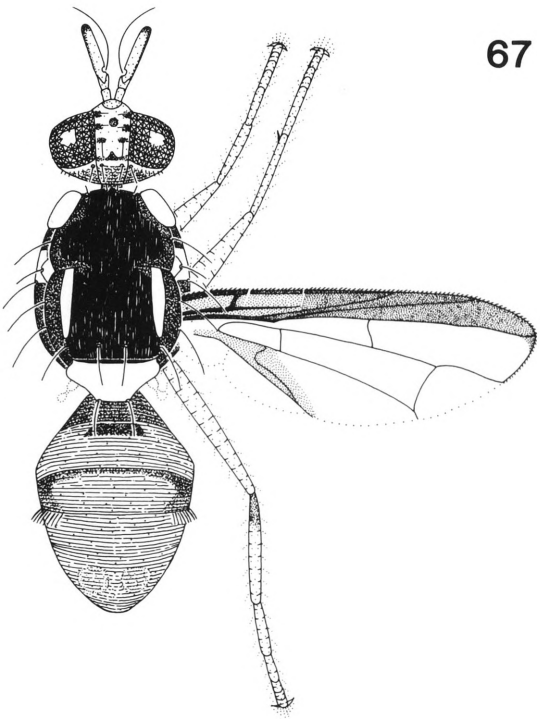
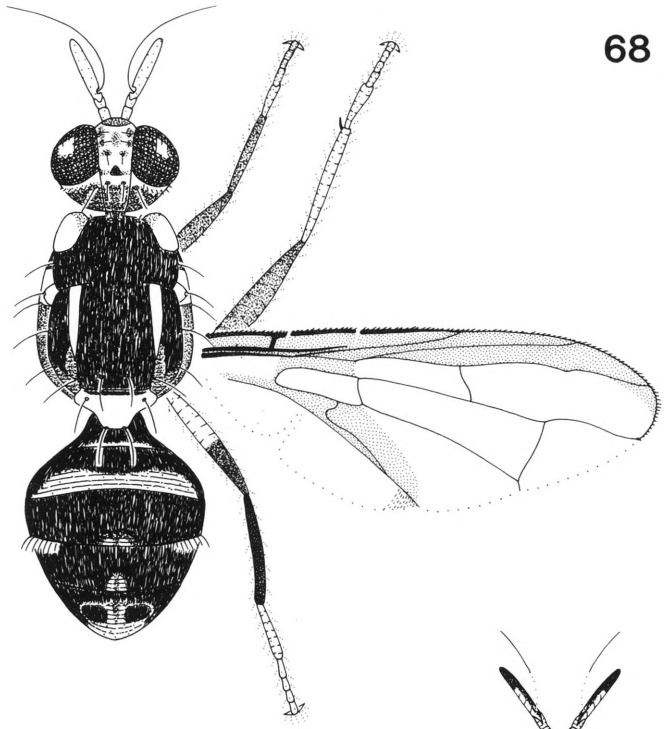


FIG. 66. *Bactrocera* (*Bactrocera*) *latissima* n. sp., adult male (x6). FIG. 67. *Bactrocera* (*Bactrocera*) *paramusae* n. sp., adult male (x8).



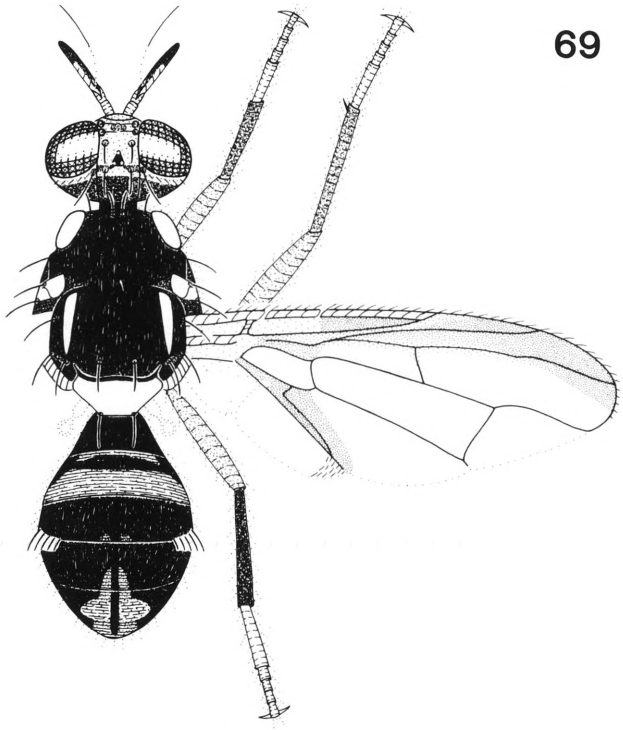


FIG. 68. *Bactrocera* (*Bactrocera*) *quadrisetosa* (Bezzi), adult male (x9). FIG. 69. *Bactrocera* (*Bactrocera*) *simulata* (Malloch), adult male (x9).

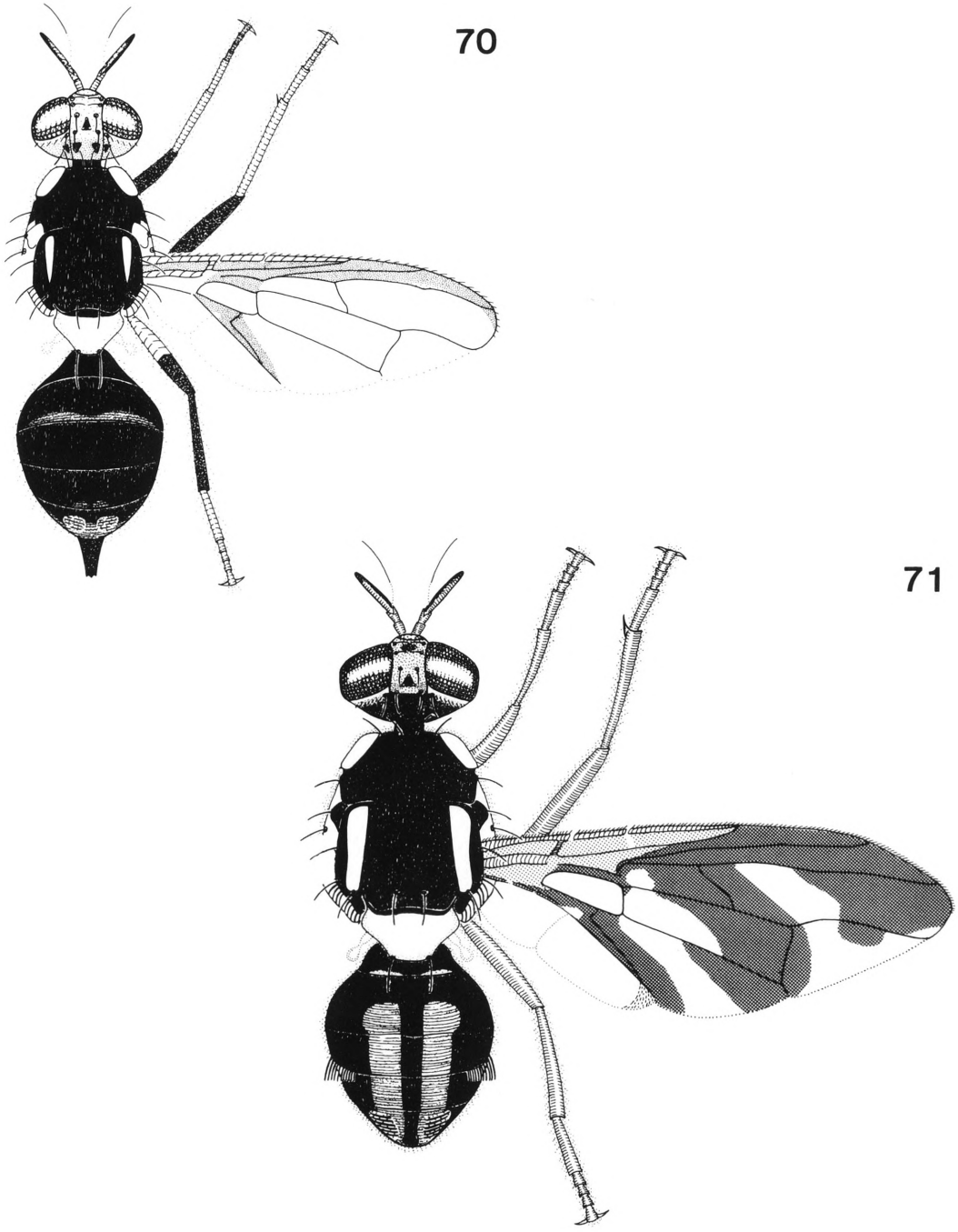
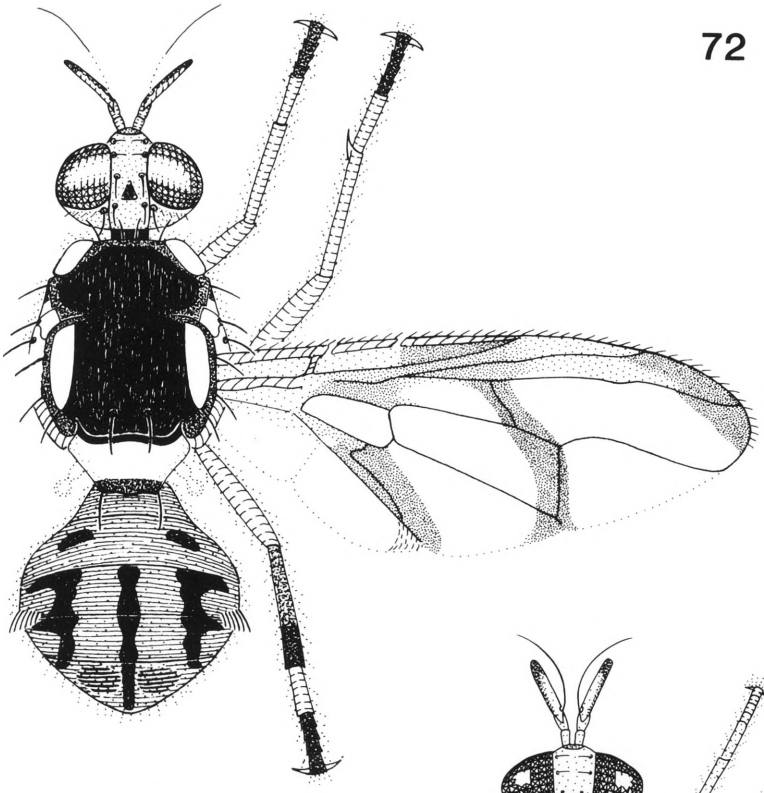


FIG. 70. *Bactrocera* (*Bactrocera*) *varipes* (Malloch), adult female (x7). FIG. 71. *Bactrocera* (*Bactrocera*) *ampla* (Drew), adult male (x9).



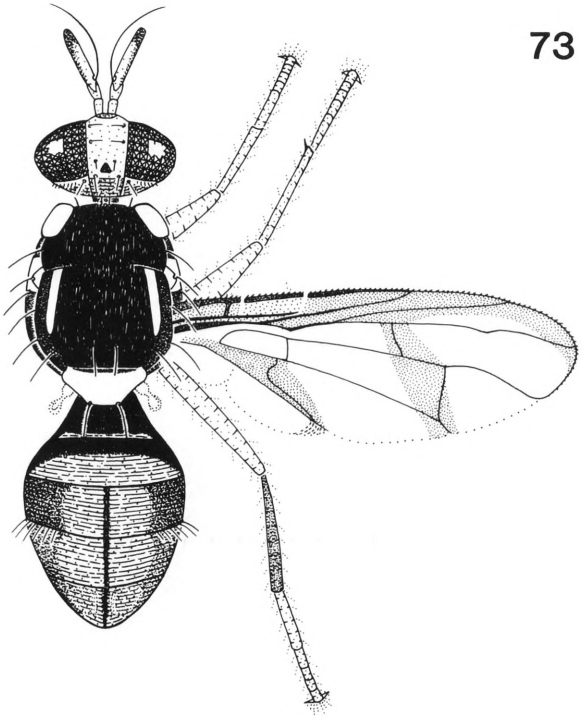
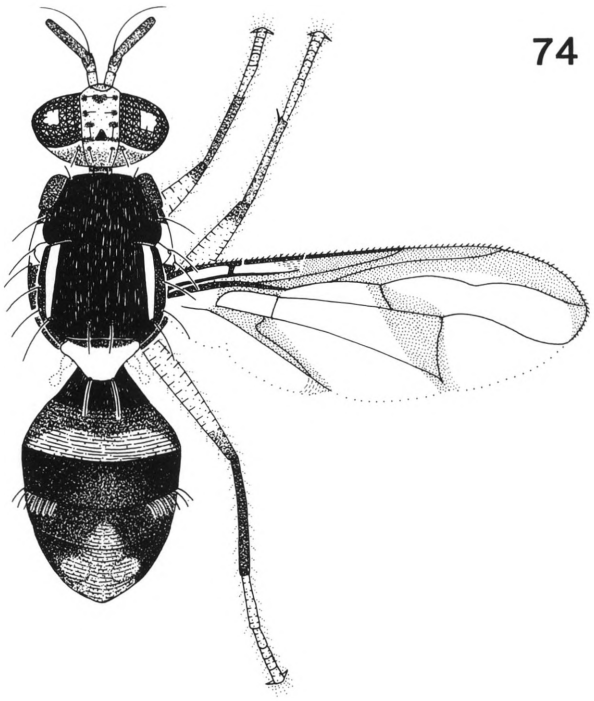
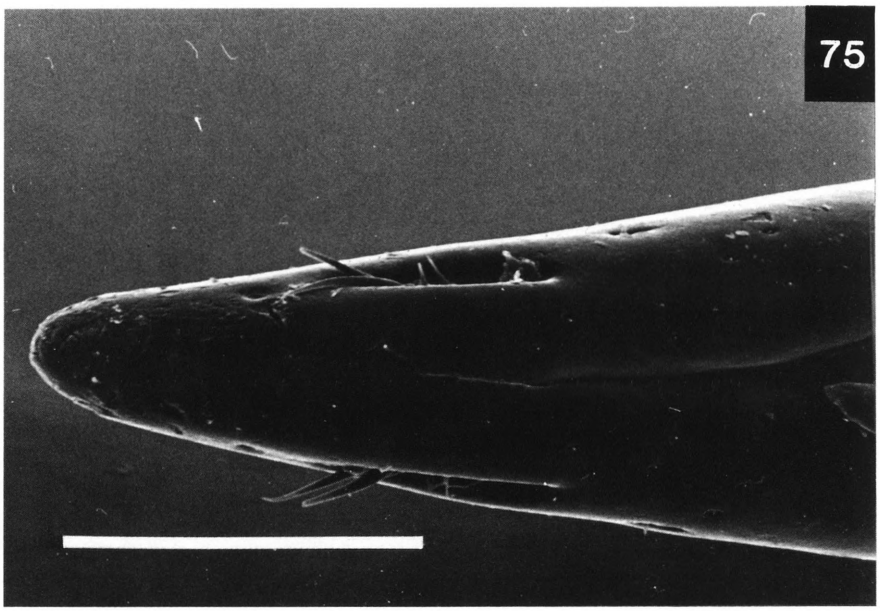
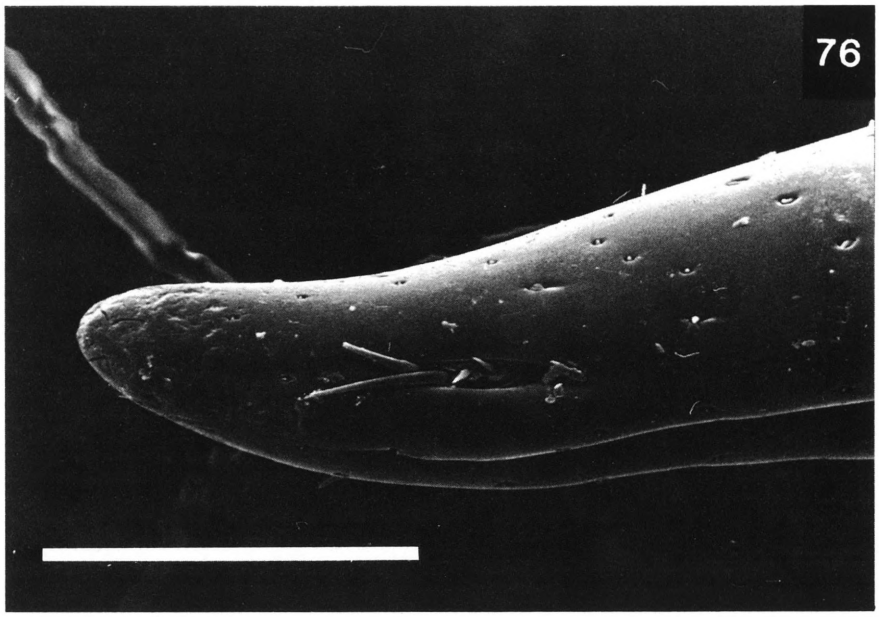


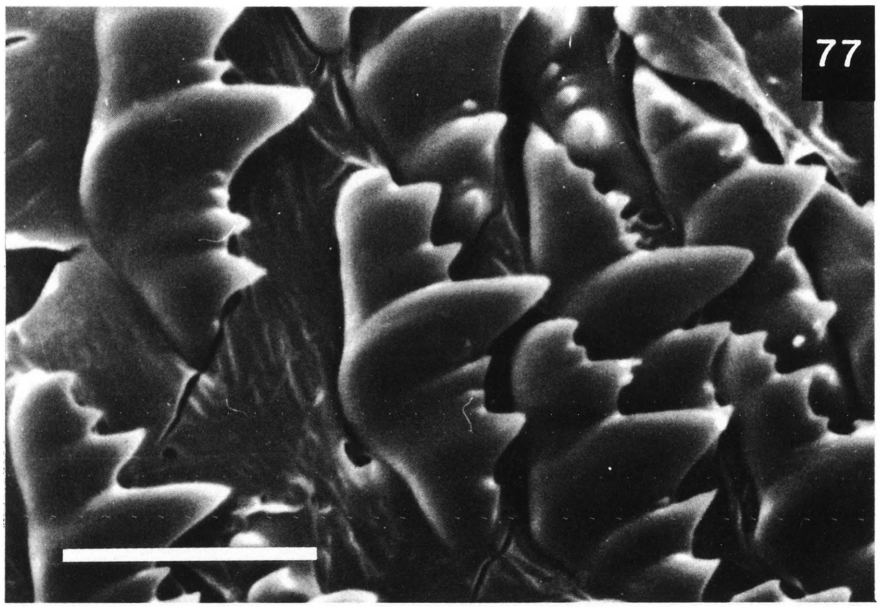
FIG. 72. *Bactrocera* (*Bactrocera*) *anomala* (Drew), adult male (x12). FIG. 73. *Bactrocera* (*Bactrocera*) *atriliniellata* n. sp., adult male (x9).





FIGS 74–75. *Bactrocera* (*Bactrocera*) *curreyi* n. sp.: 74, adult male (x9); 75, apex of aculeus dorsal view (scale 0.1 mm).





FIGS 76–77. *Bactrocera* (*Bactrocera*) *curreyi* n. sp.: 76, apex of aculeus lateral view (scale 0.1 mm); 77, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

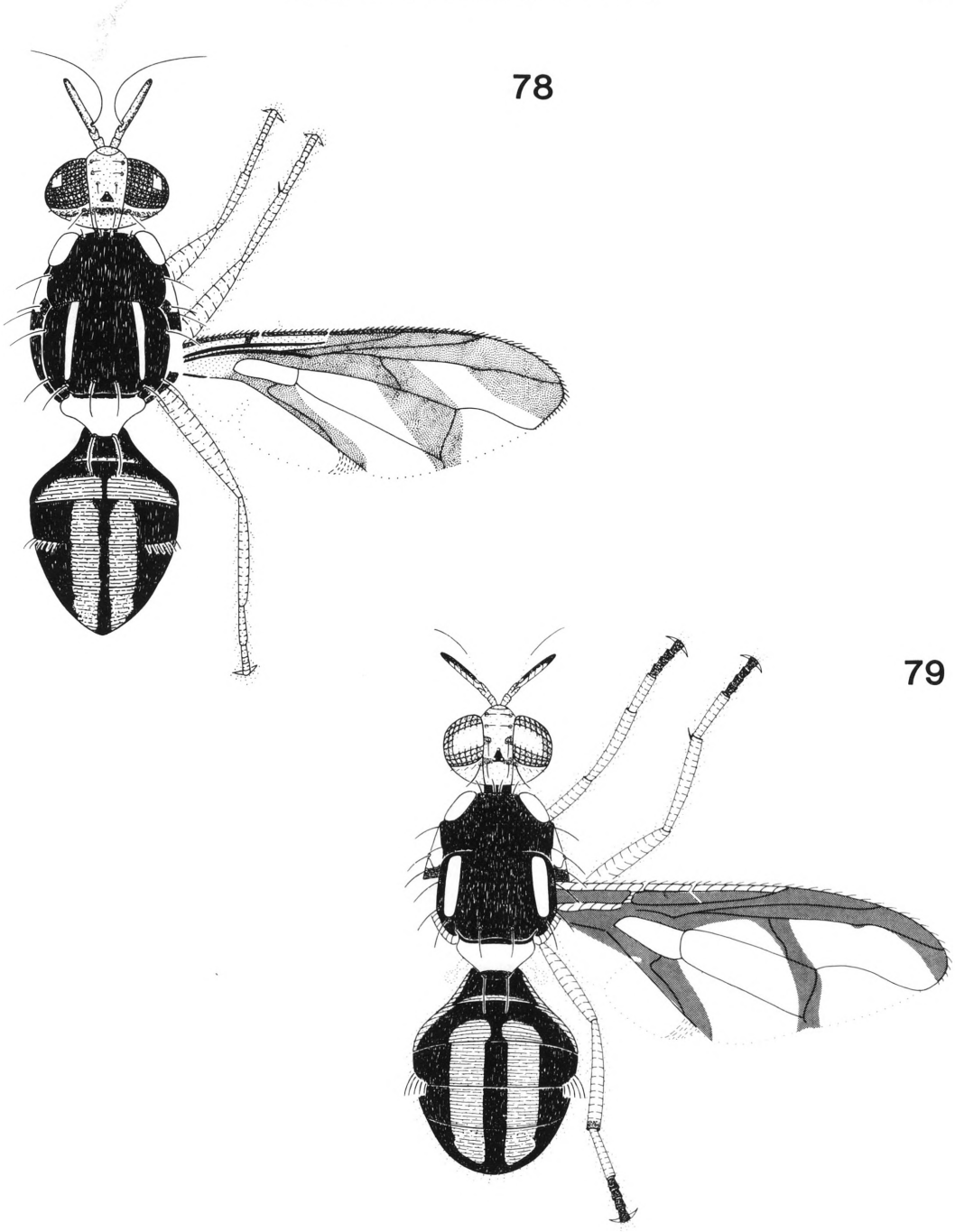
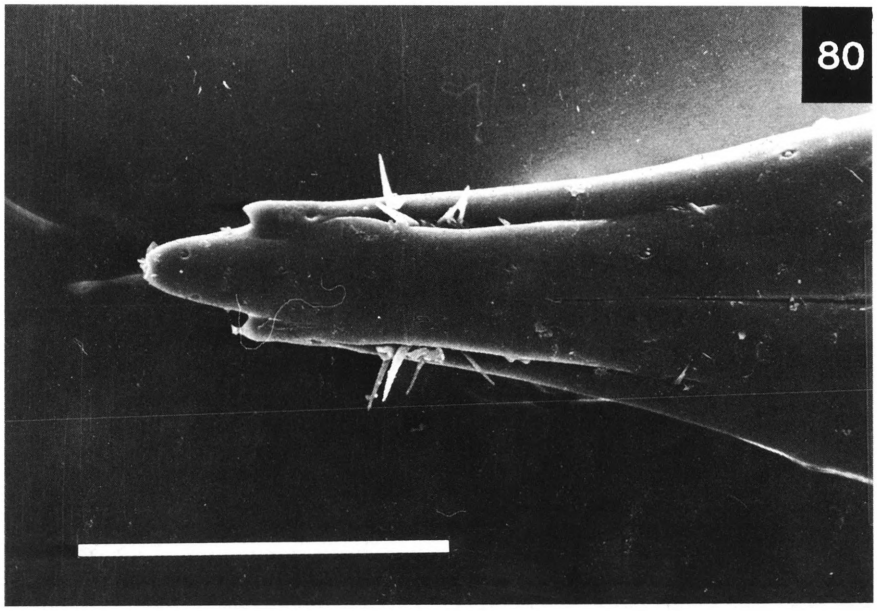
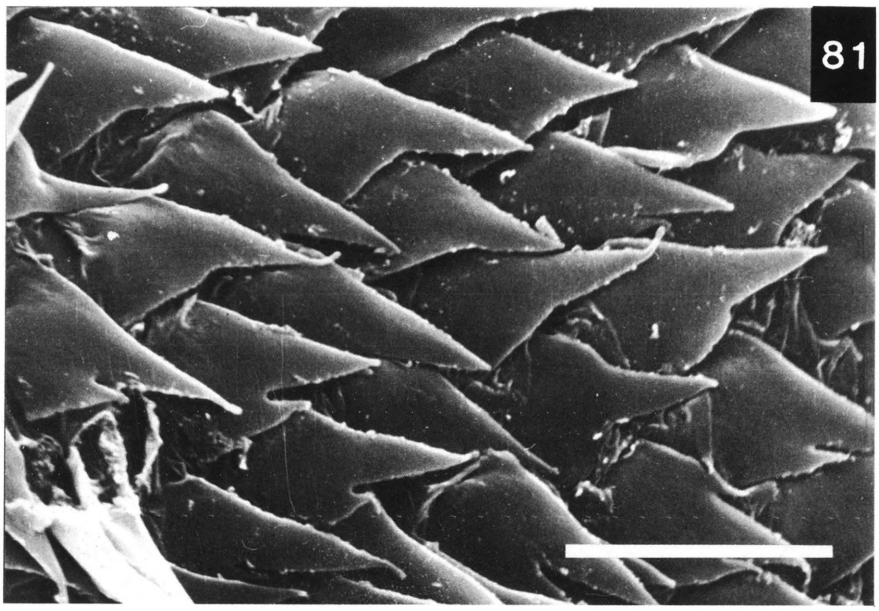


FIG. 78. *Bactrocera* (*Bactrocera*) *decumana* (Drew), adult male (x7). FIG. 79. *Bactrocera* (*Bactrocera*) *distincta* (Malloch), adult male (x10).





FIGS 80–81. *Bactrocera* (*Bactrocera*) *distincta* (Malloch): 80, apex of aculeus (scale 0.1 mm); 81, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

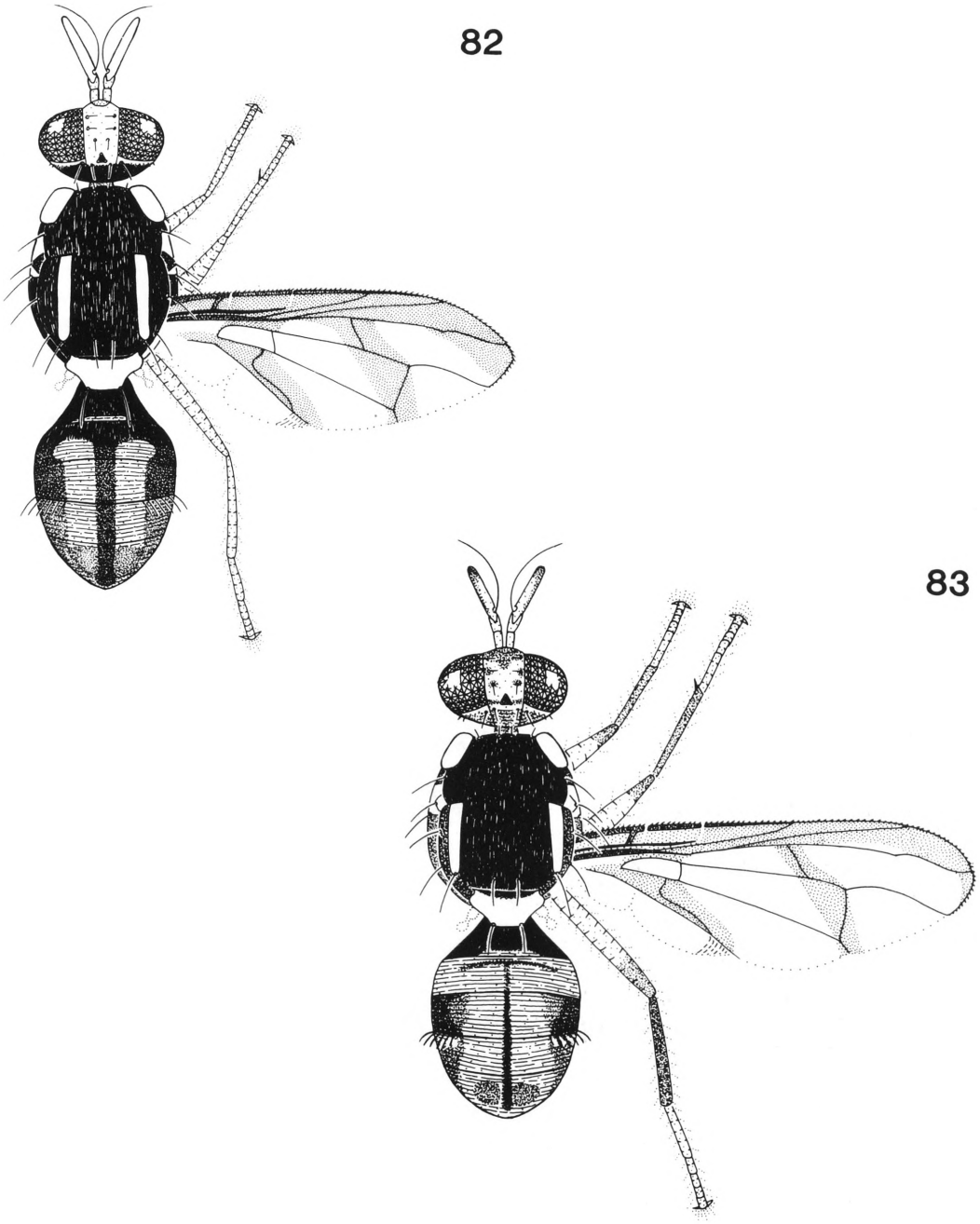
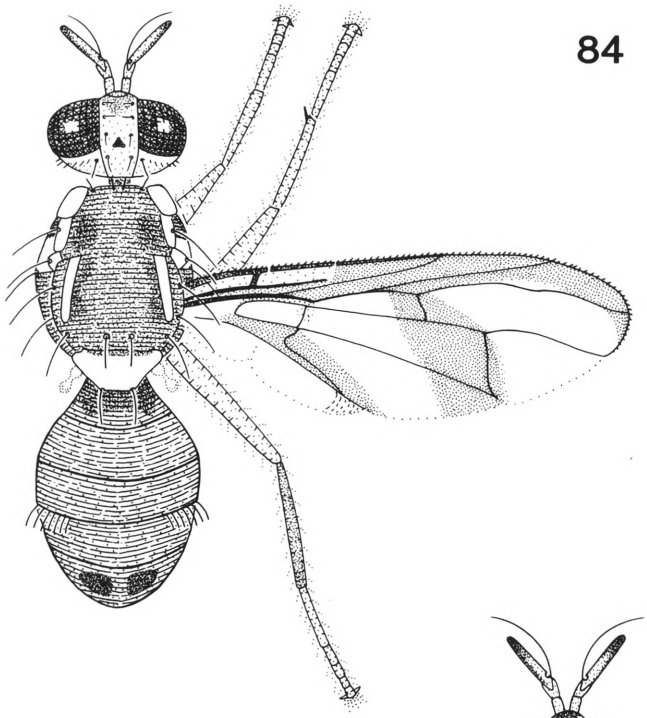


FIG. 82. *Bactrocera* (*Bactrocera*) *fergussoniensis* n. sp., adult male (x7). FIG. 83. *Bactrocera* (*Bactrocera*) *furvilineata* n. sp., adult male (x9).



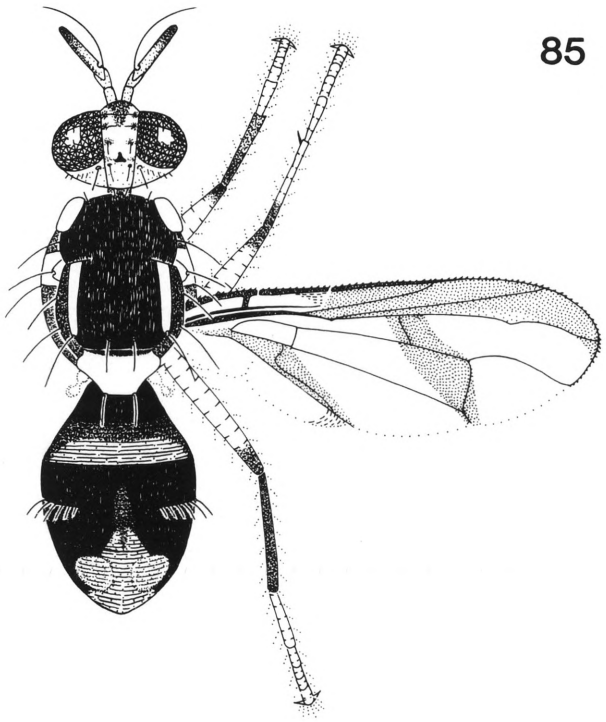


FIG. 84. *Bactrocera* (*Bactrocera*) *morobiensis* n. sp., adult male (x9). FIG. 85. *Bactrocera* (*Bactrocera*) *oblineata* n. sp., adult male (x9).

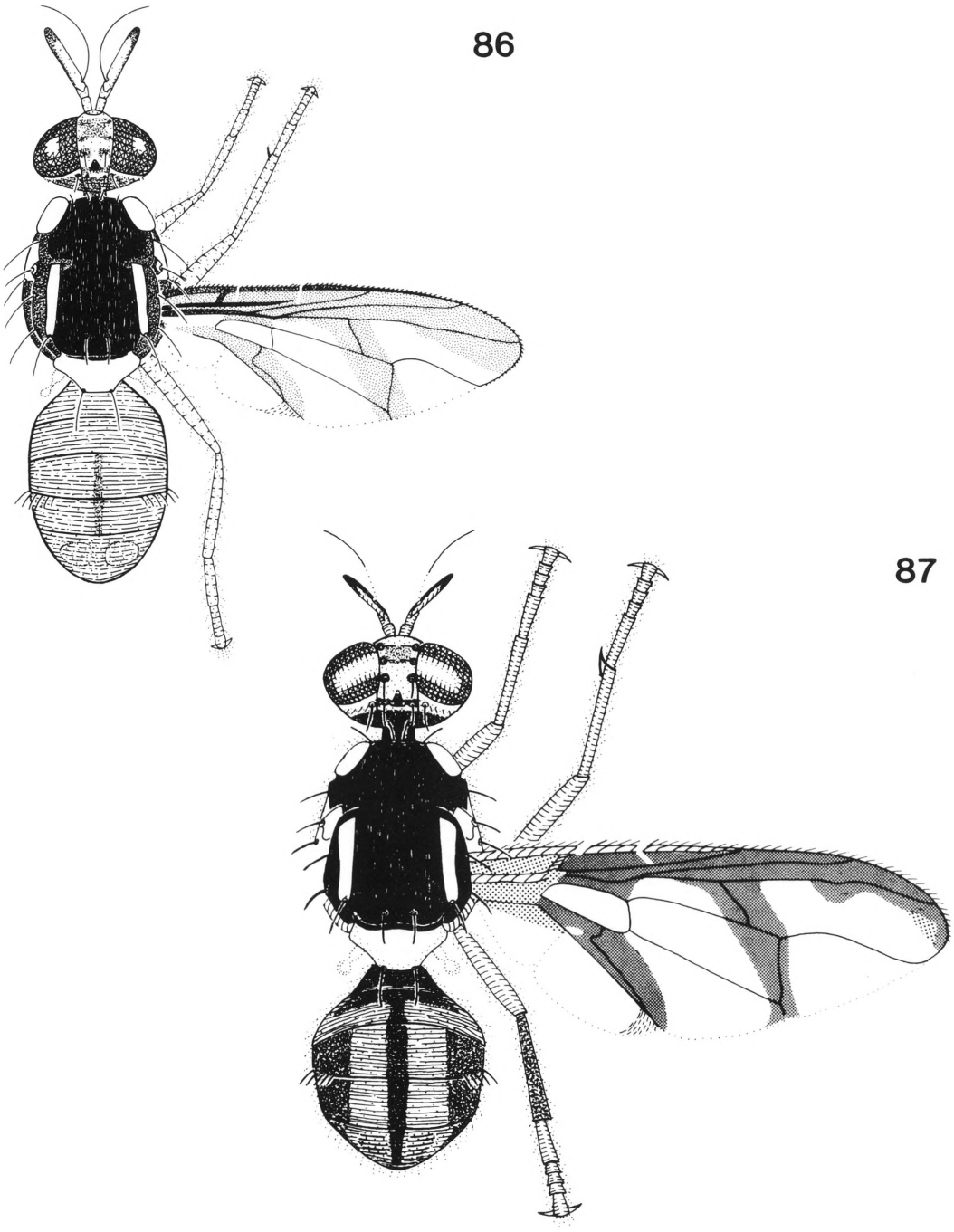


FIG. 86. *Bactrocera* (*Bactrocera*) *propedistincta* n. sp., adult male (x8). FIG. 87. *Bactrocera* (*Bactrocera*) *pseudodistincta* (Drew), adult male (x12).

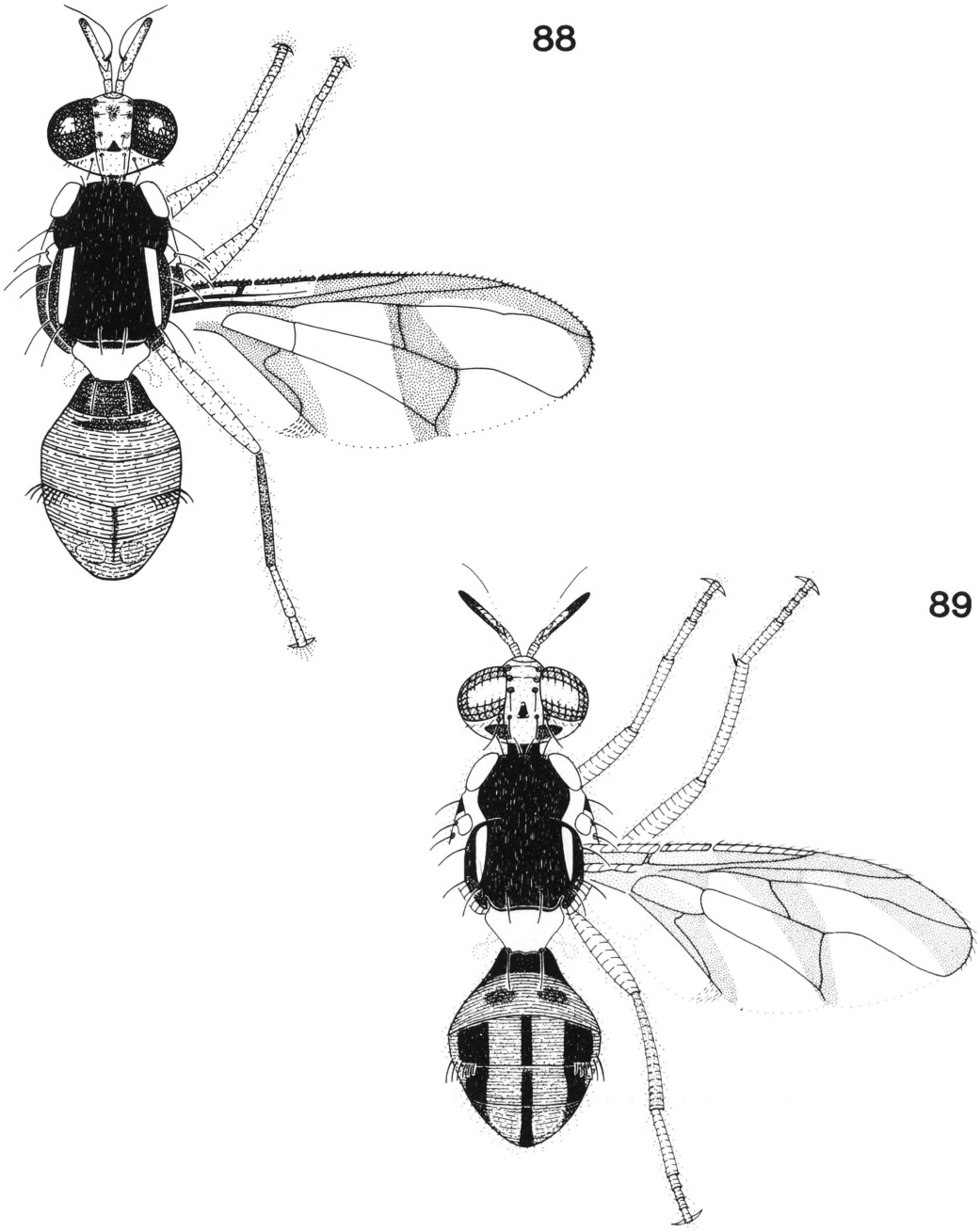


FIG. 88. *Bactrocera* (*Bactrocera*) *rhabdota* n. sp., adult male (x10). FIG. 89. *Bactrocera* (*Bactrocera*) *unifasciata* (Malloch), adult male (x12).

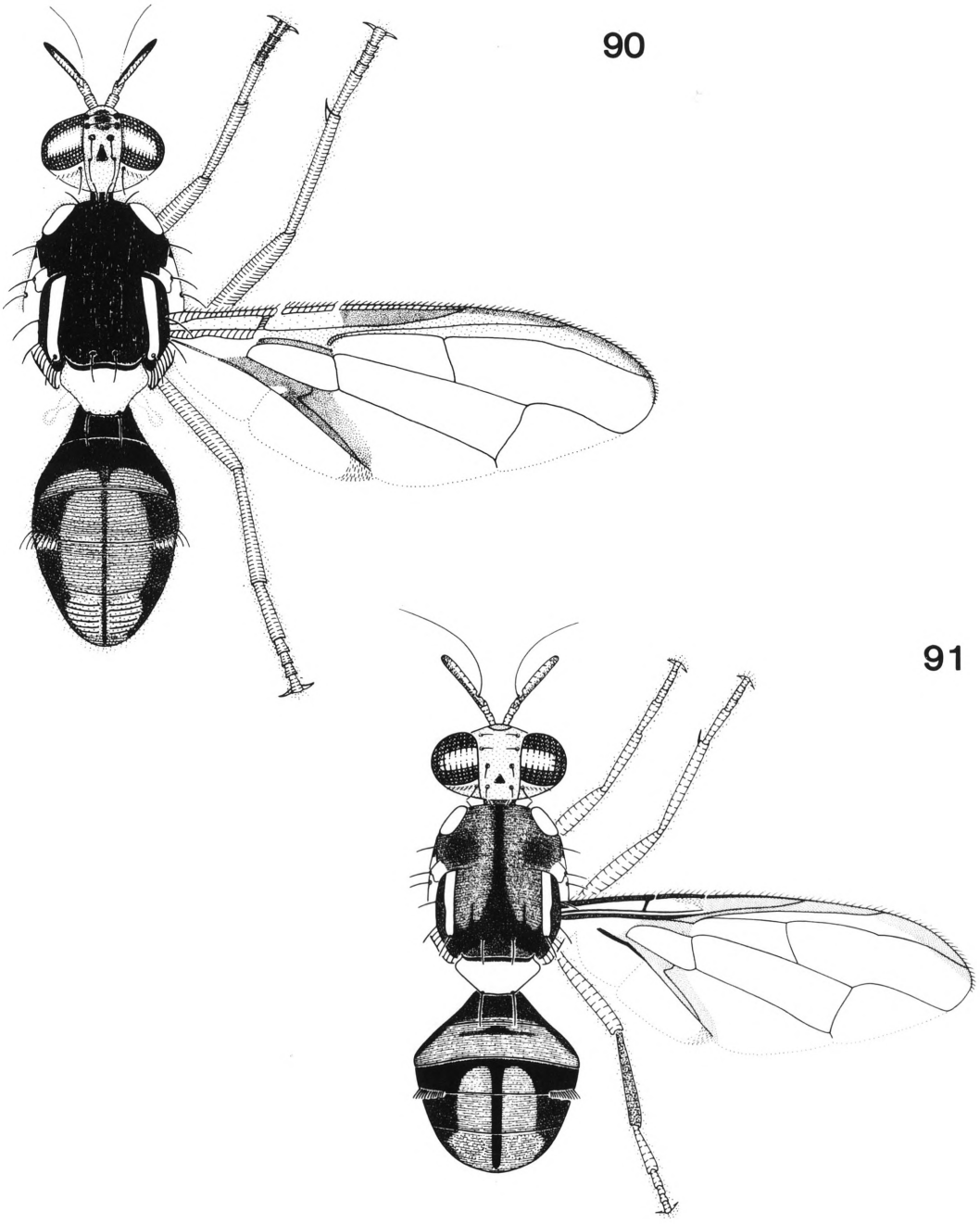
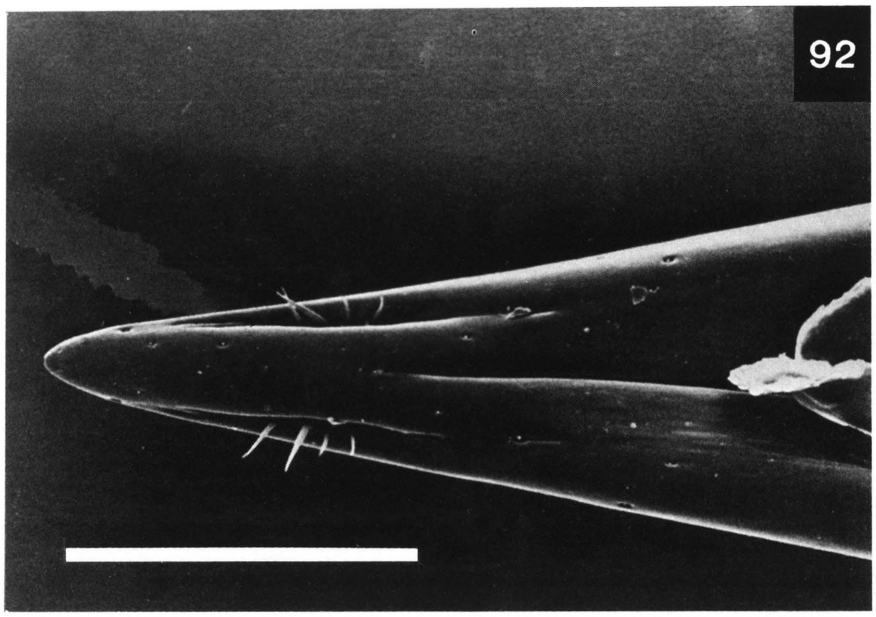
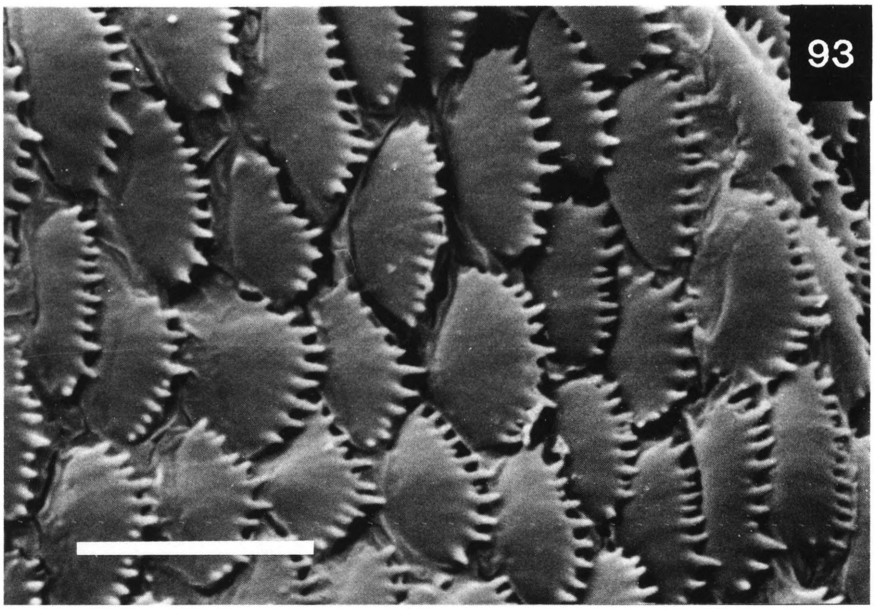
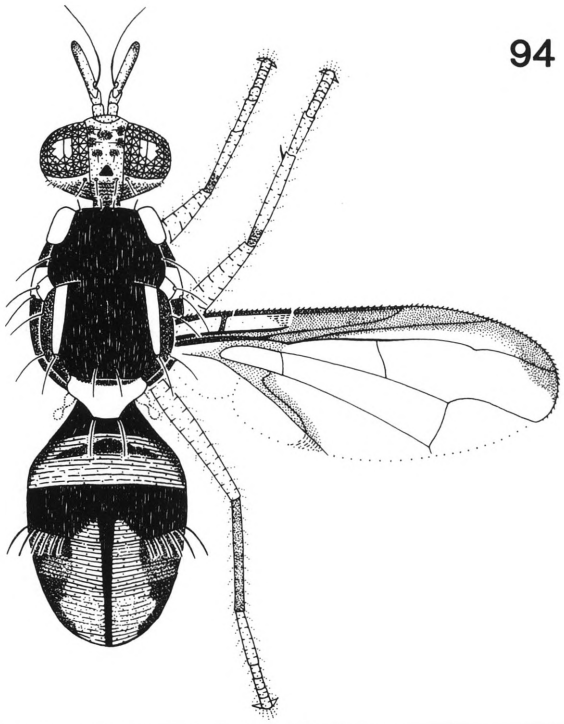


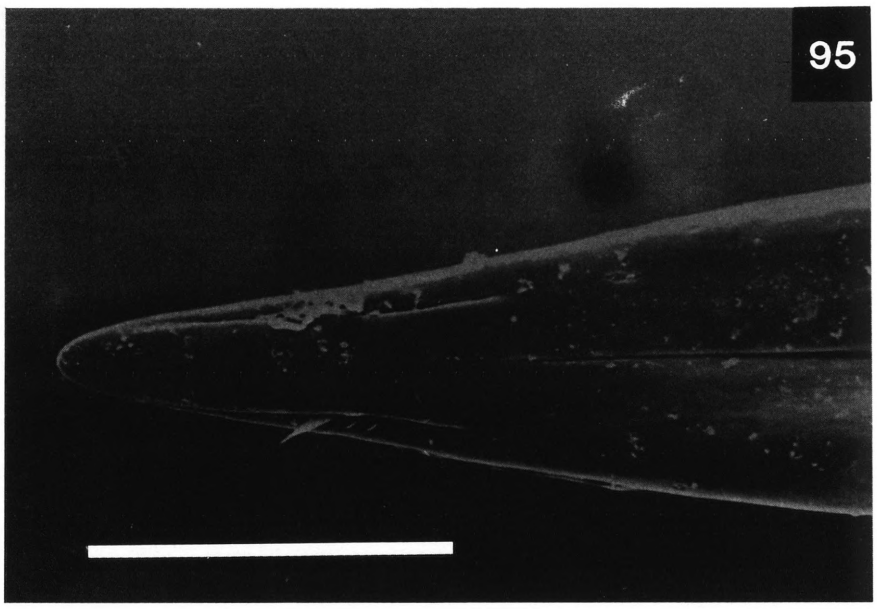
FIG. 90. *Bactrocera* (*Bactrocera*) *abdolonginqua* (Drew), adult male (x10). FIG. 91. *Bactrocera* (*Bactrocera*) *cacuminata* (Hering), adult male (x9).



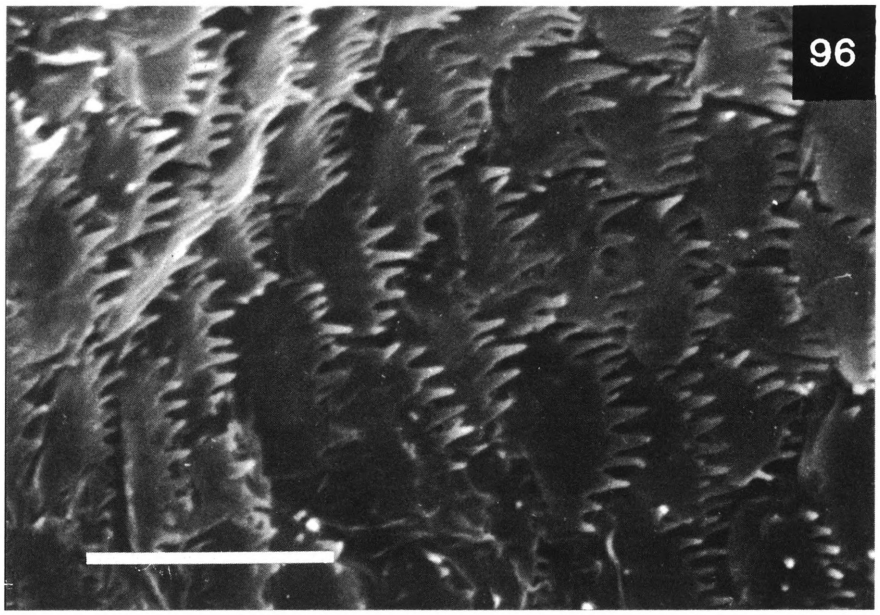


FIGS 92–93. *Bactrocera* (*Bactrocera*) *cacuminata* (Hering): 92, apex of aculeus (scale 0.1 mm); 93, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 94–95. *Bactrocera* (*Bactrocera*) *dapsiles* n. sp.: 94, adult male (x8); 95, apex of aculeus (scale 0.1 mm).



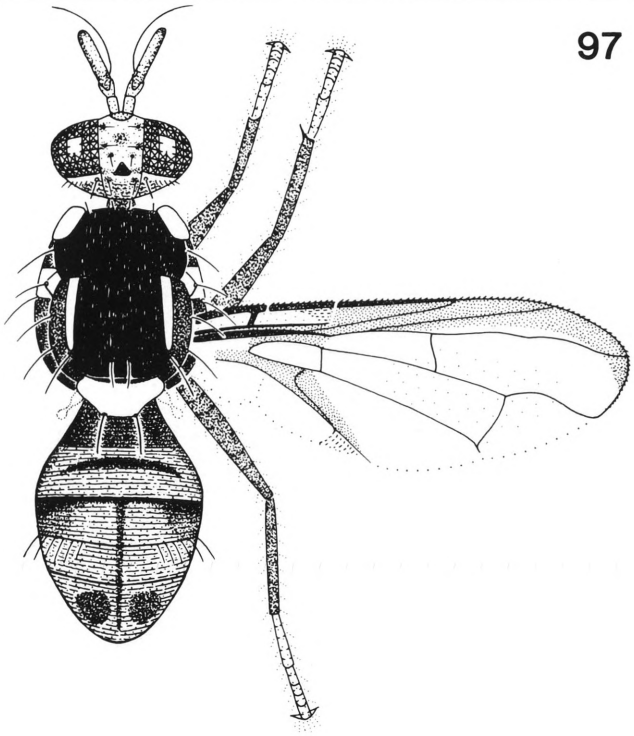
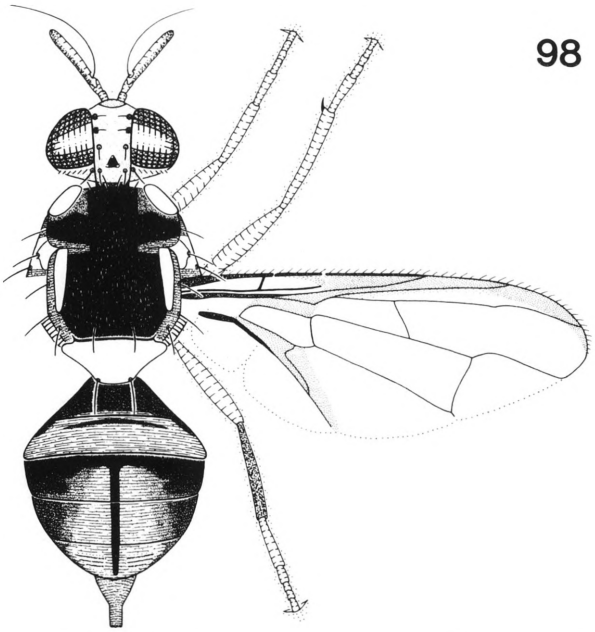
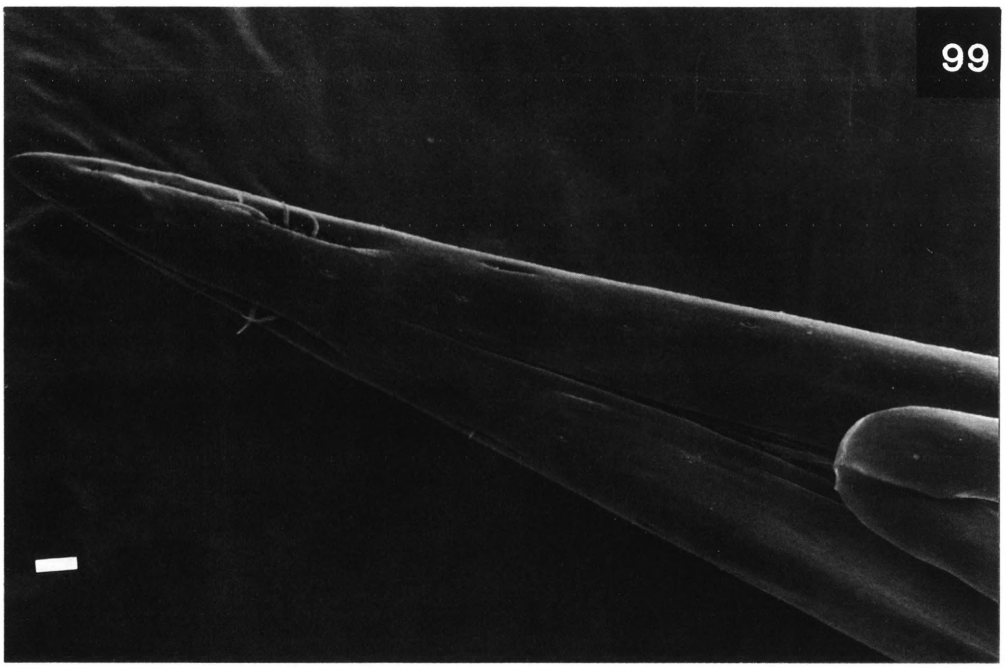
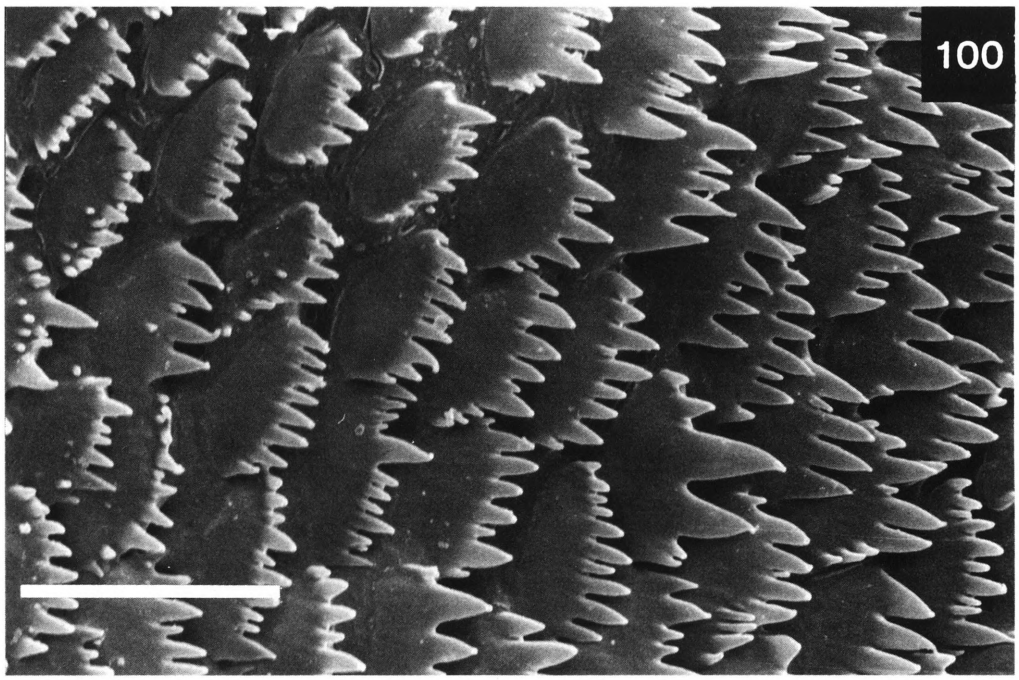


FIG. 96. *Bactrocera* (*Bactrocera*) *dapsiles* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 97. *Bactrocera* (*Bactrocera*) *diallagma* n. sp., adult male (x9).





FIGS 98–99. *Bactrocera* (*Bactrocera*) *endiandrae* (Perkins and May): 98, adult female (x10); 99, apex of aculeus (scale 0.01 mm).



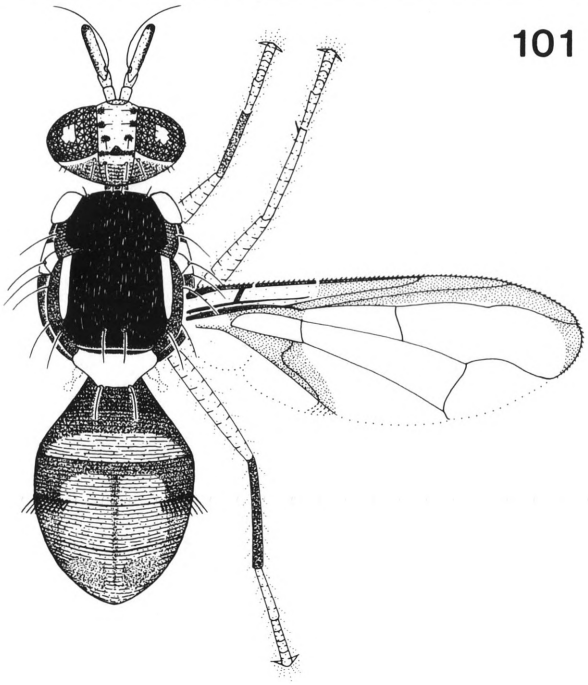
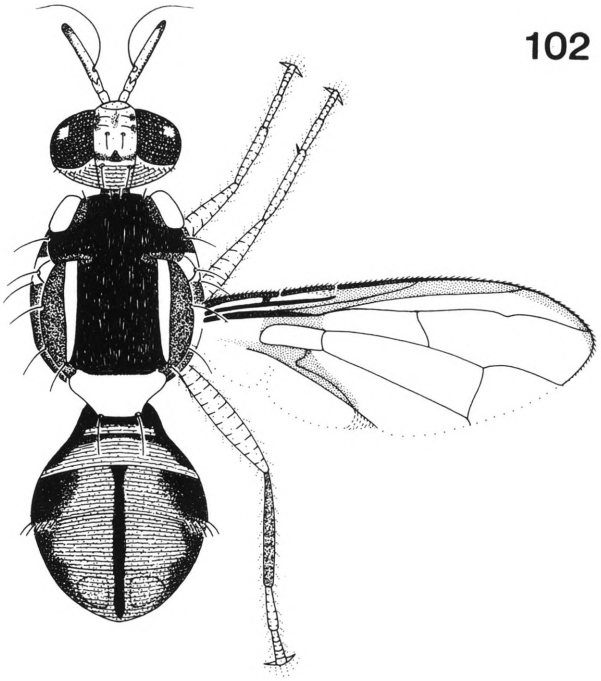


FIG. 100. *Bactrocera* (*Bactrocera*) *endiandrae* (Perkins and May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 101. *Bactrocera* (*Bactrocera*) *mimulus* n. sp., adult male (x11).



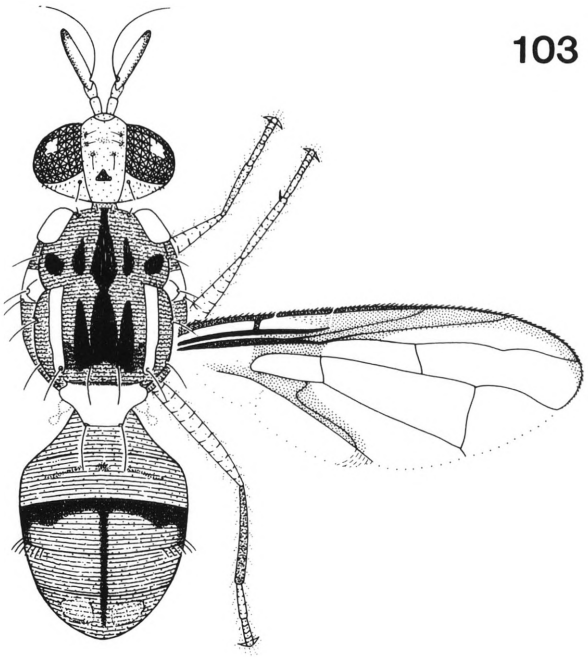
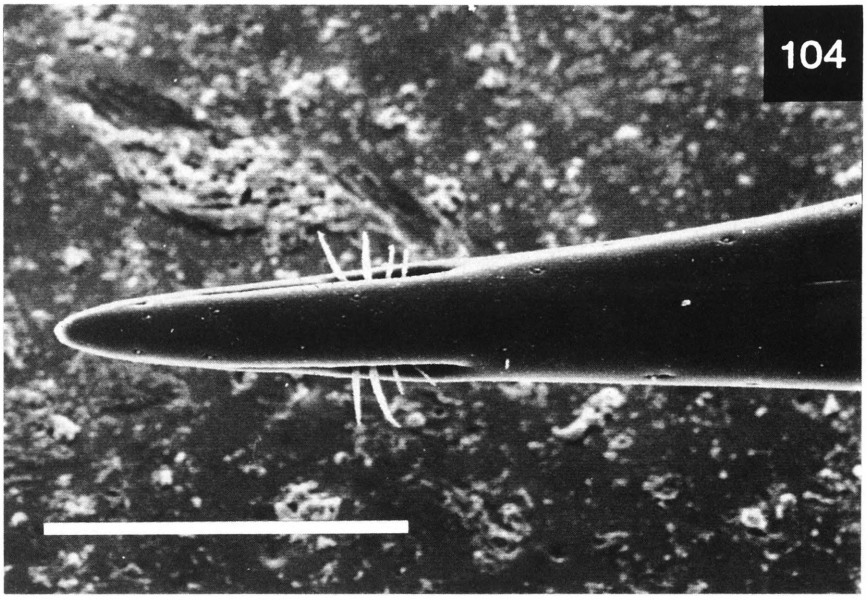
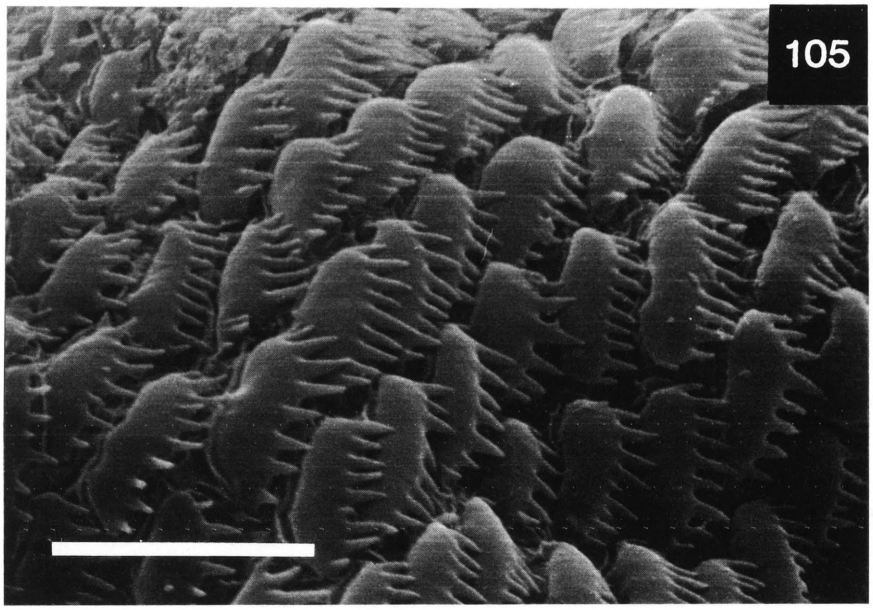
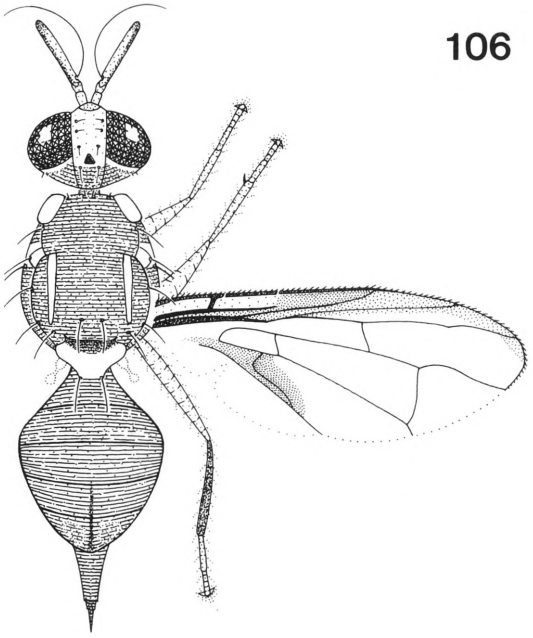


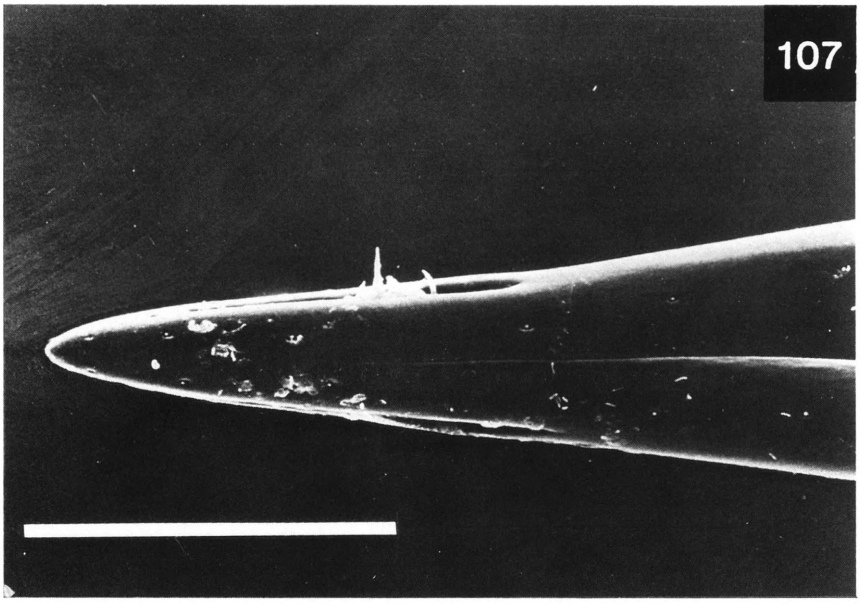
FIG. 102. *Bactrocera* (*Bactrocera*) *nigrescens* (Drew), adult male (x9). FIG. 103. *Bactrocera* (*Bactrocera*) *opiliae* (Drew and Hardy), adult male (x10).



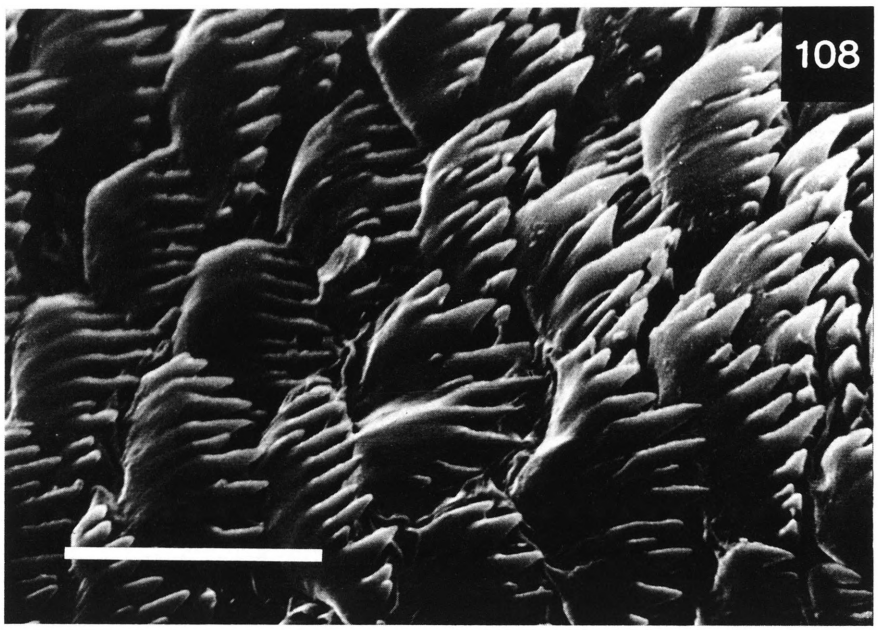


FIGS 104–105. *Bactrocera* (*Bactrocera*) *opiliae* (Drew and Hardy): 104, apex of aculeus (scale 0.1 mm); 105, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 106–107. *Bactrocera* (*Bactrocera*) *fagraea* (Tryon): 106, adult female (x8); 107, apex of aculeus (scale 0.1 mm).



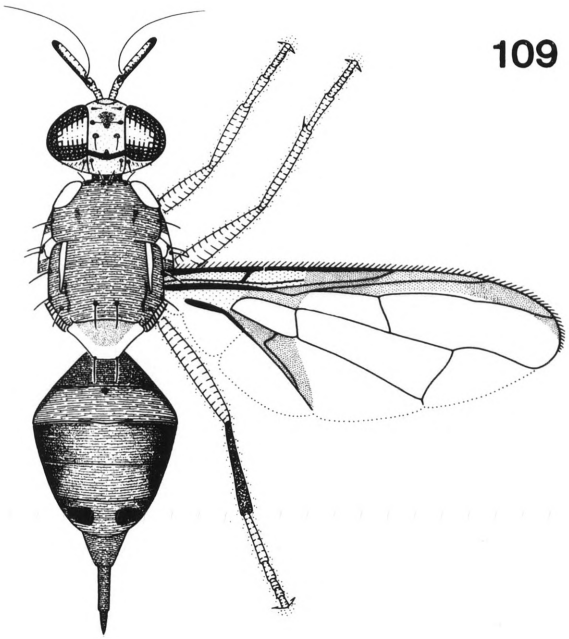
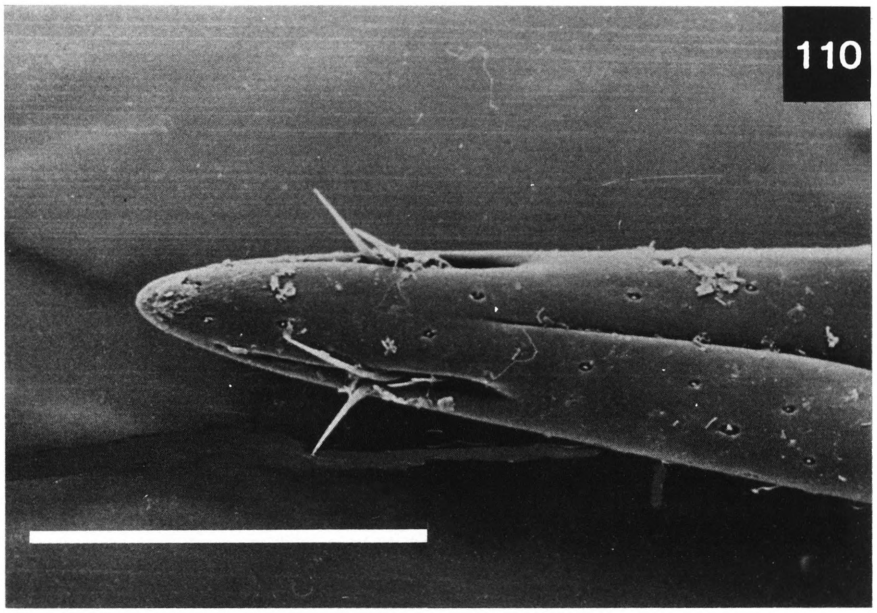
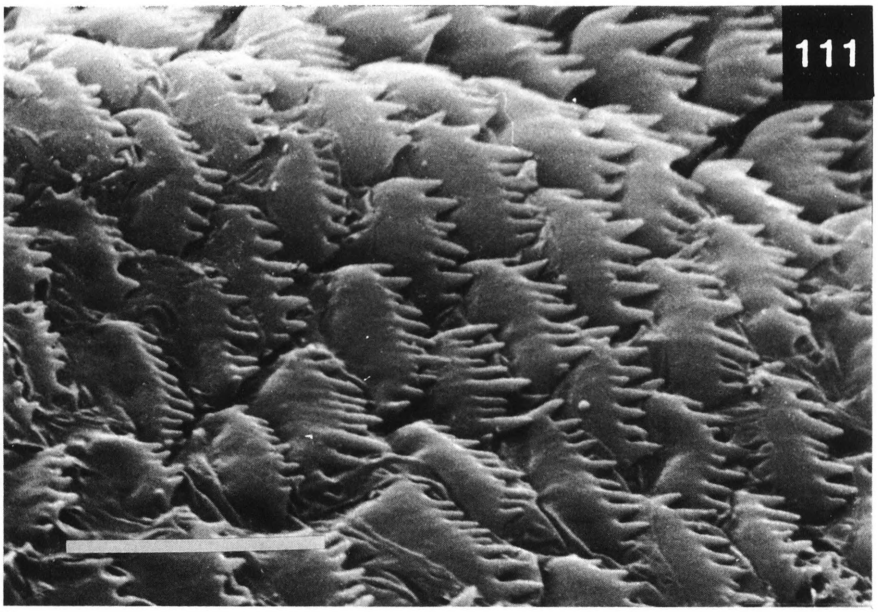
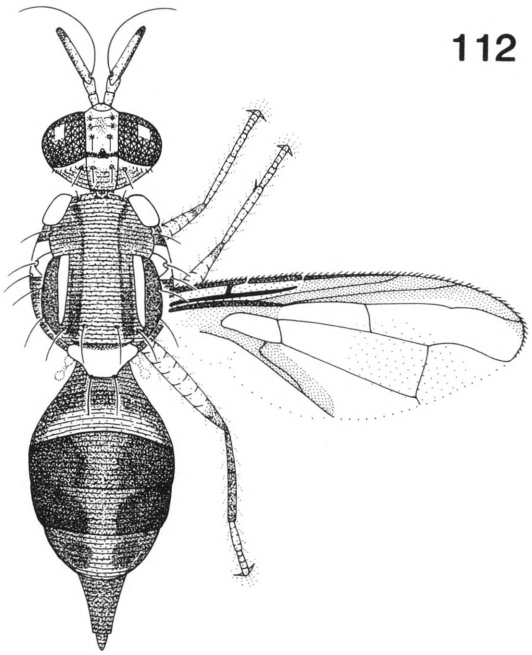


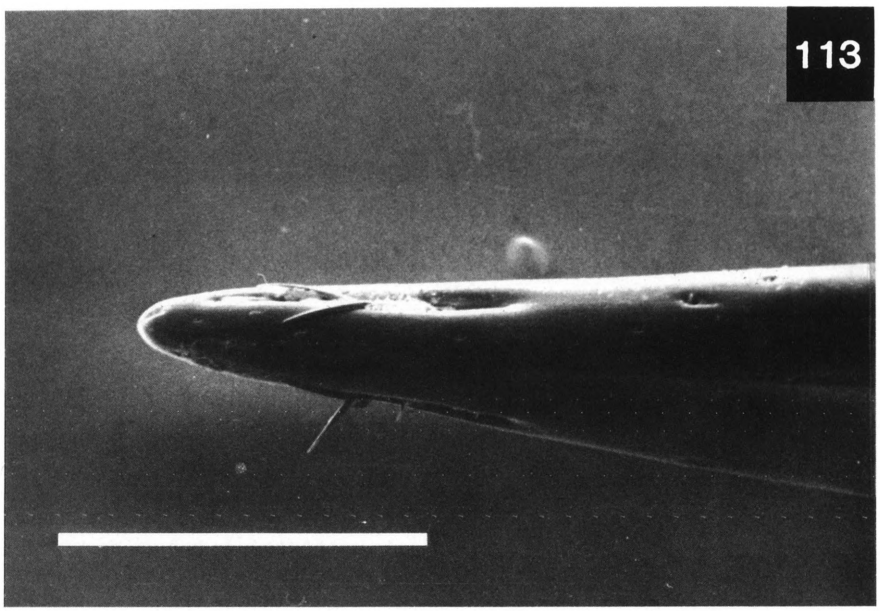
FIG. 108. *Bactrocera* (*Bactrocera*) *fagraea* (Tryon), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 109. *Bactrocera* (*Bactrocera*) *halfordiae* (Tryon), adult female (x8).



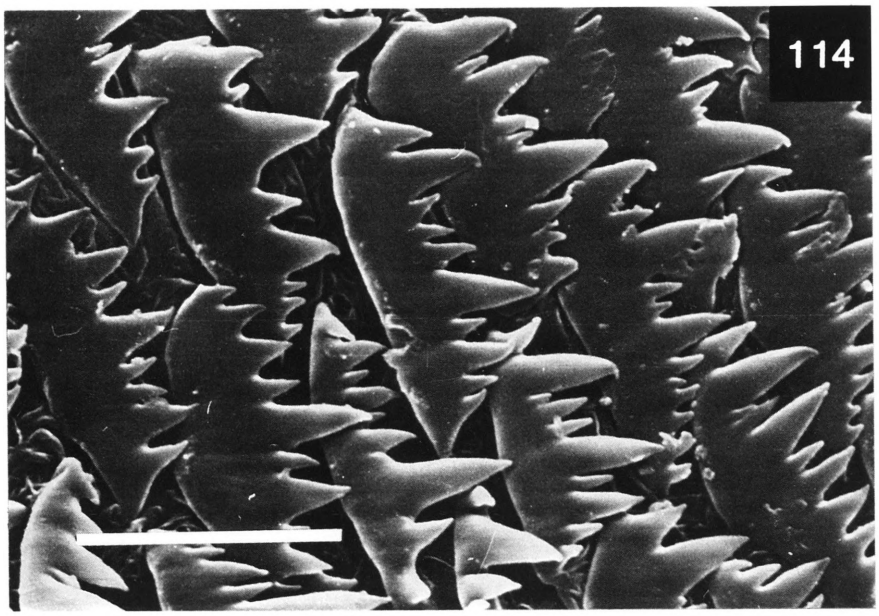


FIGS 110–111. *Bactrocera* (*Bactrocera*) *halfordiae* (Tryon): 110, apex of aculeus (scale 0.1 mm); 111, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 112–113. *Bactrocera* (*Bactrocera*) *kraussi* (Hardy): 112, adult female (x9); 113, apex of aculeus (scale 0.1 mm).



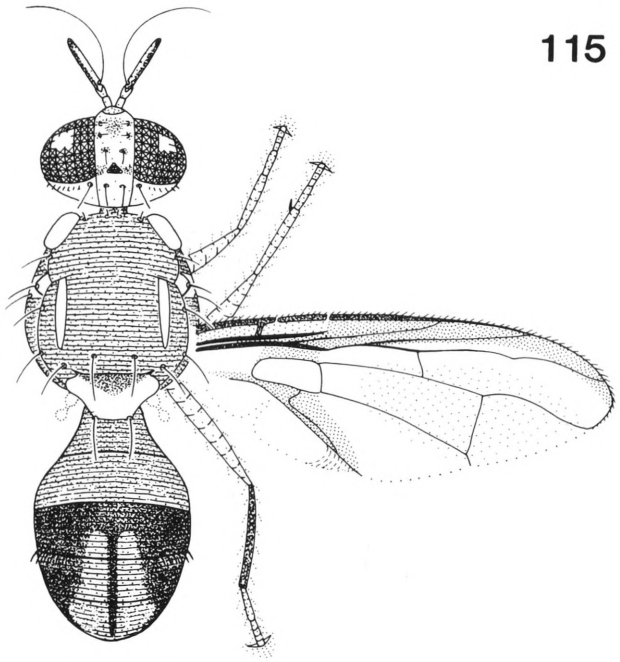
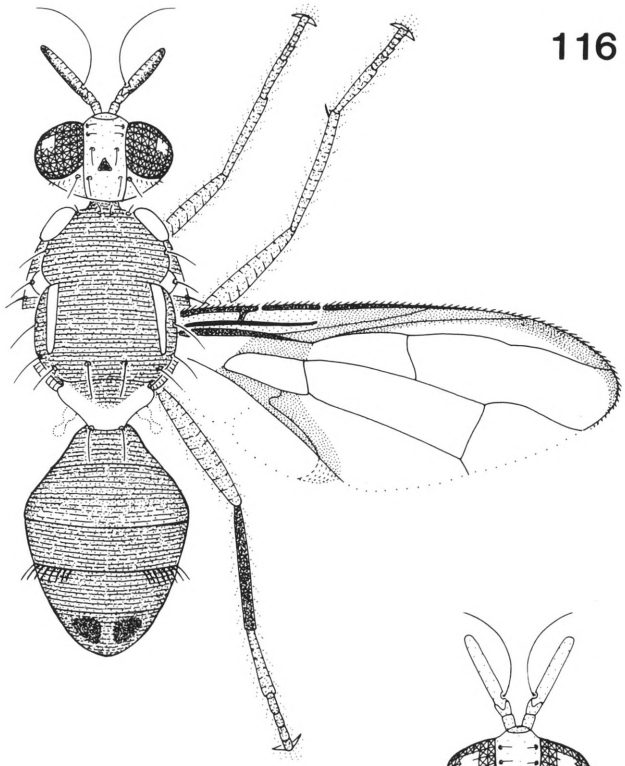


FIG. 114. *Bactrocera* (*Bactrocera*) *kraussi* (Hardy), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 115. *Bactrocera* (*Bactrocera*) *rufescens* (May), adult male (x10).



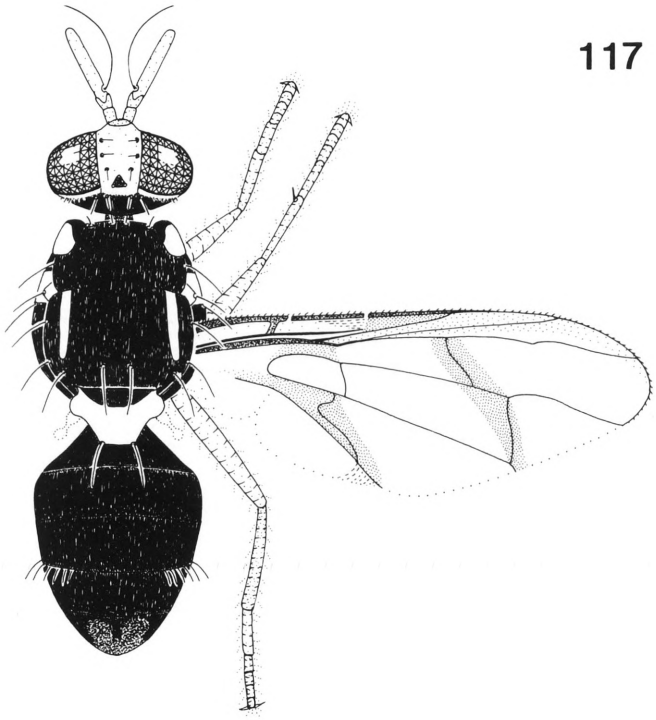
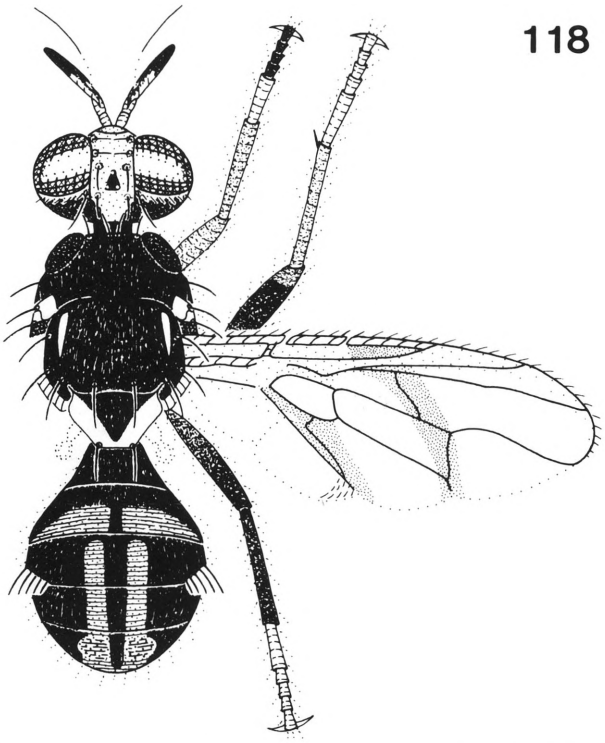
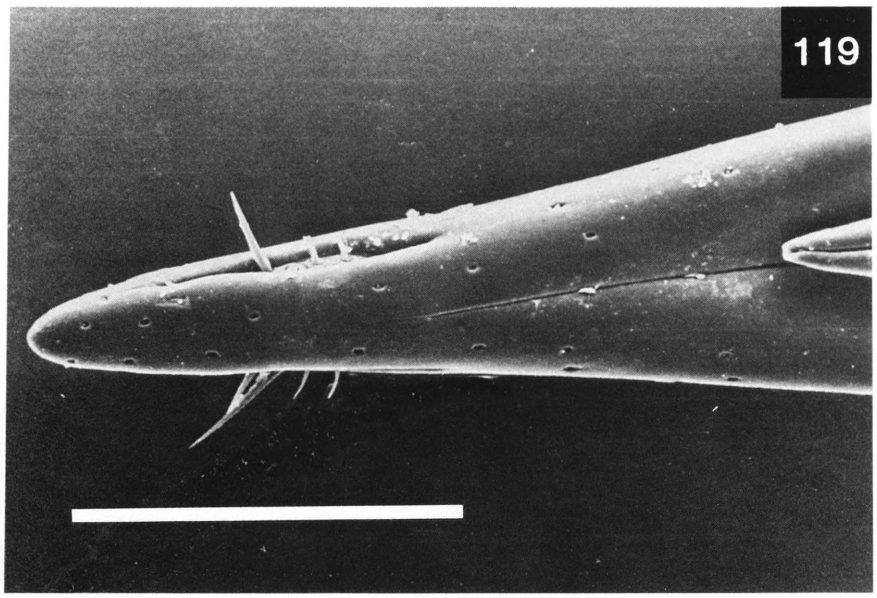
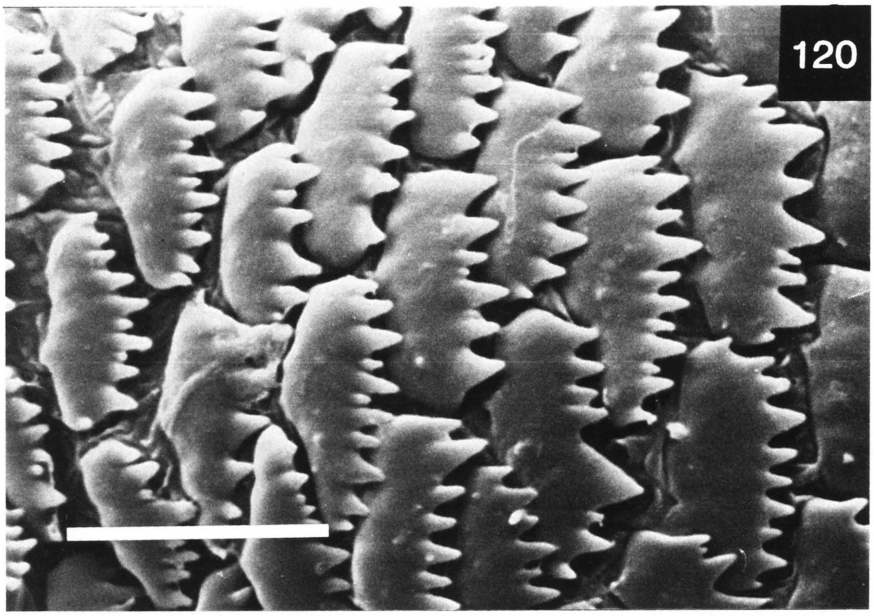


FIG. 116. *Bactrocera* (*Bactrocera*) *russeola* (Drew and Hancock), adult male (x9). FIG. 117. *Bactrocera* (*Bactrocera*) *caledoniensis* n. sp., adult male (x14).





FIGS 118–119. *Bactrocera* (*Bactrocera*) *frauenfeldi* (Schiner): 118, adult male (x11); 119, apex of aculeus (scale 0.1 mm).



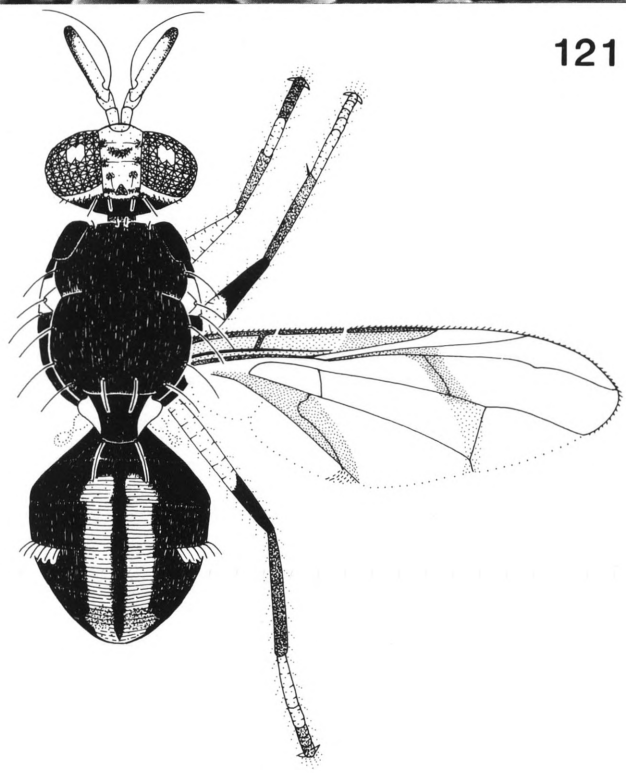
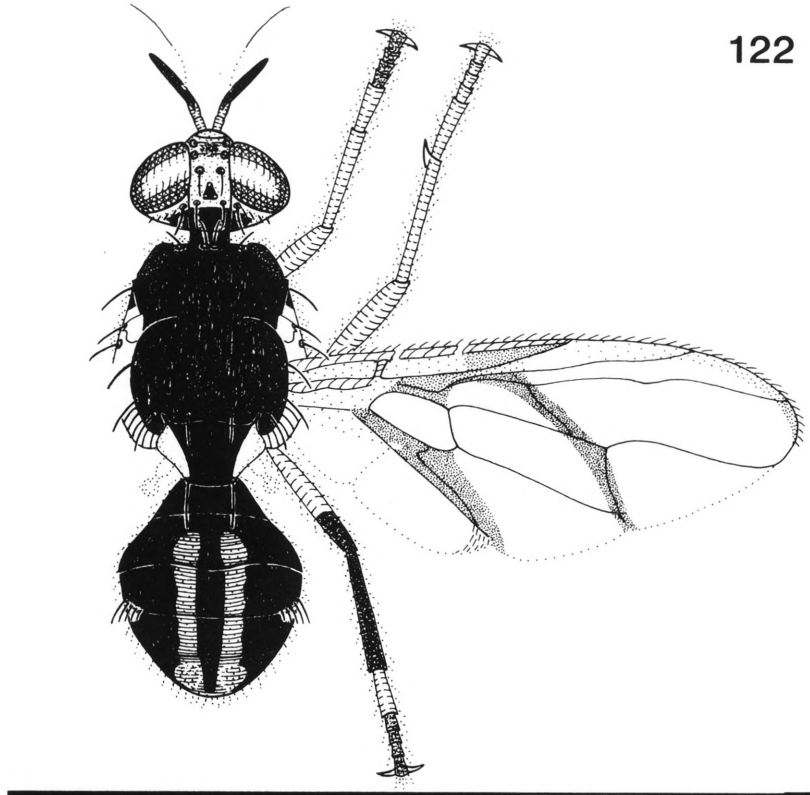
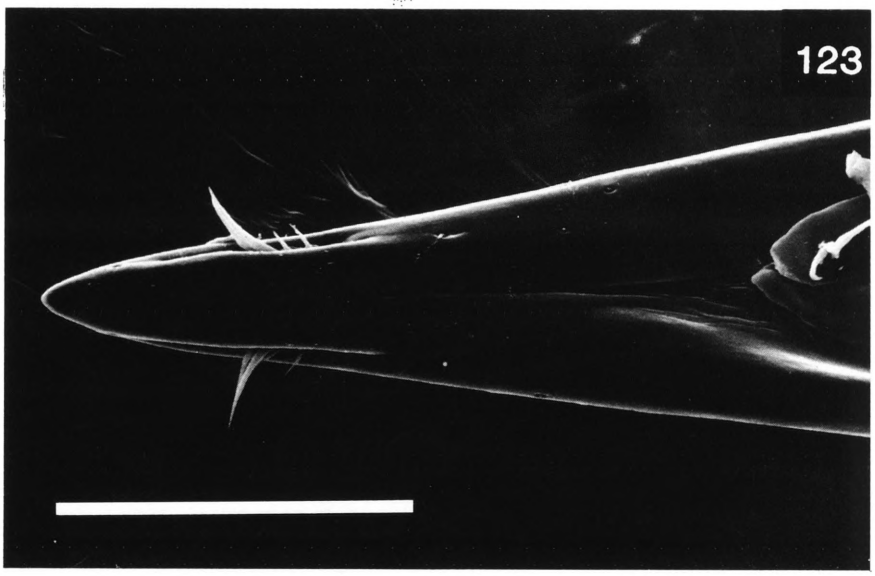
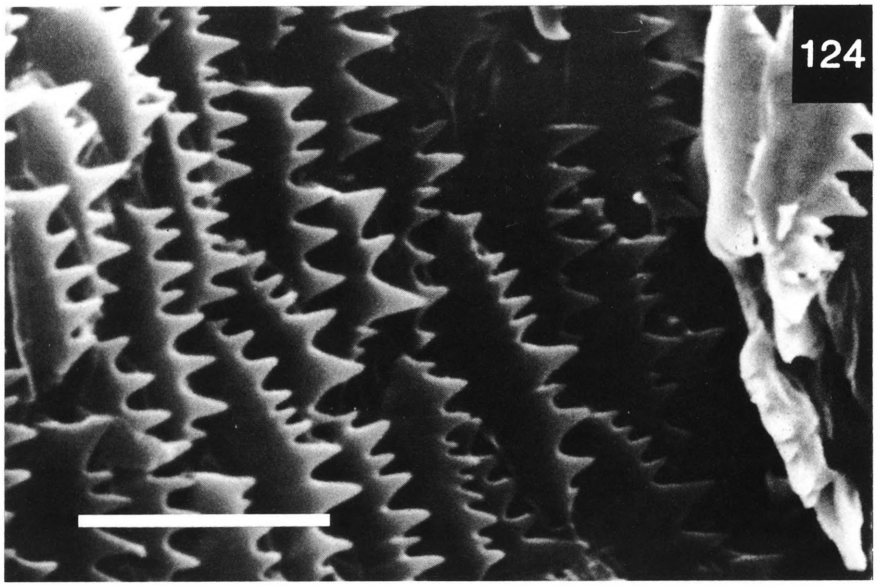


FIG. 120. *Bactrocera* (*Bactrocera*) *frauenfeldi* (Schiner), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 121. *Bactrocera* (*Bactrocera*) *parafrauenfeldi* n. sp., adult male (x11).





FIGS 122–123. *Bactrocera* (*Bactrocera*) *trilineola* n. nom.: 122, adult male (x14); 123, apex of aculeus (scale 0.1 mm).



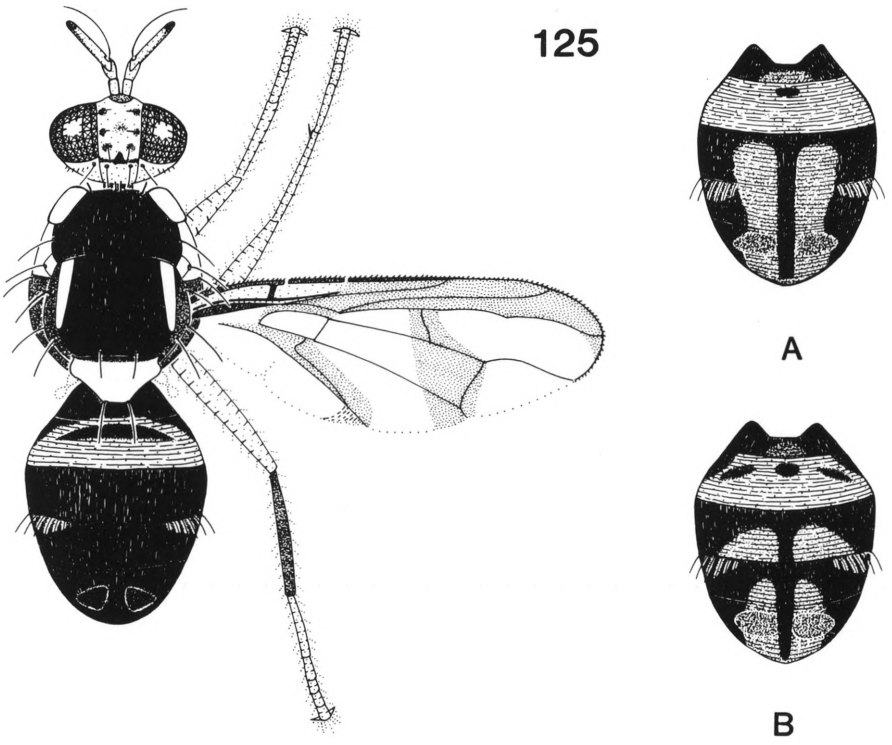
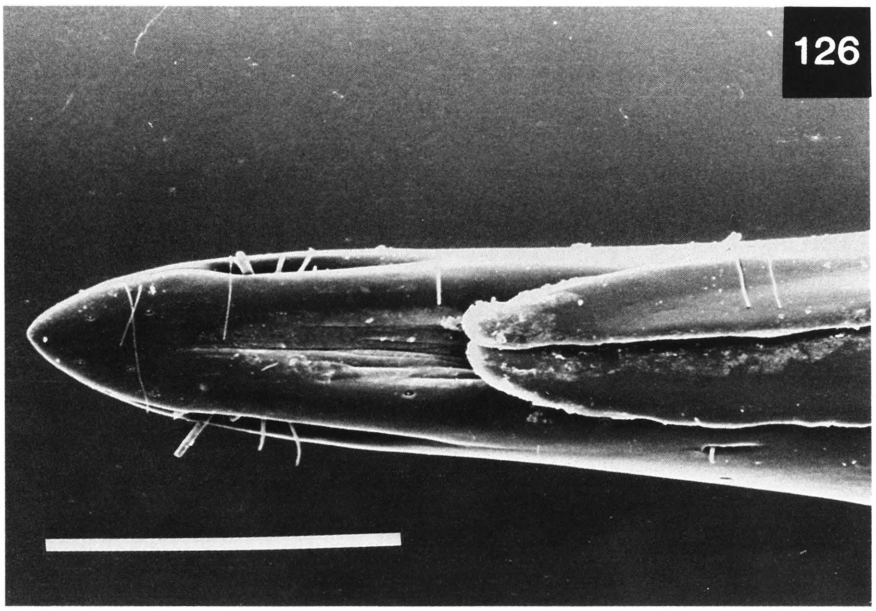
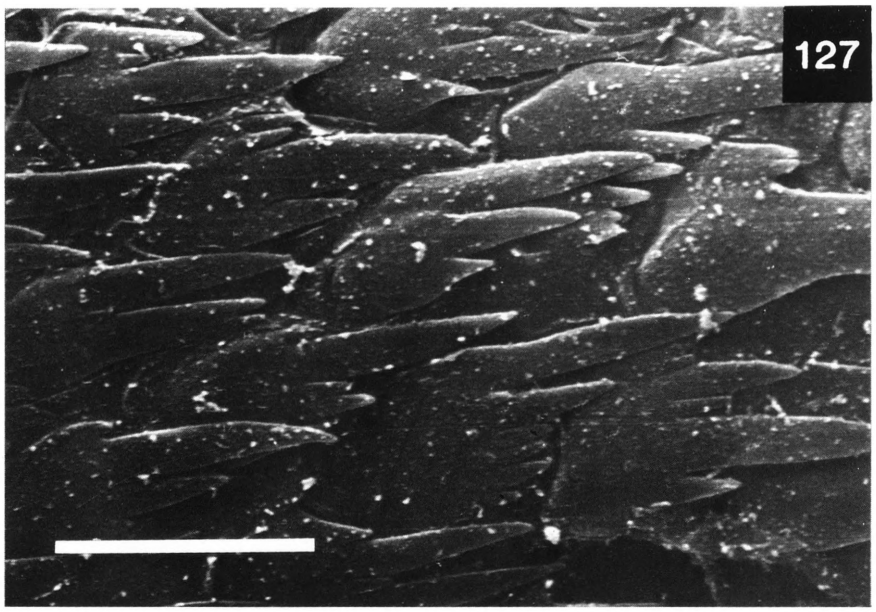
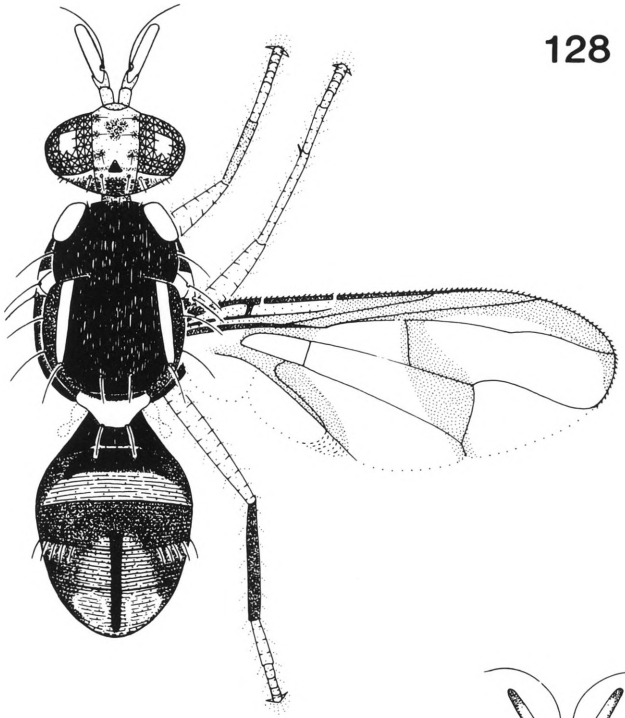


FIG. 124. *Bactrocera* (*Bactrocera*) *trilineola* n. nom., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 125. *Bactrocera* (*Bactrocera*) *fulvicauda* (Perkins), adult male (x7).





FIGS 126–127. *Bactrocera* (*Bactrocera*) *fulvicauda* (Perkins): 126, apex of aculeus (scale 0.1 mm); 127, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



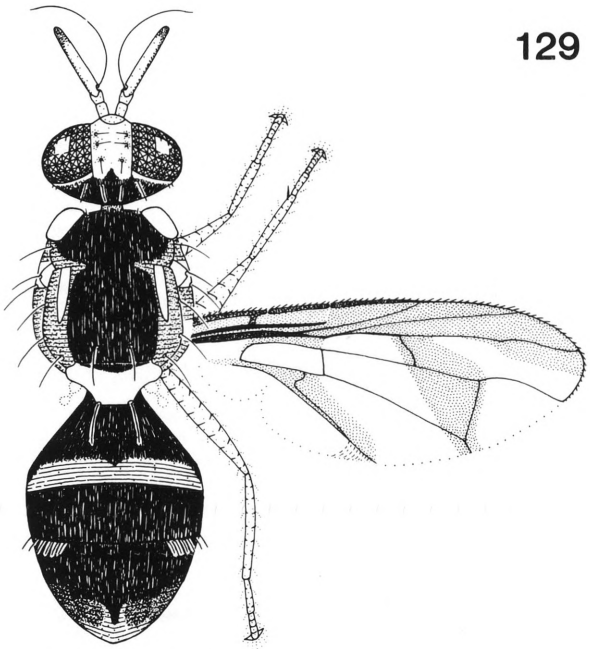


FIG. 128. *Bactrocera* (*Bactrocera*) *latilineata* n. sp., adult male (x9). FIG. 129. *Bactrocera* (*Bactrocera*) *pulchra* Tryon, adult male (x8).

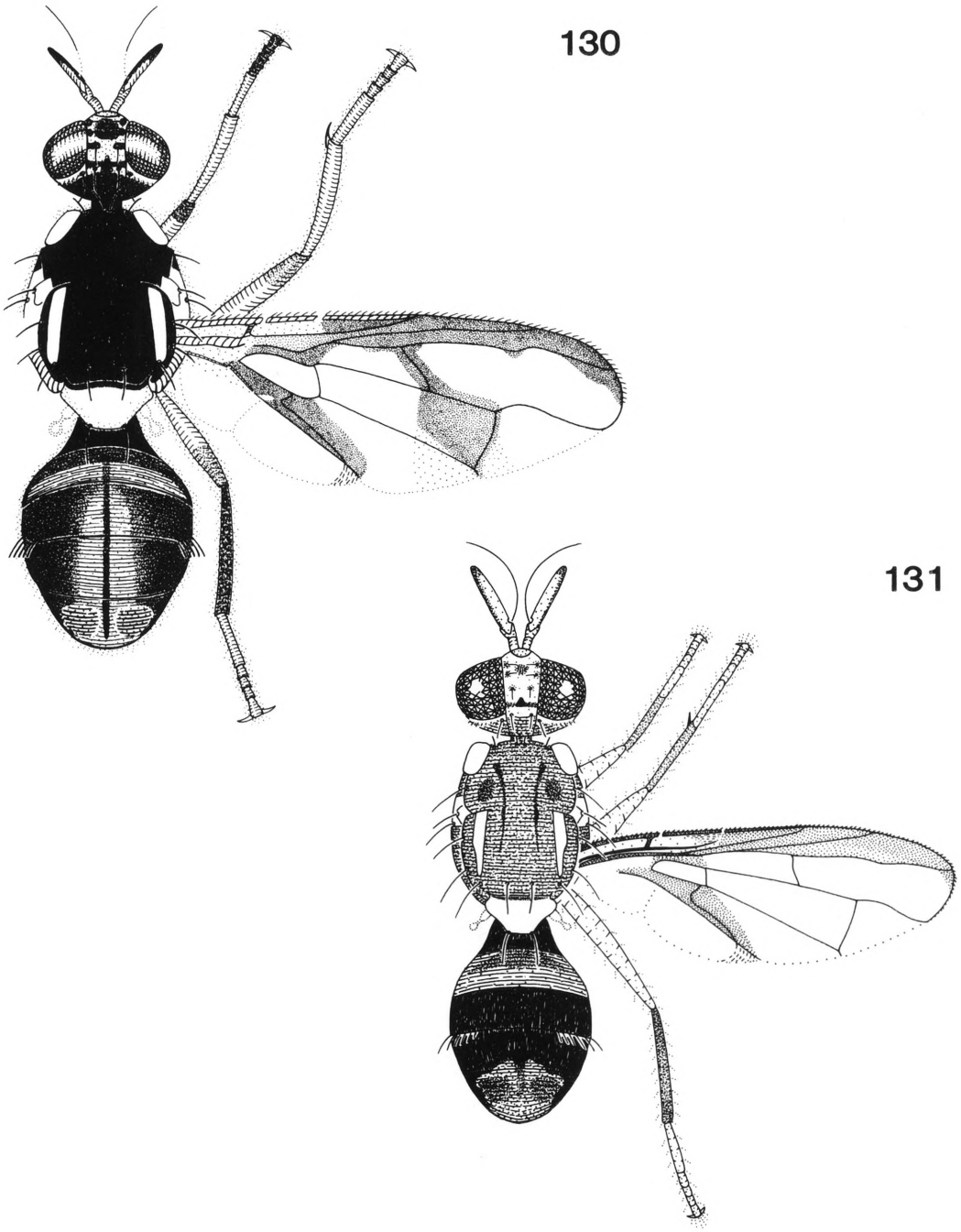
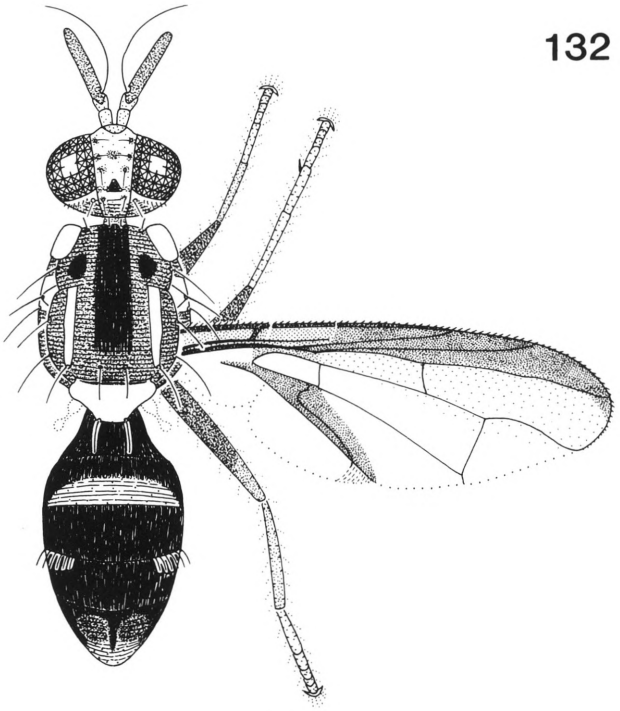
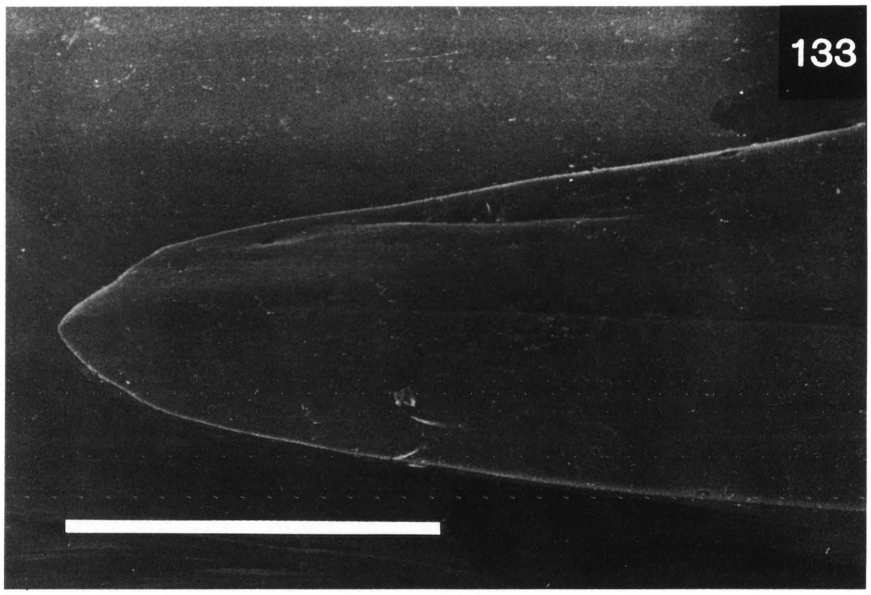
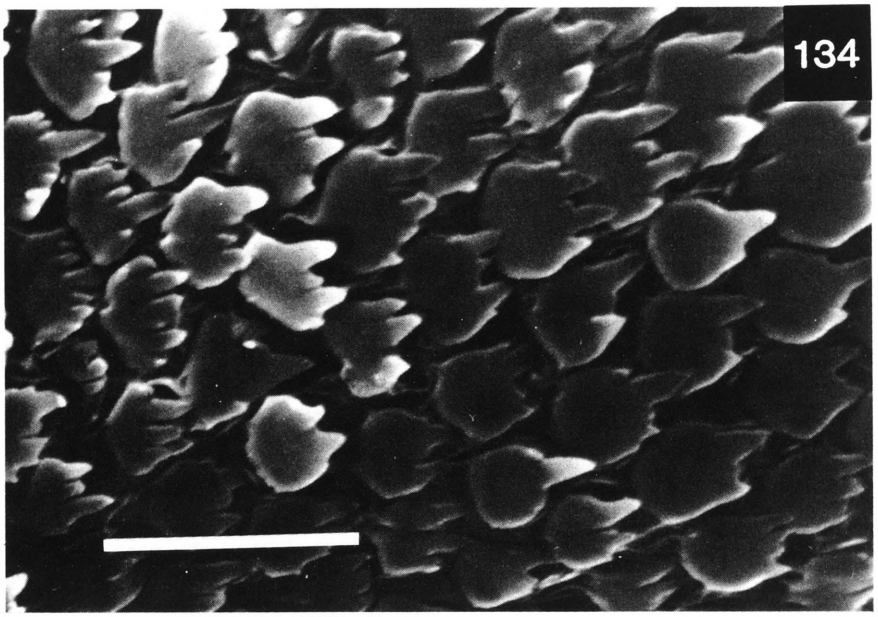


FIG. 130. *Bactrocera* (*Bactrocera*) *unistriata* (Drew), adult male (x9). FIG. 131. *Bactrocera* (*Bactrocera*) *furfurosa* n. sp., adult male (x9).





FIGS 132–133. *Bactrocera* (*Bactrocera*) *nigrovittata* n. sp.: 132, adult male (x10); 133, apex of aculeus (scale 0.1 mm).



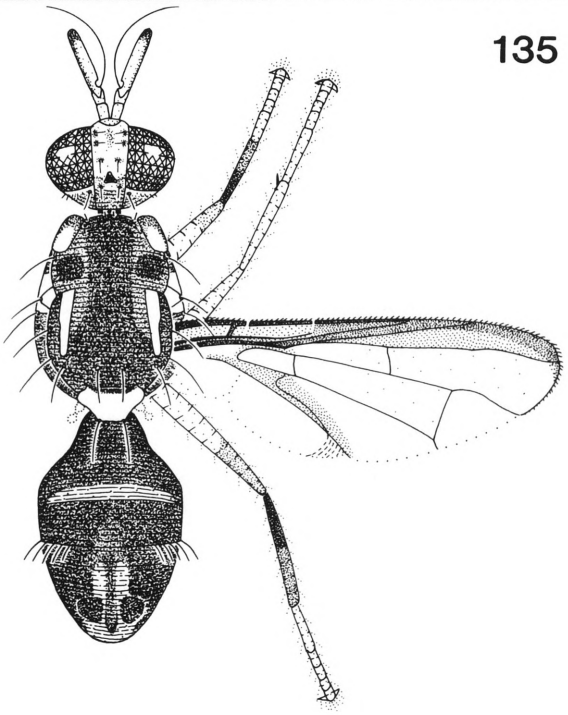
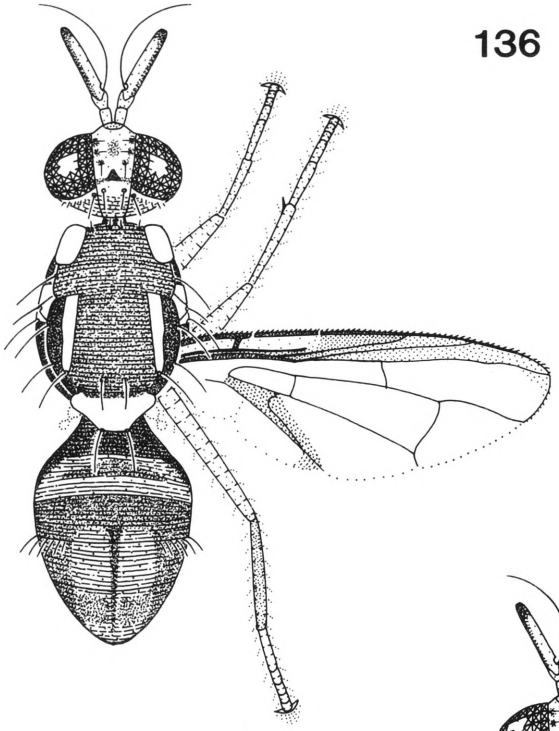


FIG. 134. *Bactrocera* (*Bactrocera*) *nigrovittata* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 135. *Bactrocera* (*Bactrocera*) *obfuscata* n. sp., adult male (x7).



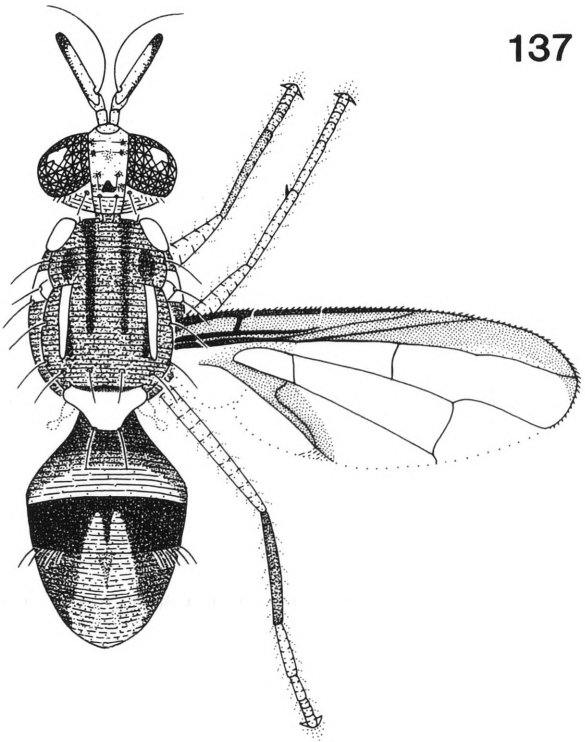
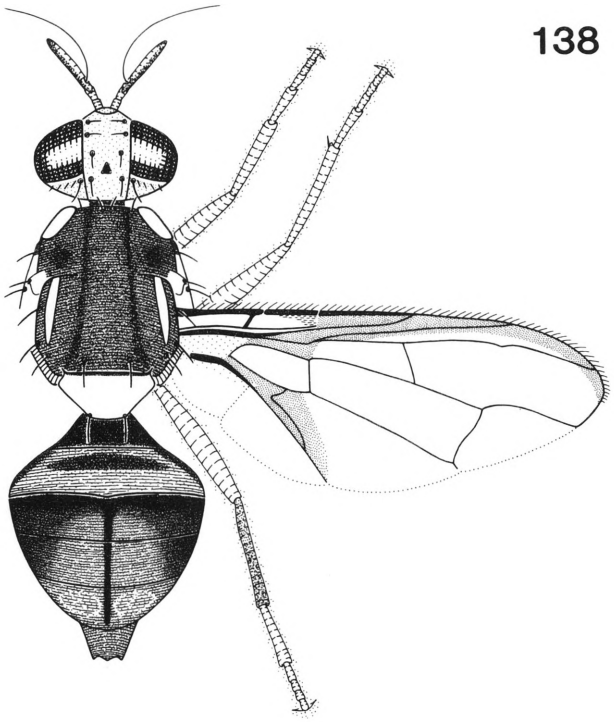
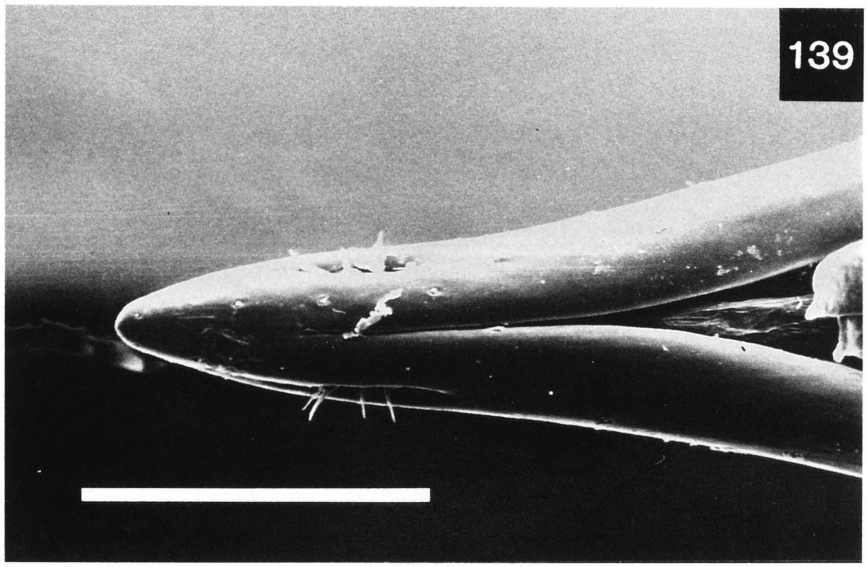
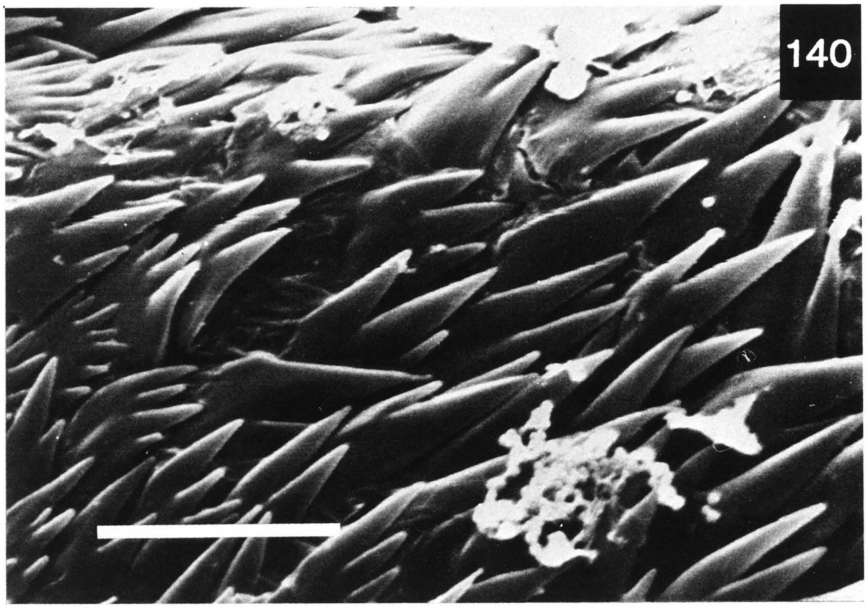


FIG. 136. *Bactrocera* (*Bactrocera*) *popondettiensis* n. sp., adult male (x9). FIG. 137. *Bactrocera* (*Bactrocera*) *ustulata* n. sp., adult male (x10).





FIGS 138–139. *Bactrocera* (*Bactrocera*) *mayi* (Hardy): 138, adult female (x10); 139, apex of aculeus (scale 0.1 mm).



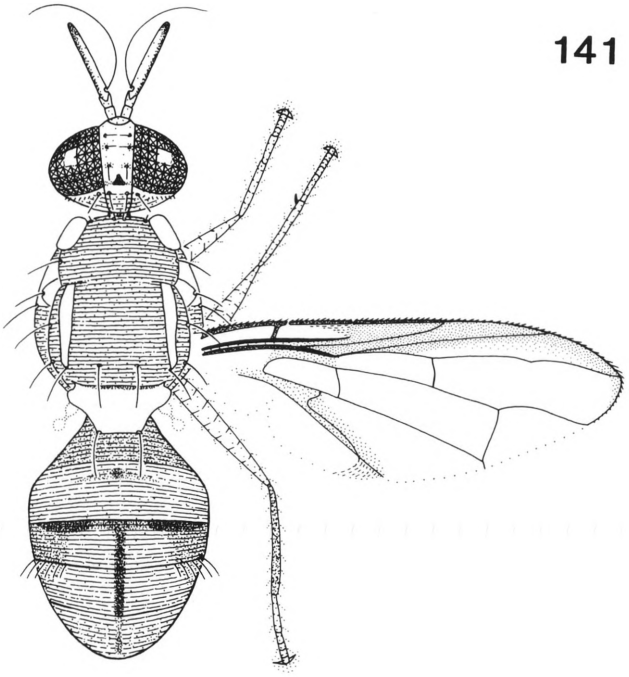
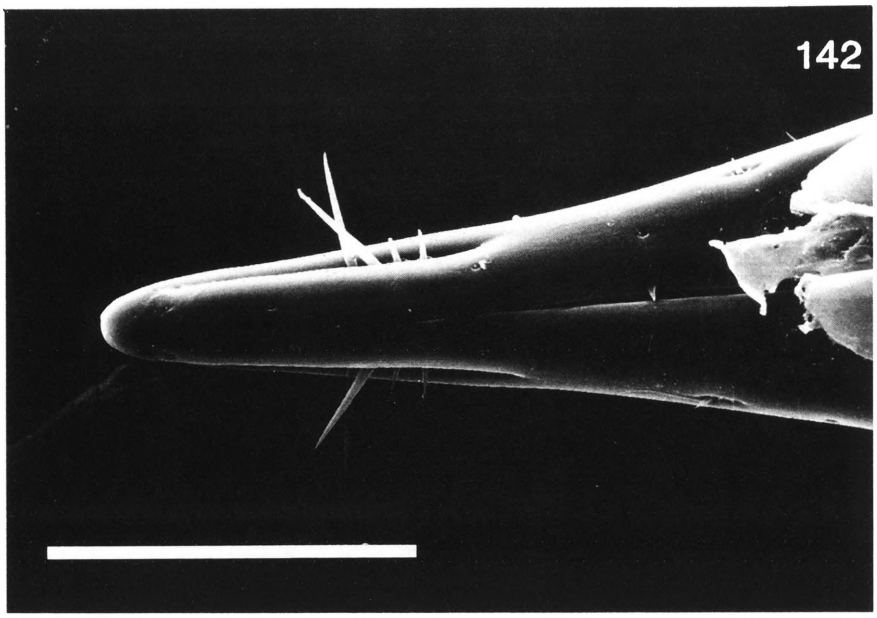
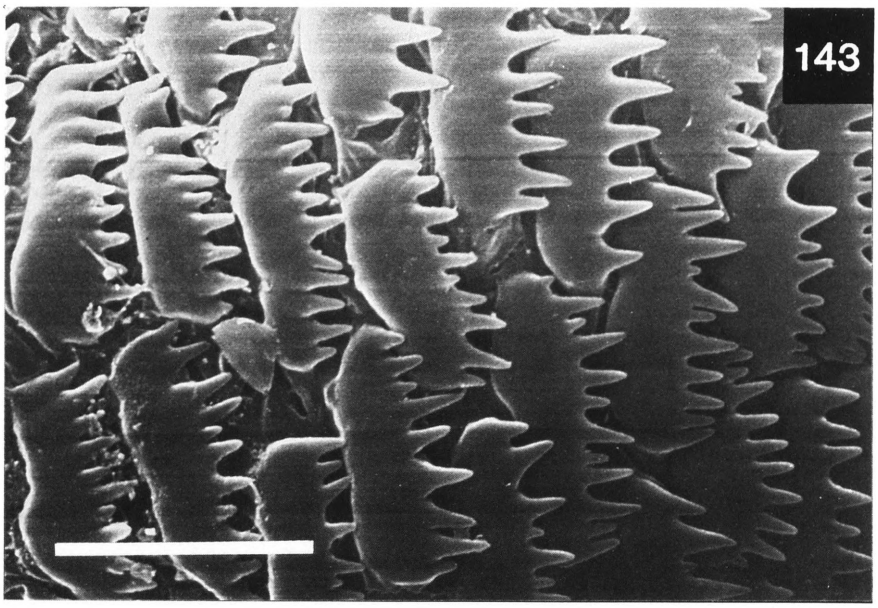
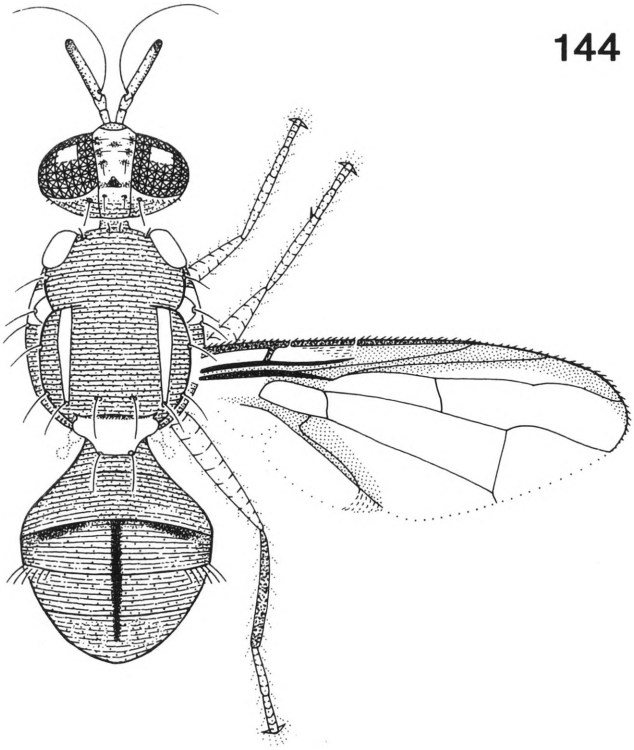


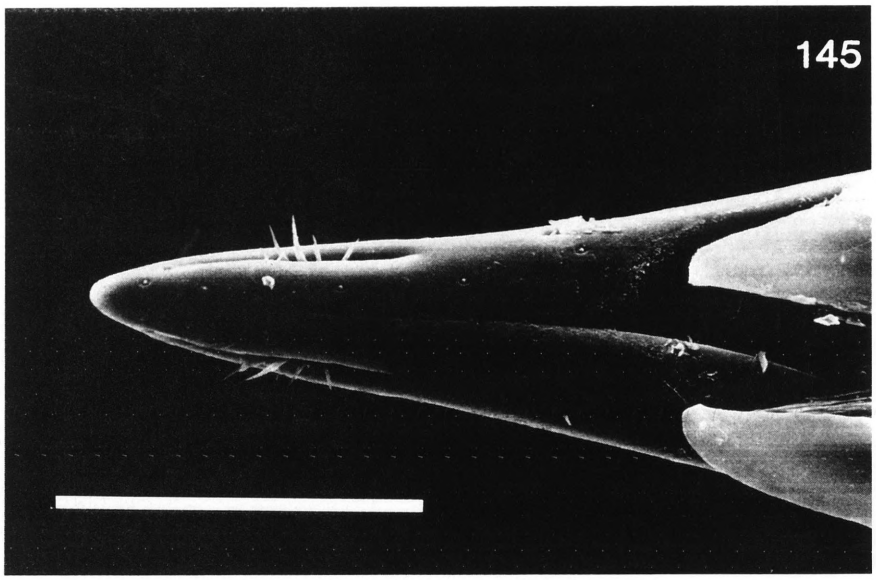
FIG. 140. *Bactrocera* (*Bactrocera*) *mayi* (Hardy), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 141. *Bactrocera* (*Bactrocera*) *pallida* (Perkins and May), adult male (x10).



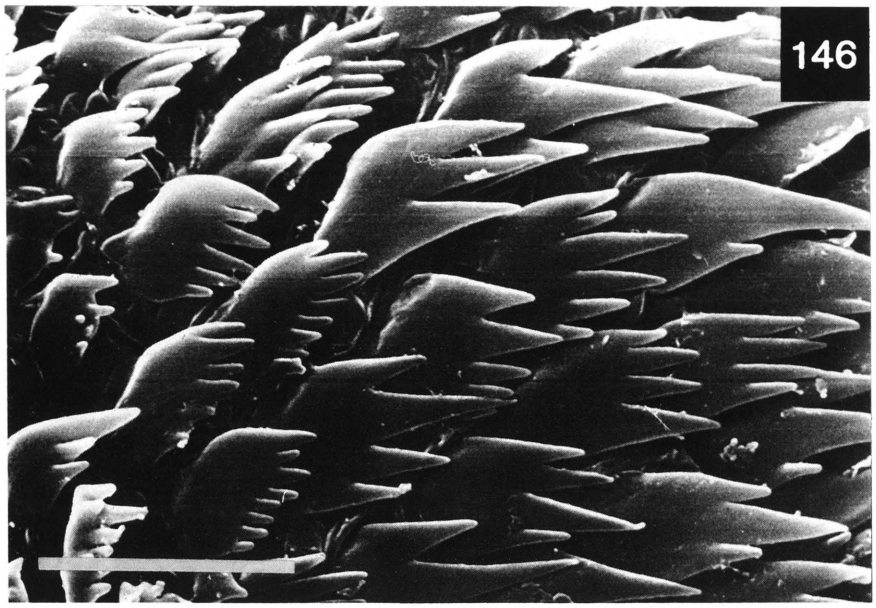


FIGS 142–143. *Bactrocera* (*Bactrocera*) *pallida* (Perkins and May): 142, apex of aculeus (scale 0.1 mm); 143, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 144–145. *Bactrocera* (*Bactrocera*) *tenuifascia* (May): 144, adult male (x11); 145, apex of aculeus (scale 0.1 mm).



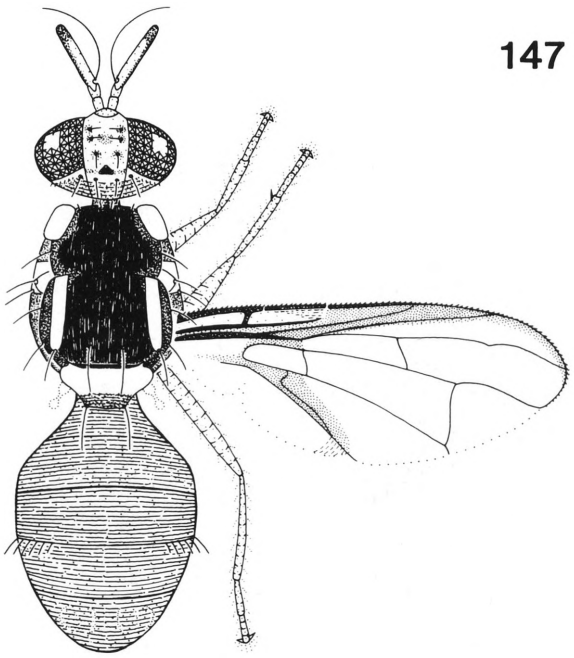
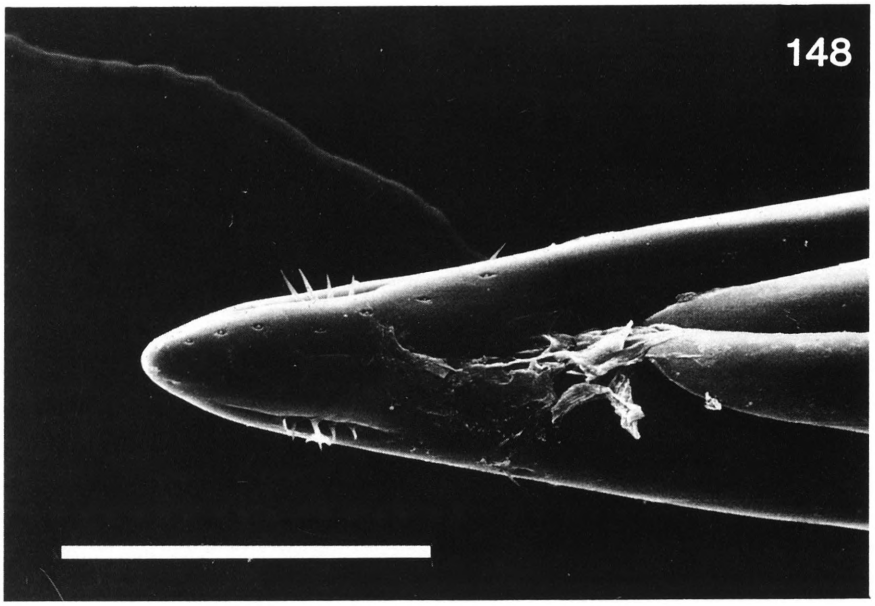
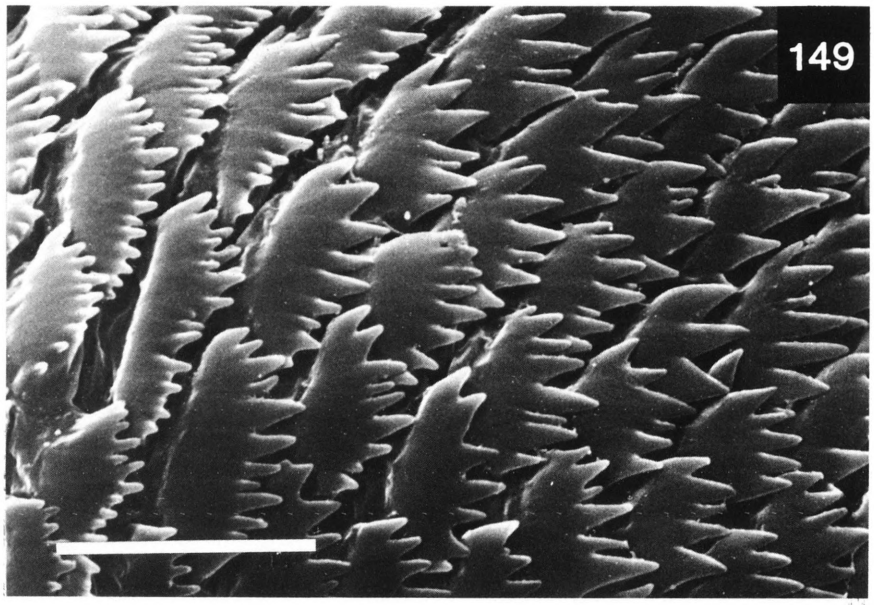


FIG. 146. *Bactrocera* (*Bactrocera*) *tenuifascia* (May), spicules on distal end of middle segment of ovipositor (scale 0.01mm). FIG. 147. *Bactrocera* (*Bactrocera*) *bancroftii* (Tryon), adult male (x9).





FIGS 148–149. *Bactrocera* (*Bactrocera*) *bancroftii* (Tryon): 148, apex of aculeus (scale 0.1 mm); 149, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

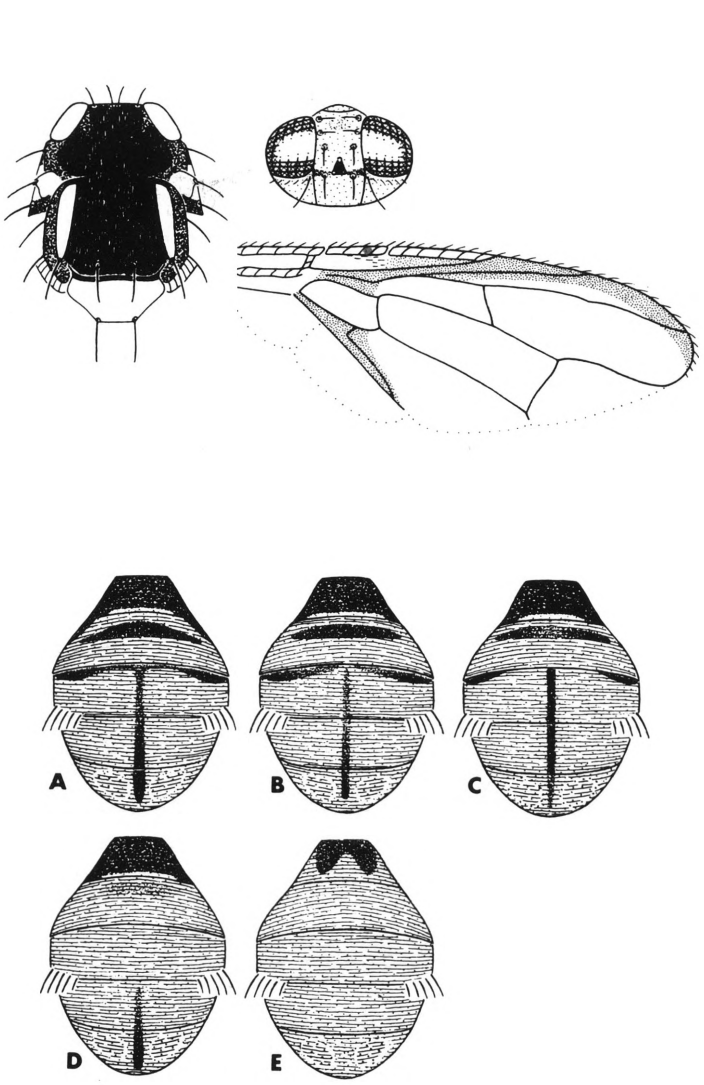
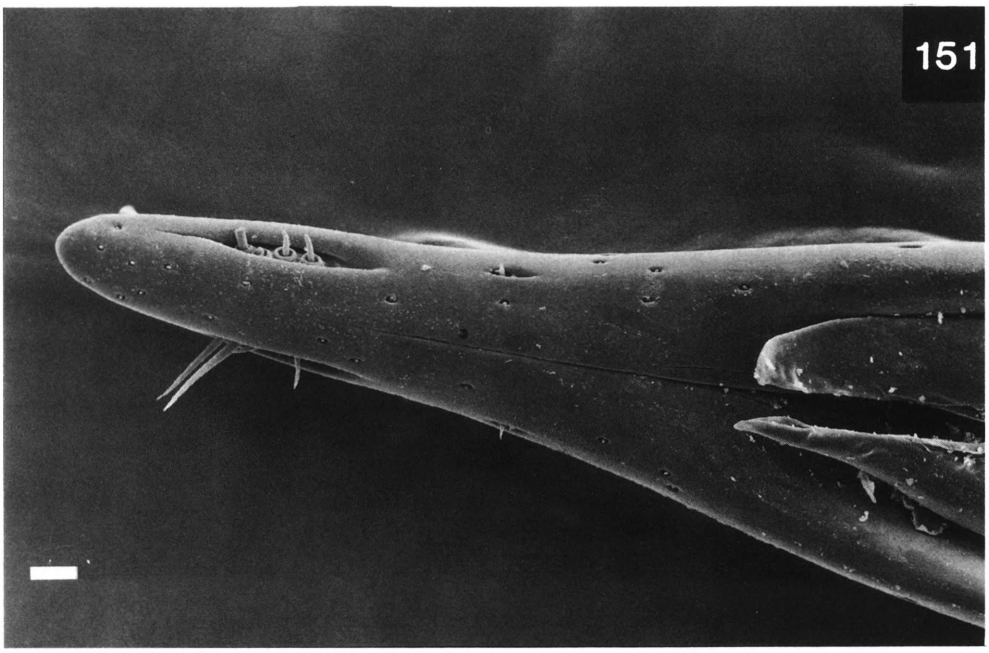
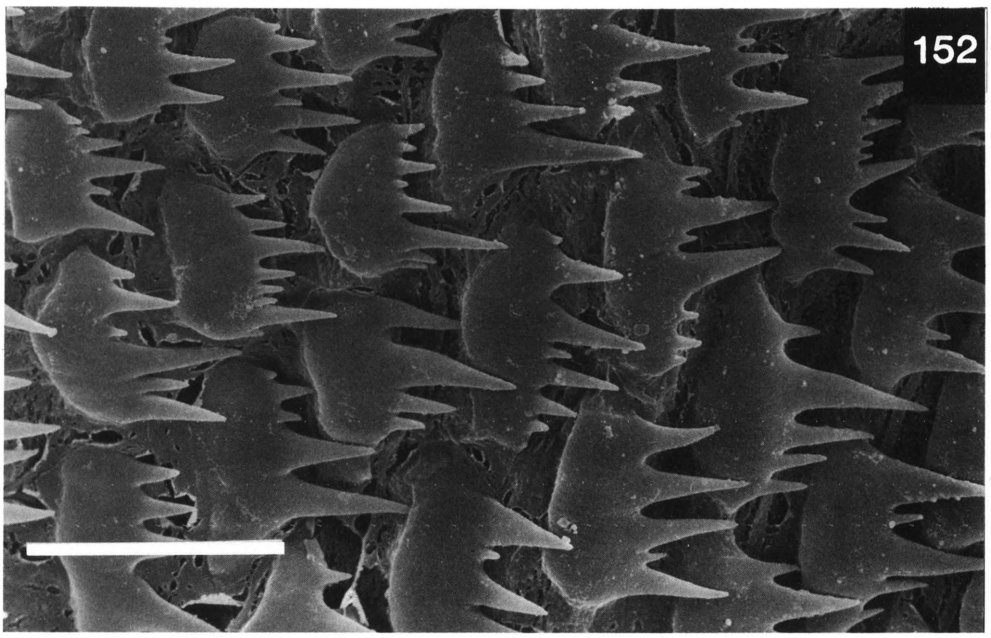
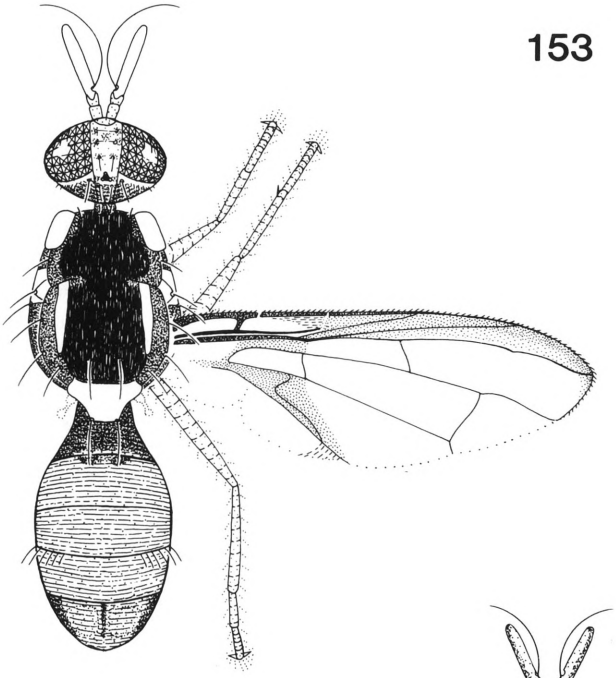


FIG. 150. *Bactrocera* (*Bactrocera*) *musae* (Tryon), adult male (x10). A–E, colour variations of abdomen.





FIGS 151–152. *Bactrocera* (*Bactrocera*) *musae* (Tryon): 151, apex of aculeus (scale 0.01 mm); 152, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



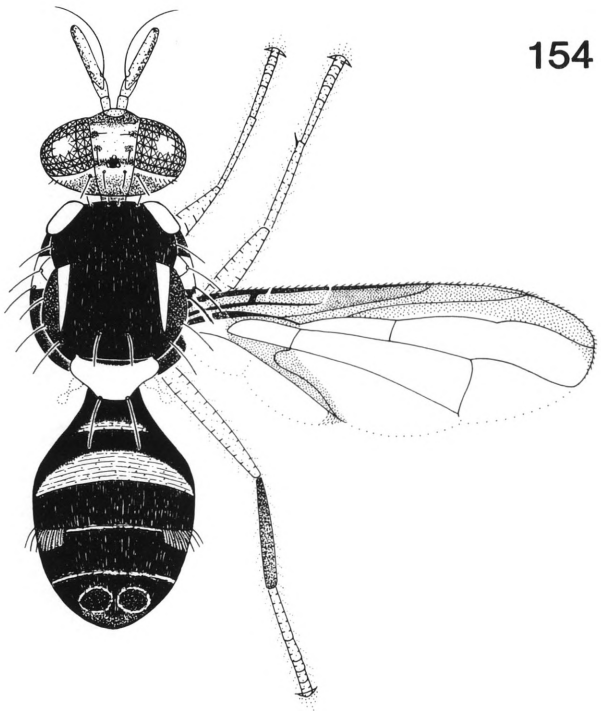


FIG. 153. *Bactrocera* (*Bactrocera*) *prolixa* n. sp., adult male (x8). FIG. 154. *Bactrocera* (*Bactrocera*) *batemani* n. sp., adult male (x9).

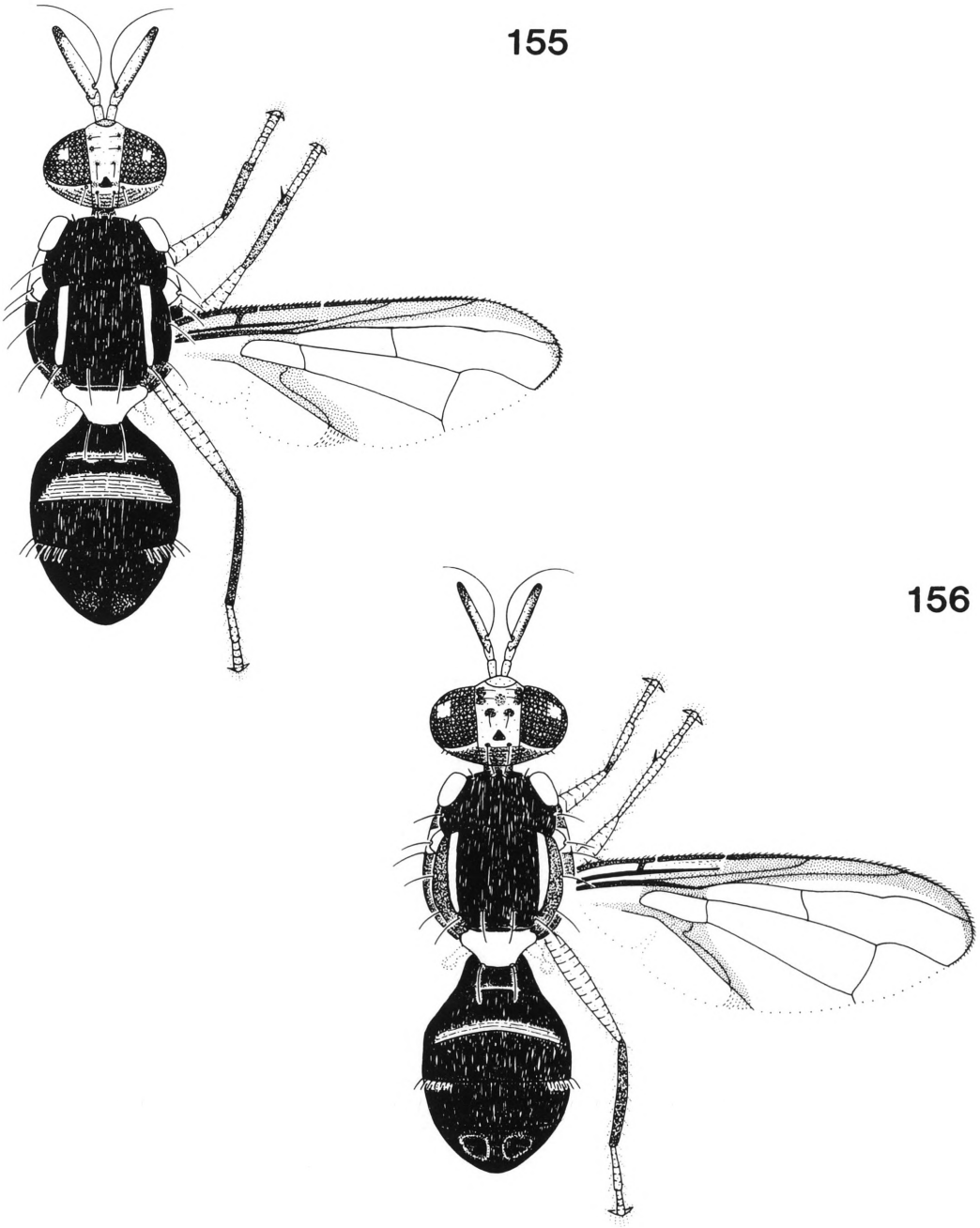
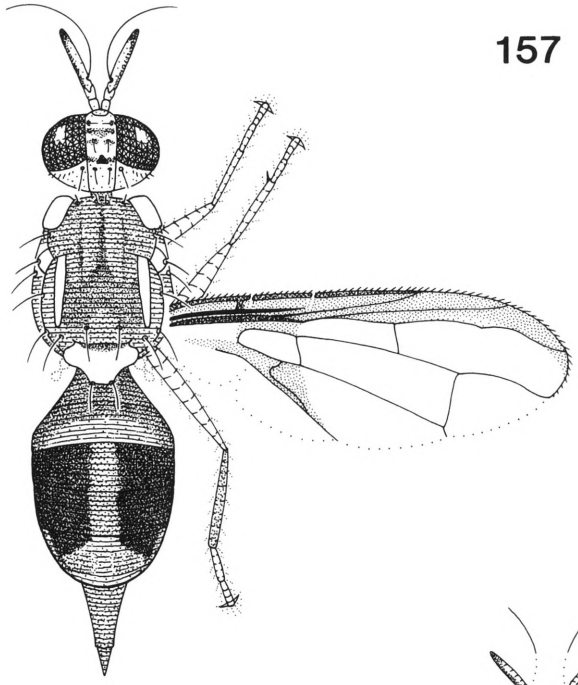


FIG. 155. *Bactrocera* (*Bactrocera*) *kelaena* n. sp., adult male (x11). FIG. 156. *Bactrocera* (*Bactrocera*) *nigella* (Drew), adult male (x8).



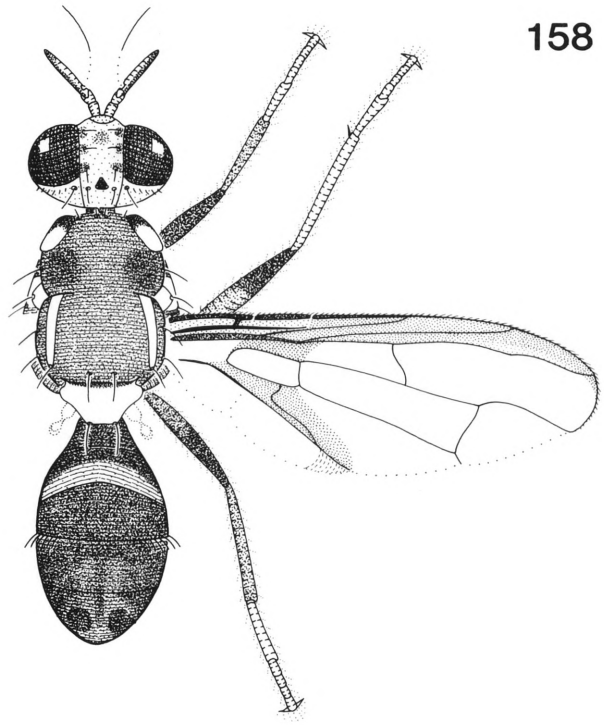
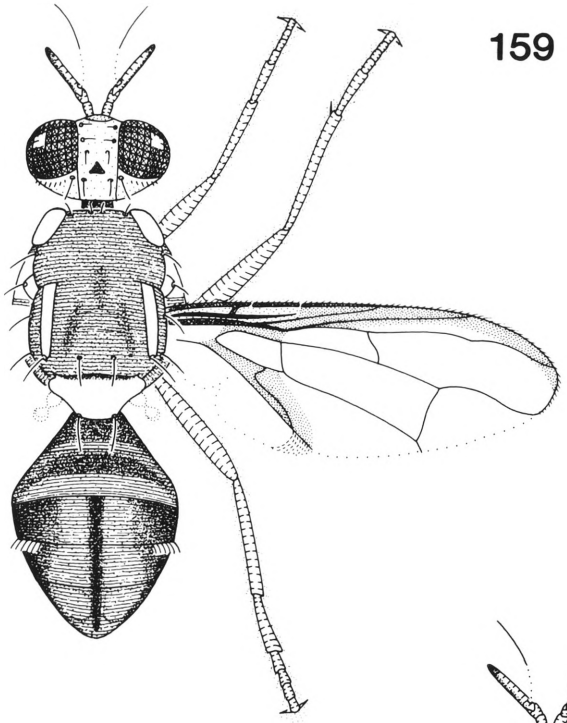


FIG. 157. *Bactrocera* (*Bactrocera*) *notatagena* (May), adult female (x11). FIG. 158. *Bactrocera* (*Bactrocera*) *romigae* (Drew and Hancock), adult male (x9).



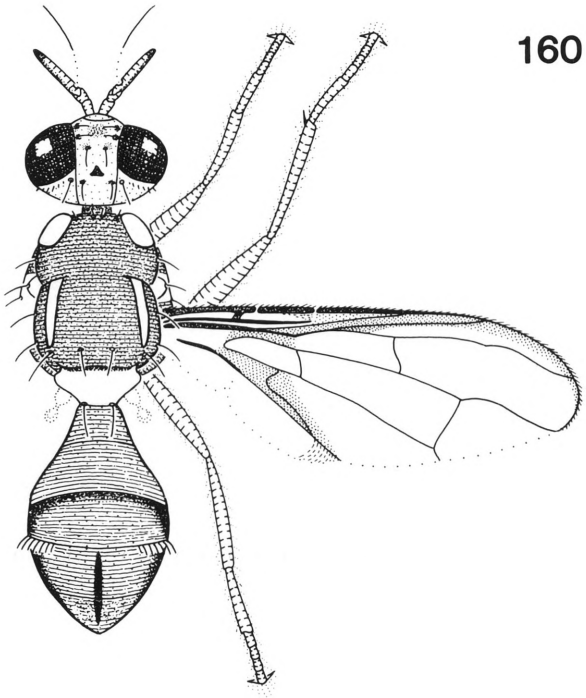


FIG. 159. *Bactrocera* (*Bactrocera*) *antigone* (Drew and Hancock), adult male (x10). FIG. 160. *Bactrocera* (*Bactrocera*) *aurantiaca* (Drew and Hancock), adult male (x10).

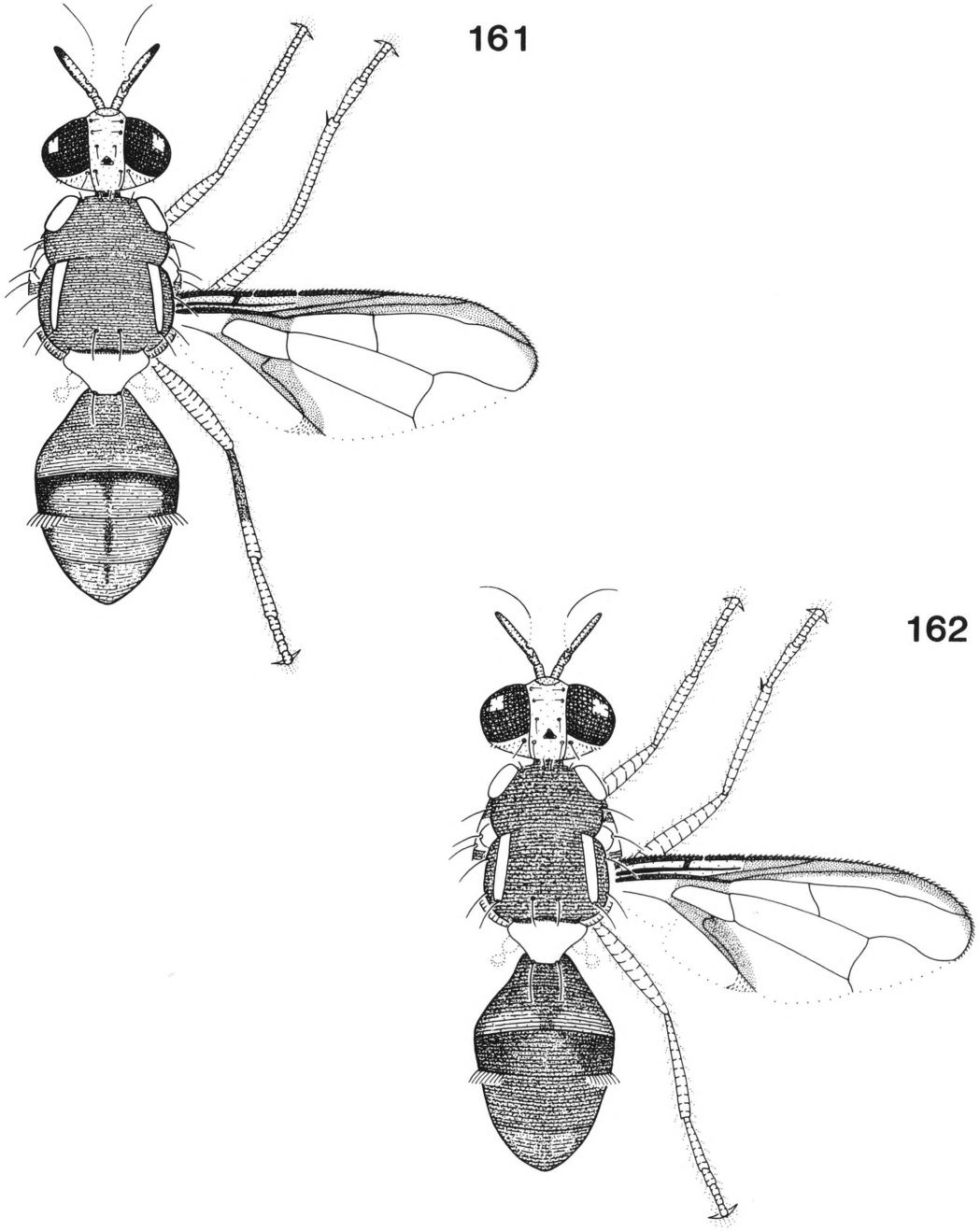
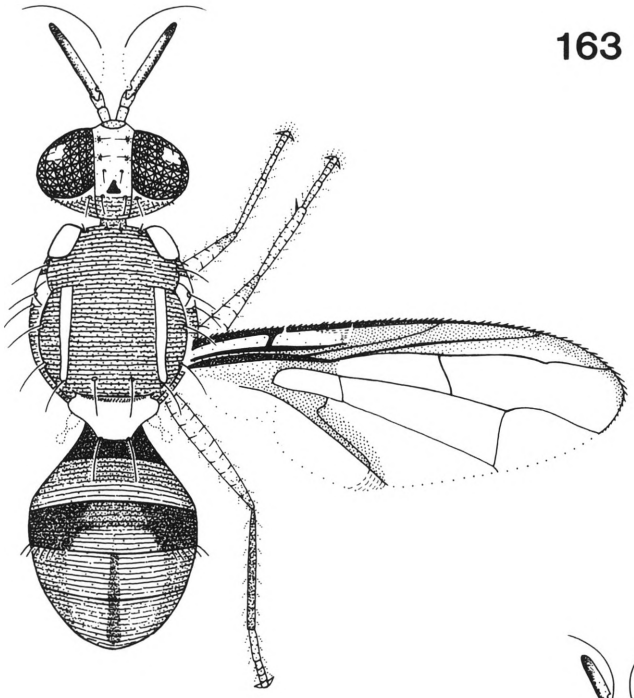


FIG. 161. *Bactrocera* (*Bactrocera*) *erubescentis* (Drew and Hancock), adult male (x11). FIG. 162. *Bactrocera* (*Bactrocera*) *peninsularis* (Drew and Hancock), adult male (x10).



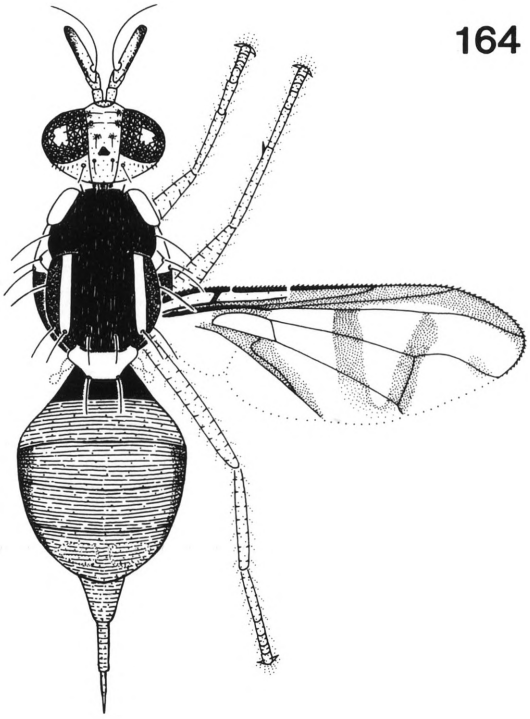


FIG. 163. *Bactrocera* (*Bactrocera*) *quadrata* (May), adult male (x10). FIG. 164. *Bactrocera* (*Bactrocera*) *absidata* n. sp., adult female (x7).

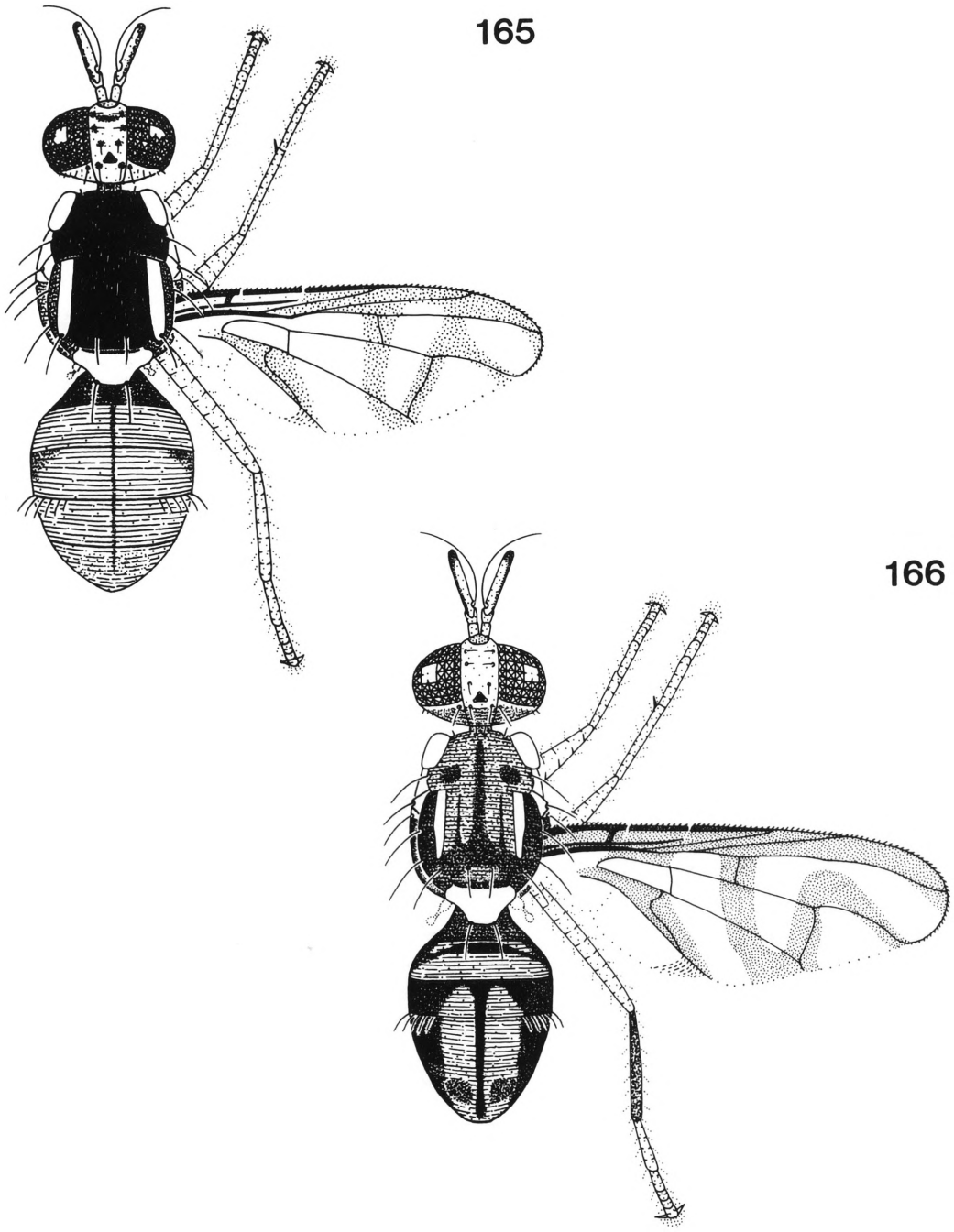
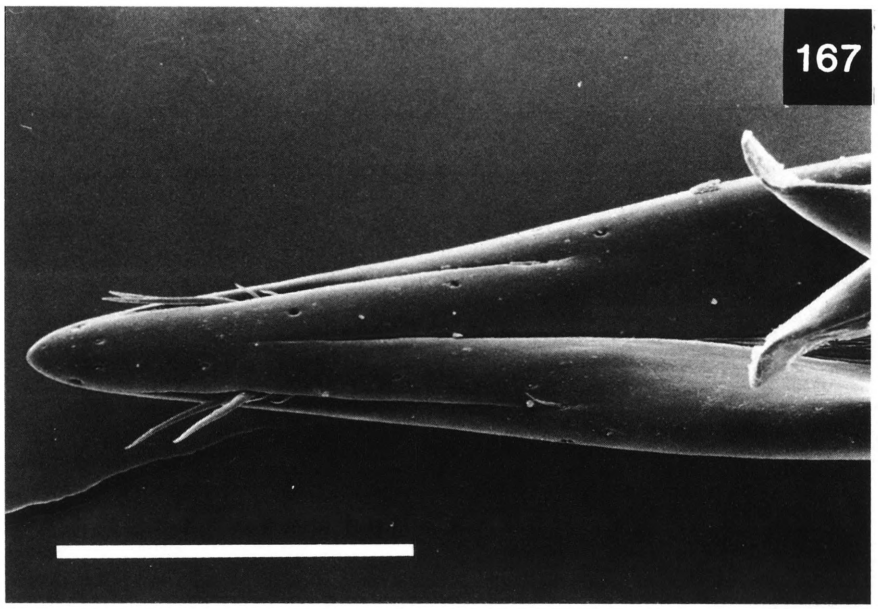
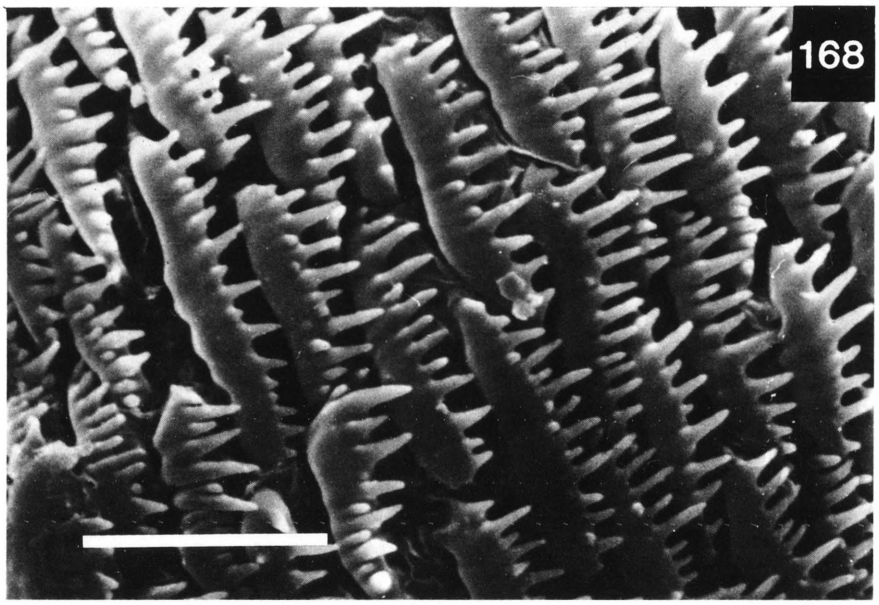


FIG. 165. *Bactrocera* (*Bactrocera*) *anfracta* n. sp., adult male (x9). FIG. 166. *Bactrocera* (*Bactrocera*) *manskii* (Perkins and May), adult male (x11).





FIGS 167–168. *Bactrocera* (*Bactrocera*) *manskii* (Perkins and May): 167, apex of aculeus (scale 0.1 mm); 168, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

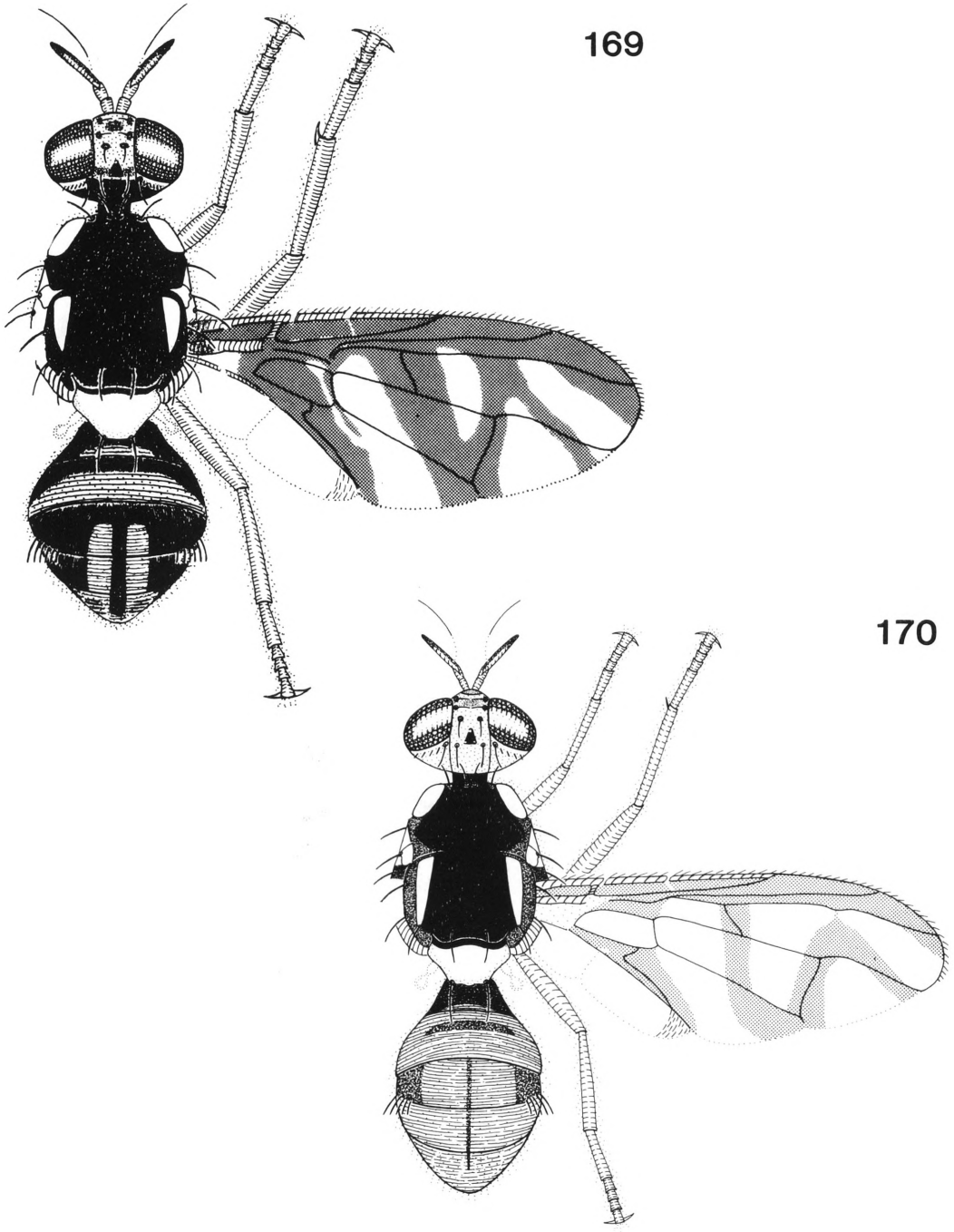


FIG. 169. *Bactrocera* (*Bactrocera*) *nigrescentis* (Drew), adult male (x14). FIG. 170. *Bactrocera* (*Bactrocera*) *recurrens* (Hering), adult male (x12).

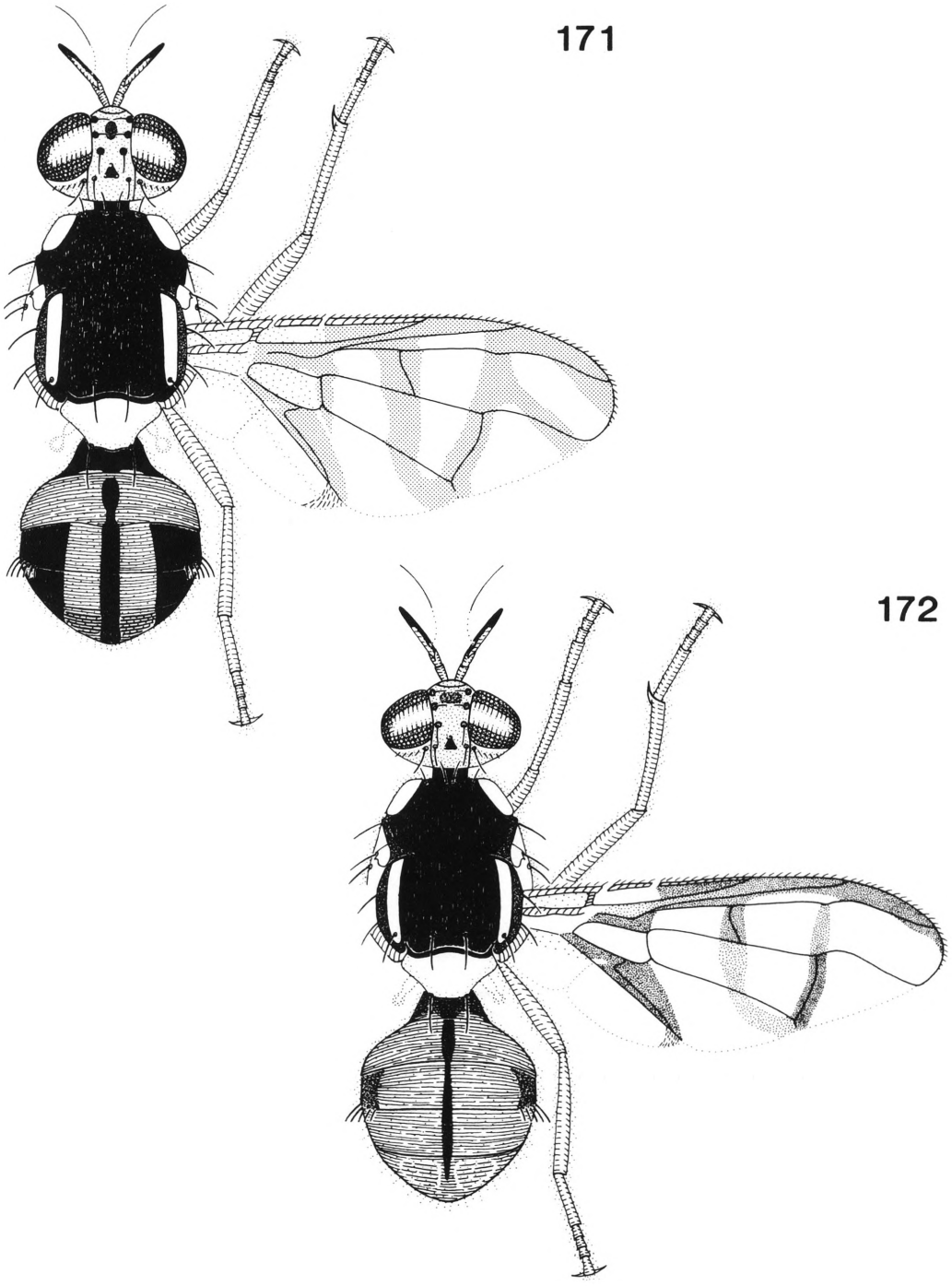


FIG. 171. *Bactrocera* (*Bactrocera*) *redunca* (Drew), adult male (x9). FIG. 172. *Bactrocera* (*Bactrocera*) *resima* (Drew), adult male (x9).

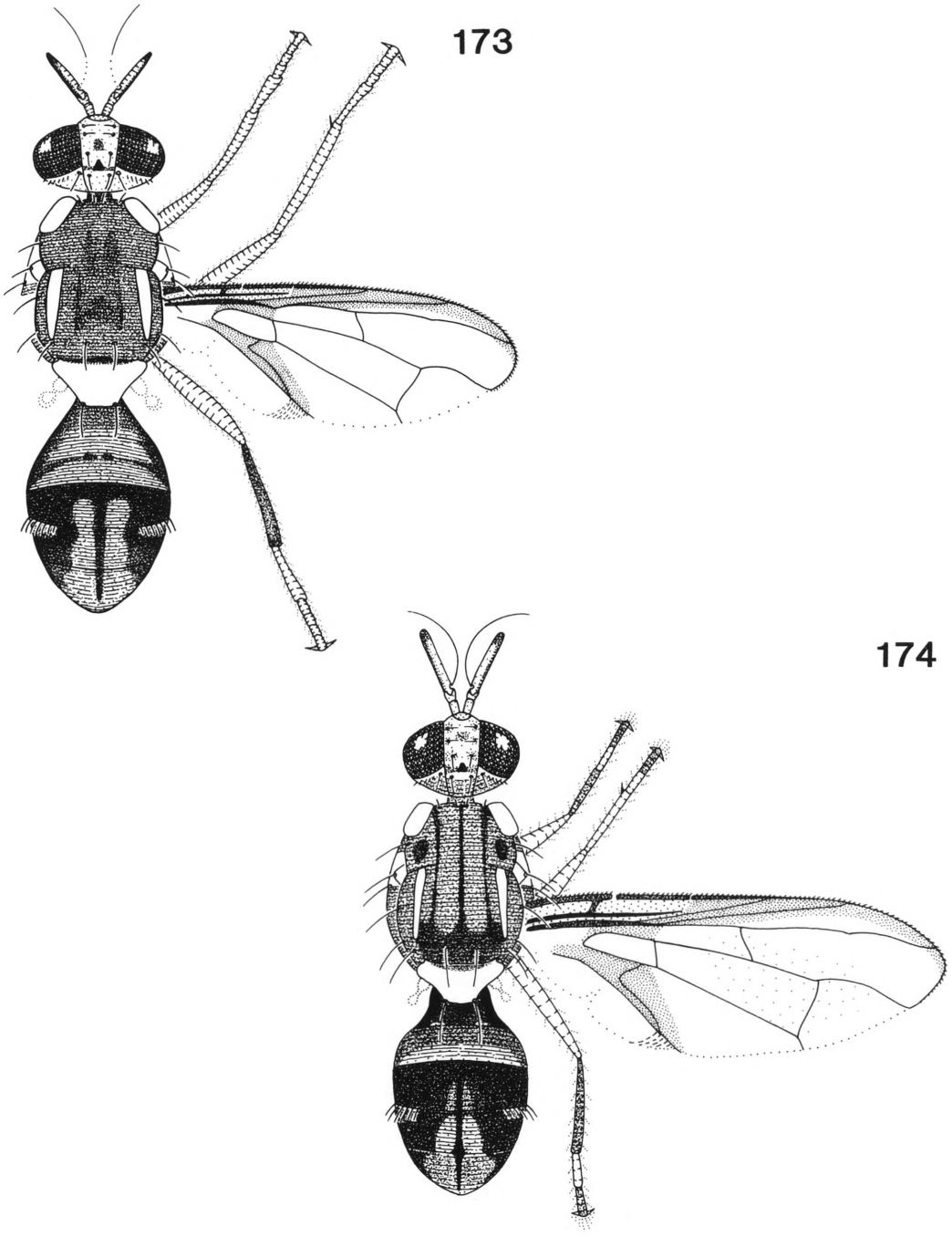
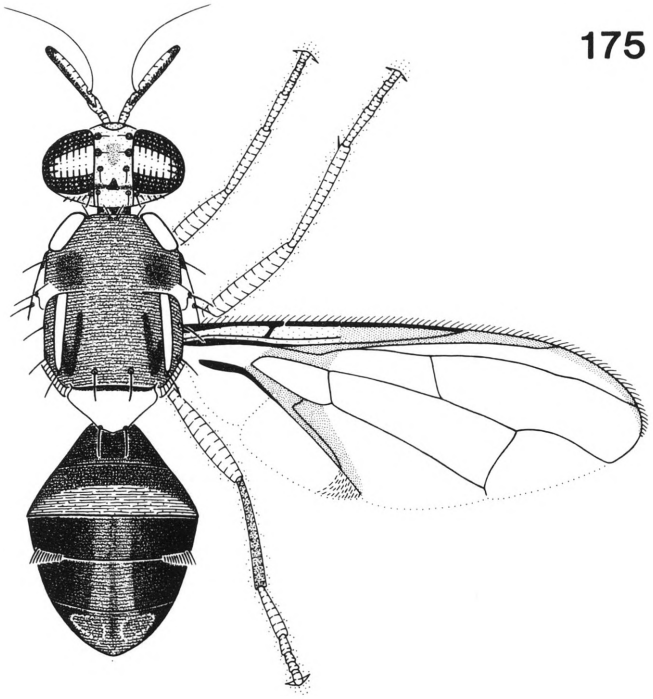
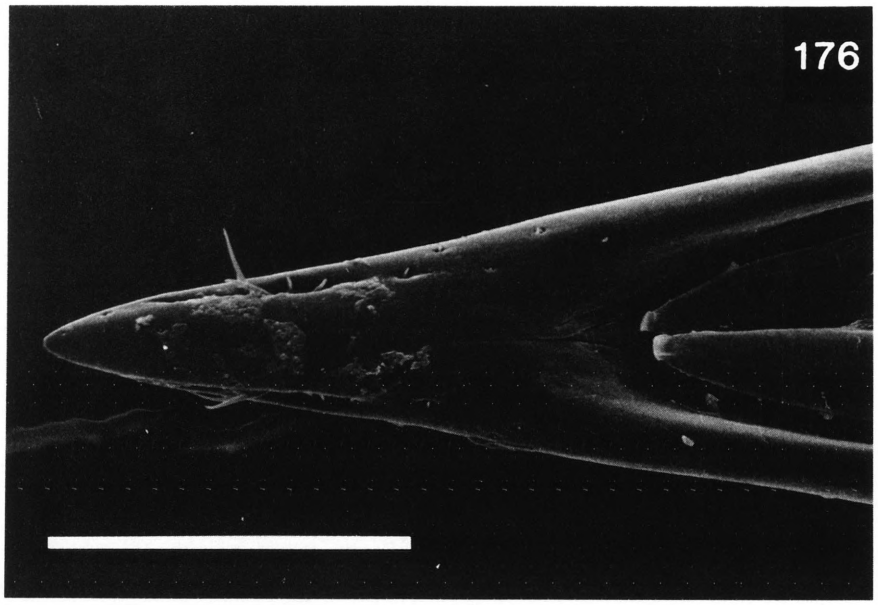
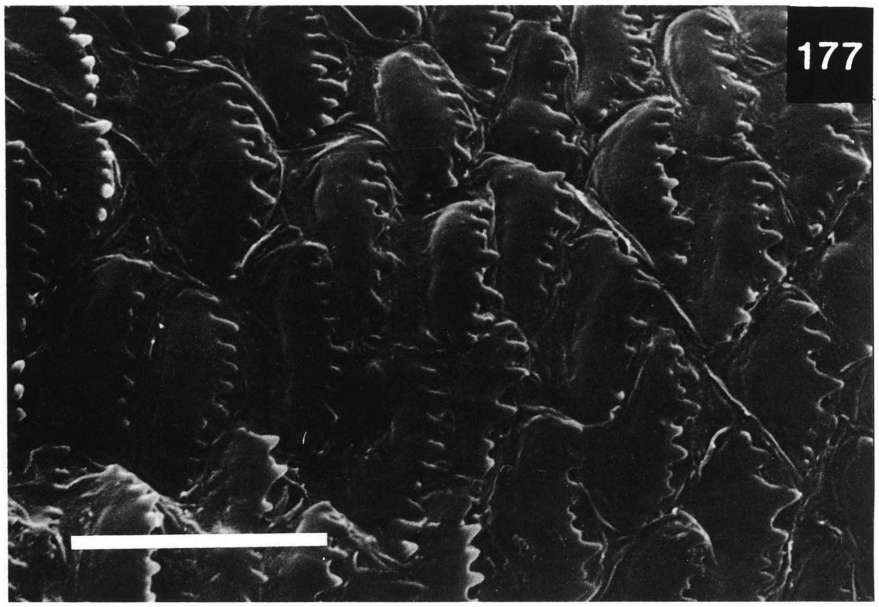


FIG. 173. *Bactrocera* (*Bactrocera*) *abscondita* (Drew and Hancock), adult male (x9). FIG. 174. *Bactrocera* (*Bactrocera*) *abundans* n. sp., adult male (x9).





FIGS 175–176. *Bactrocera* (*Bactrocera*) *breviaculeus* (Hardy): 175, adult male (x11); 176, apex of aculeus (scale 0.1 mm).



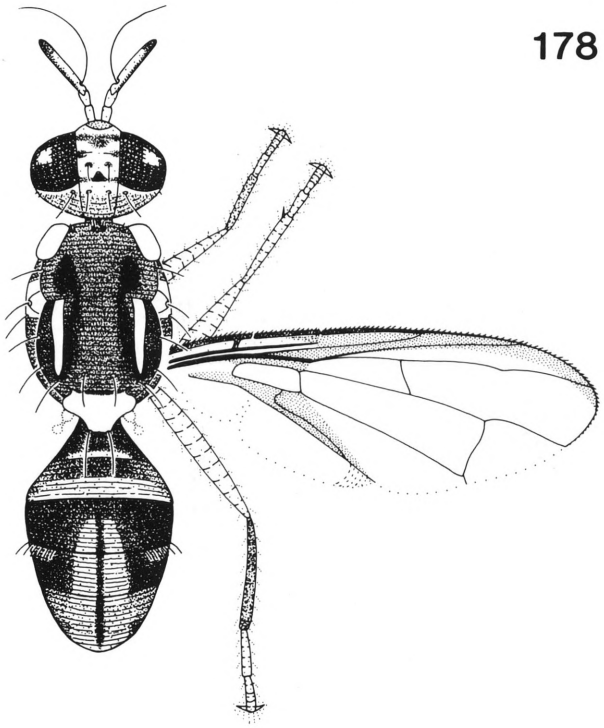


FIG. 177. *Bactrocera* (*Bactrocera*) *breviaculeus* (Hardy), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 178. *Bactrocera* (*Bactrocera*) *cinnamea* n. sp., adult male (x9).

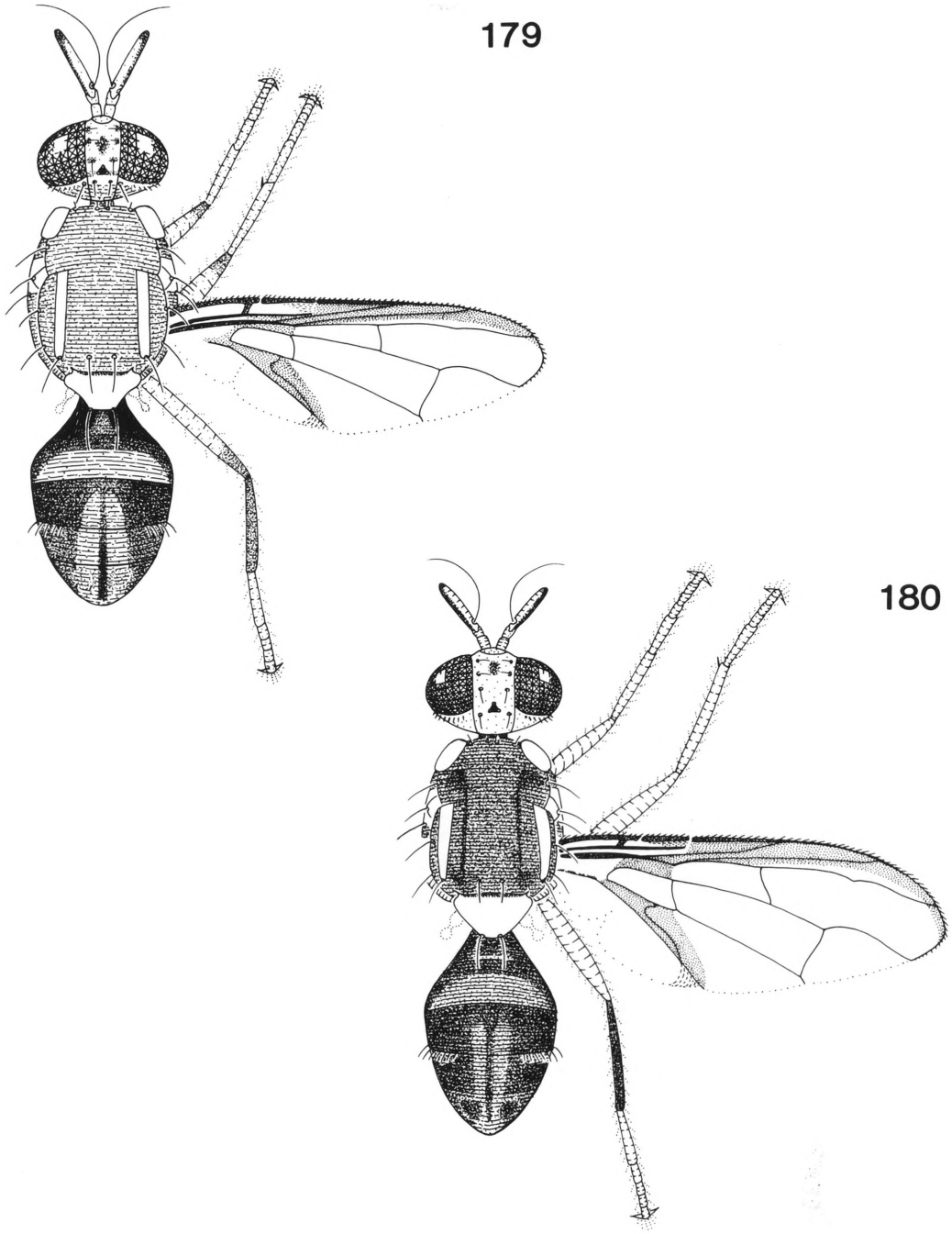
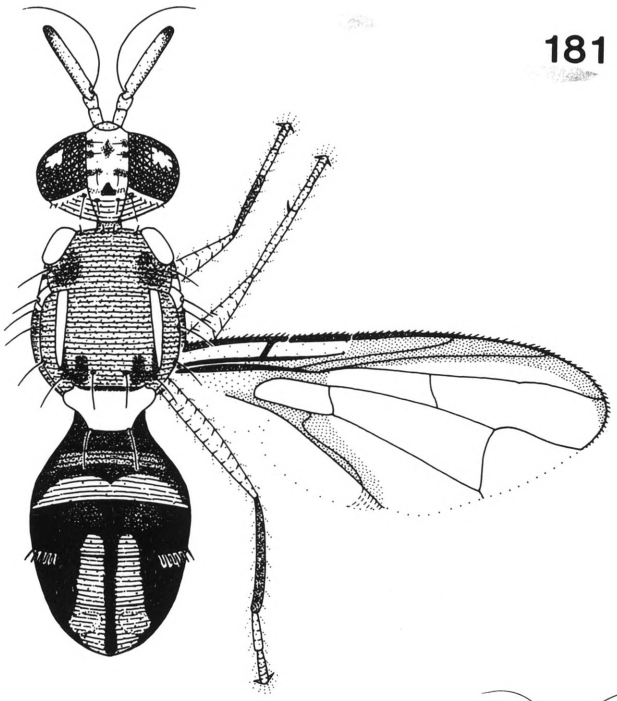


FIG. 179. *Bactrocera* (*Bactrocera*) *quasisilvicola* n. sp., adult male (x10). FIG. 180. *Bactrocera* (*Bactrocera*) *rufofuscula* (Drew and Hancock), adult male (x11).



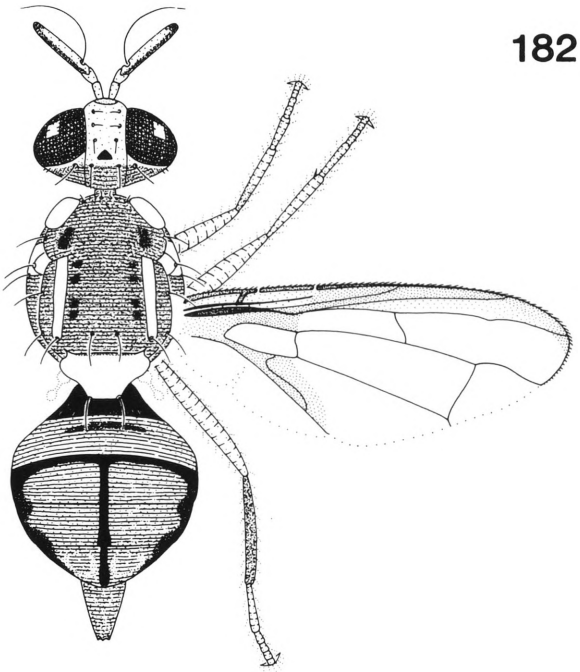
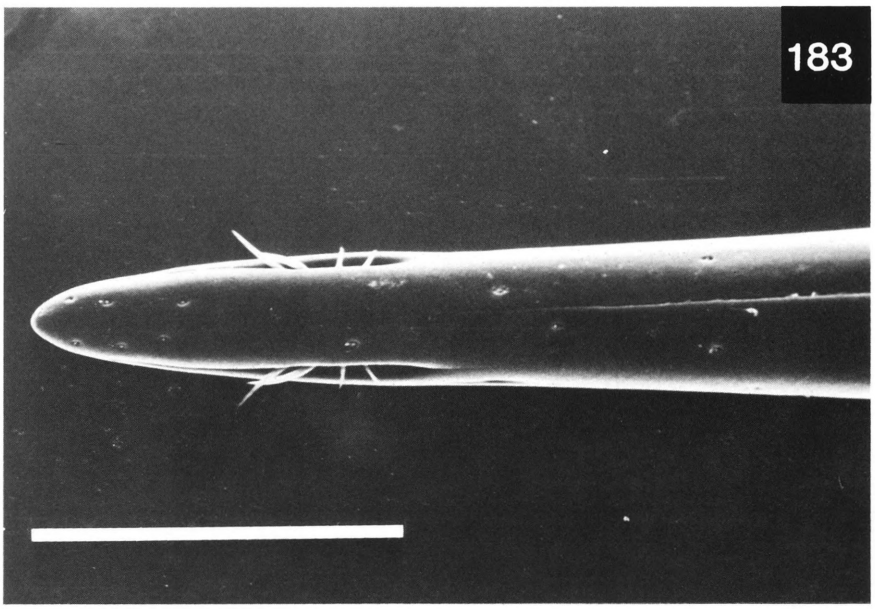
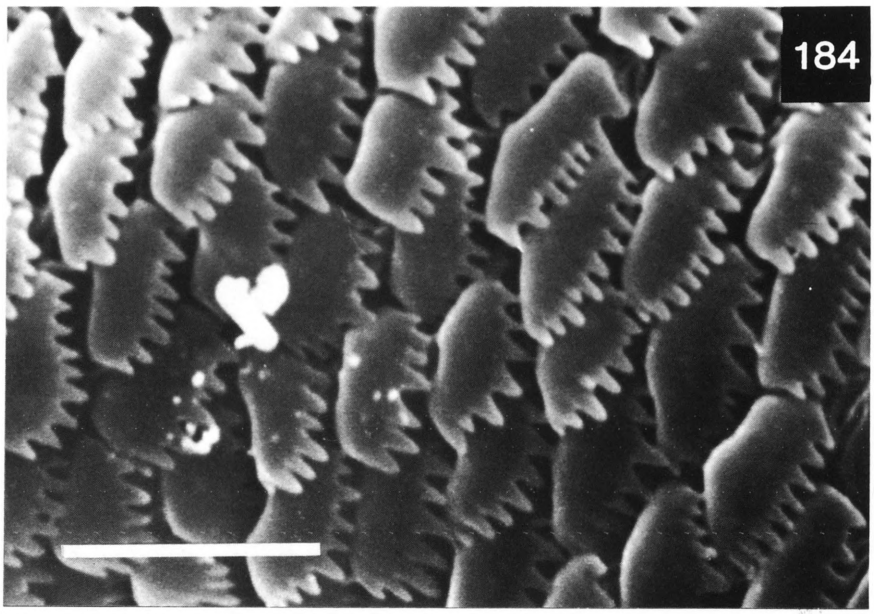
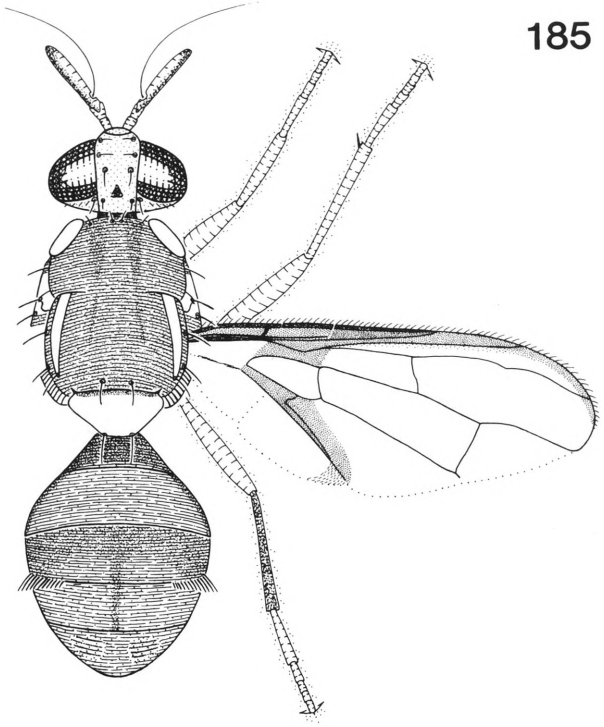


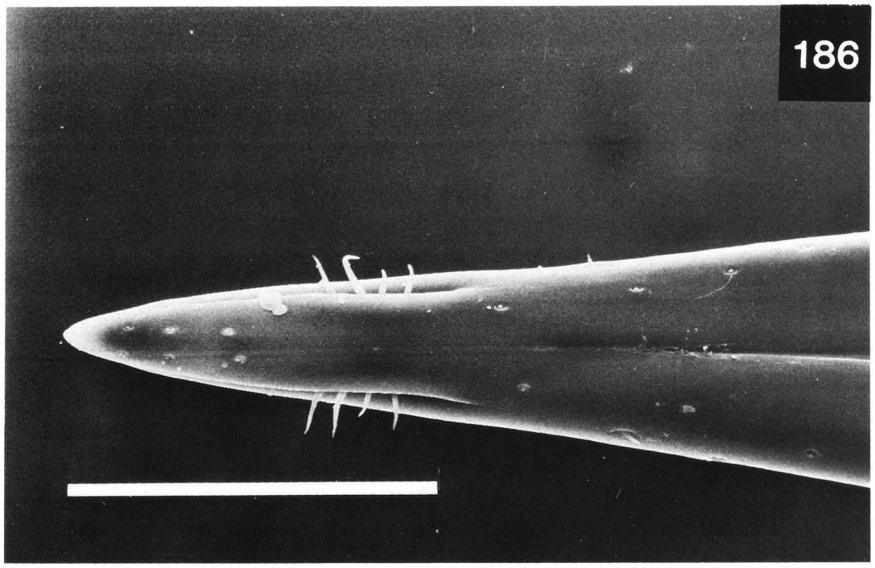
FIG. 181. *Bactrocera* (*Bactrocera*) *silvicola* (May), adult male (x12). FIG. 182. *Bactrocera* (*Bactrocera*) *turneri* n. sp., adult female (x8).



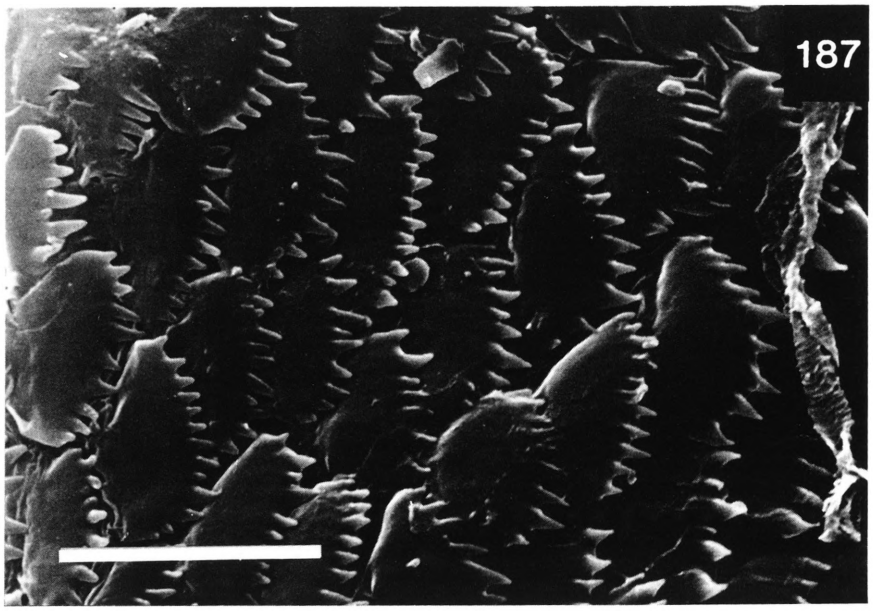


FIGS 183–184. *Bactrocera* (*Bactrocera*) *turneri* n. sp.: 183, apex of aculeus (scale 0.1 mm); 184, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 185–186. *Bactrocera* (*Bactrocera*) *aquilonis* (May): 185, adult male (x10); 186, apex of aculeus (scale 0.1 mm).



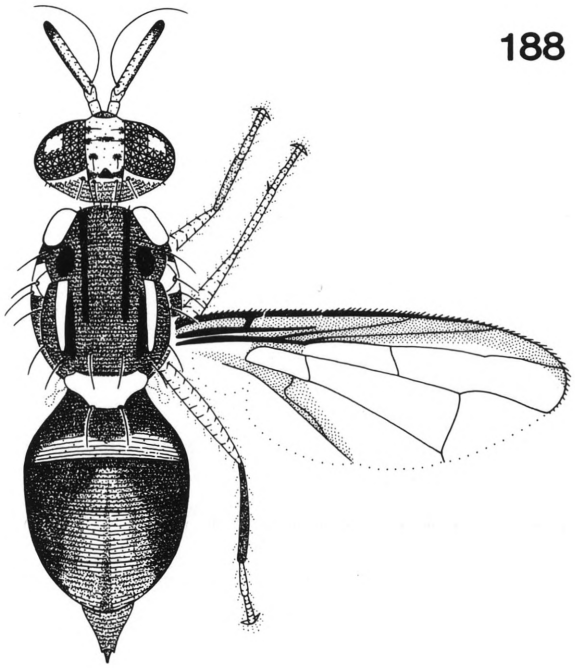
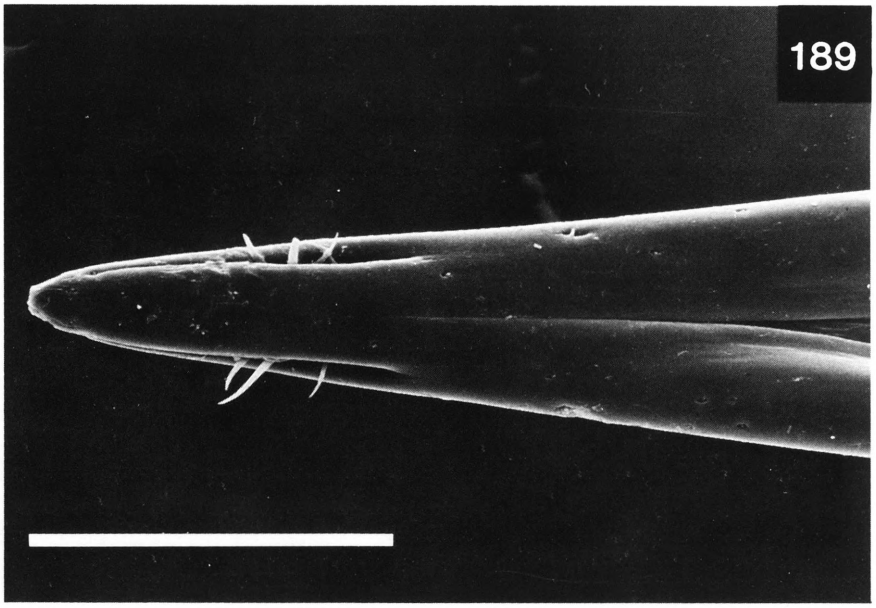
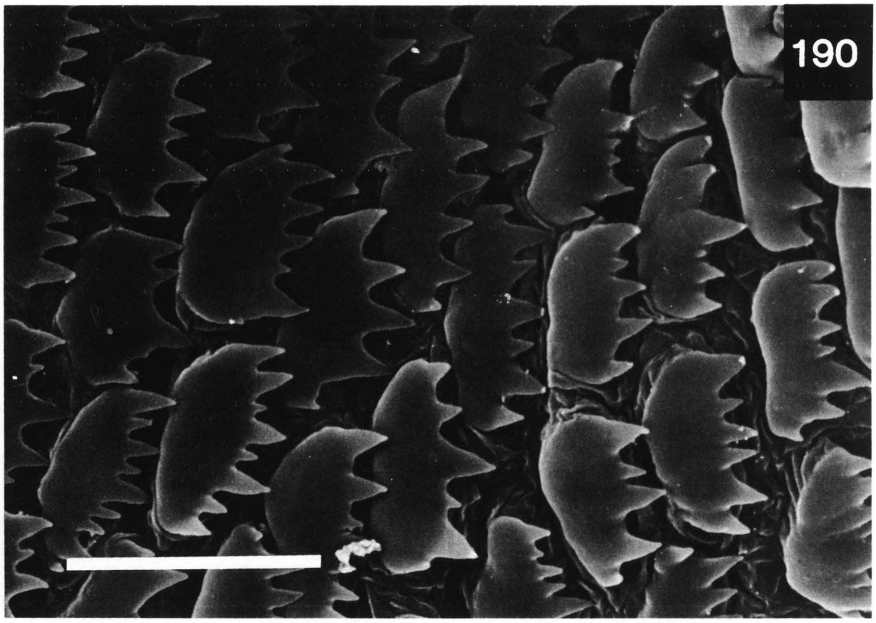
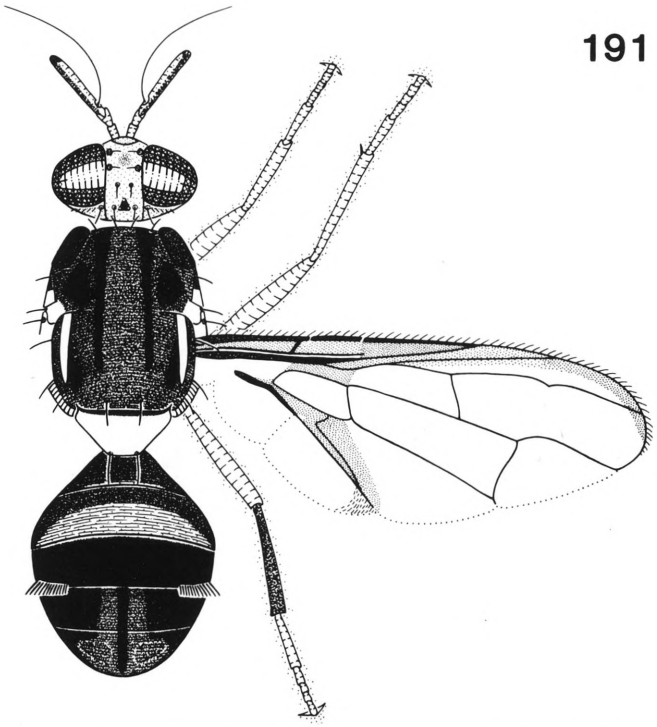


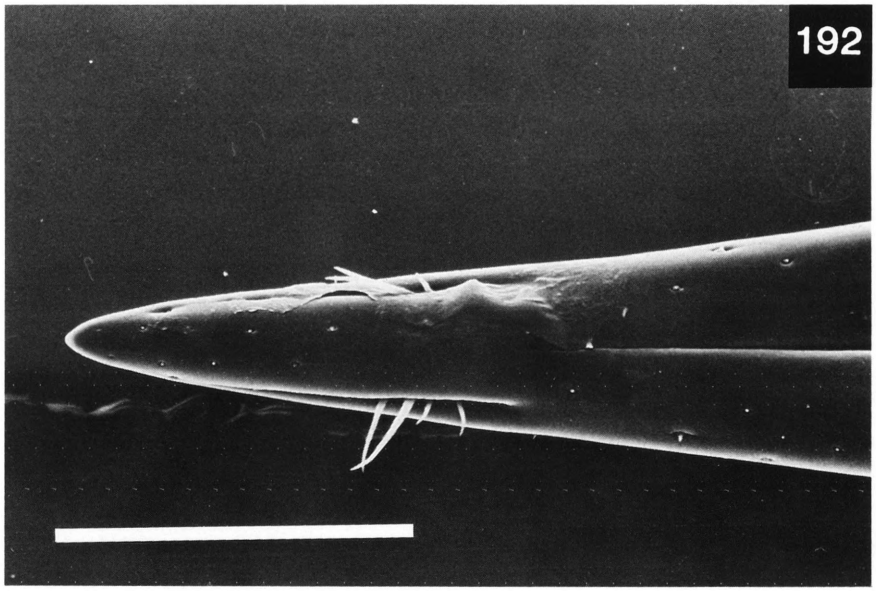
FIG. 187. *Bactrocera* (*Bactrocera*) *aquilonis* (May), spicules on distal end of middle segment of ovipositor (scale 0.01mm). FIG. 188. *Bactrocera* (*Bactrocera*) *melas* (Perkins and May), adult female (x9).



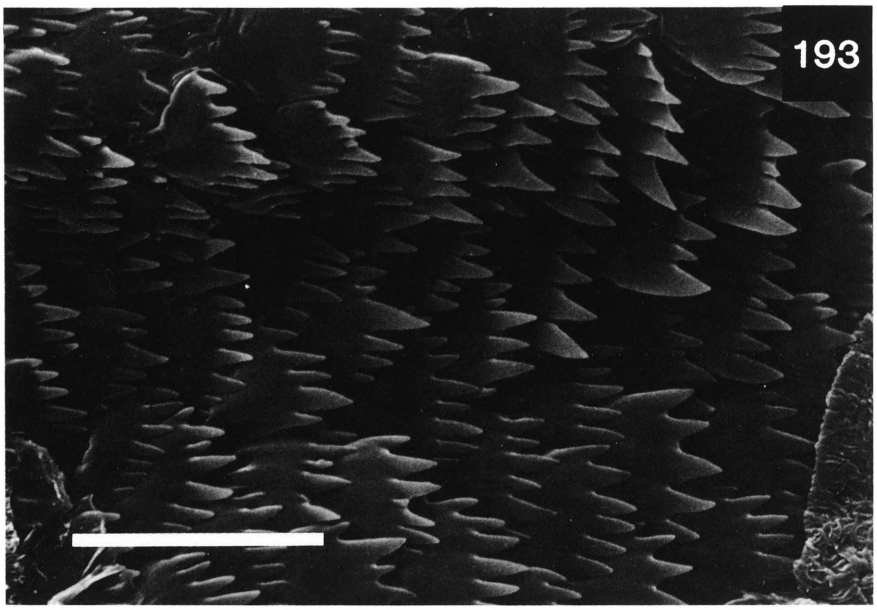


FIGS 189–190. *Bactrocera* (*Bactrocera*) *melas* (Perkins and May): 189, apex of aculeus (scale 0.1 mm); 190, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 191–192. *Bactrocera* (*Bactrocera*) *neohumeralis* (Hardy): 191, adult male (x10); 192, apex of aculeus (scale 0.1 mm).



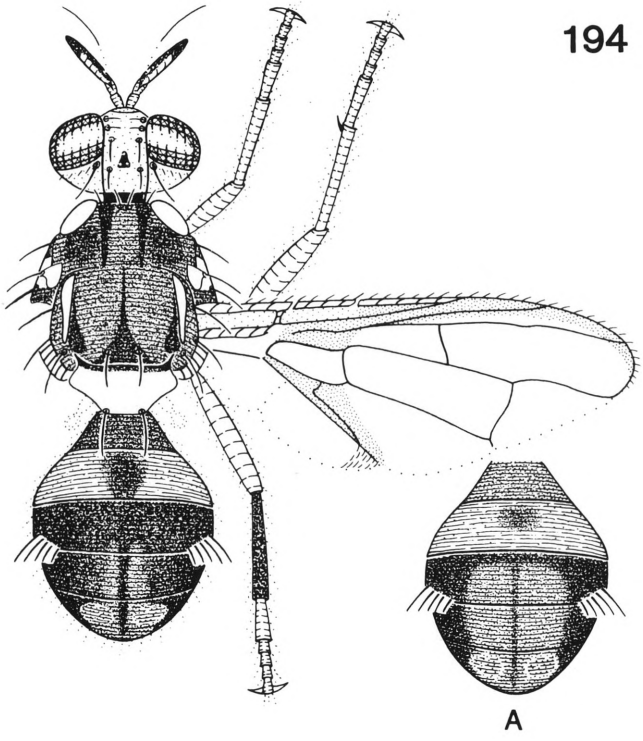
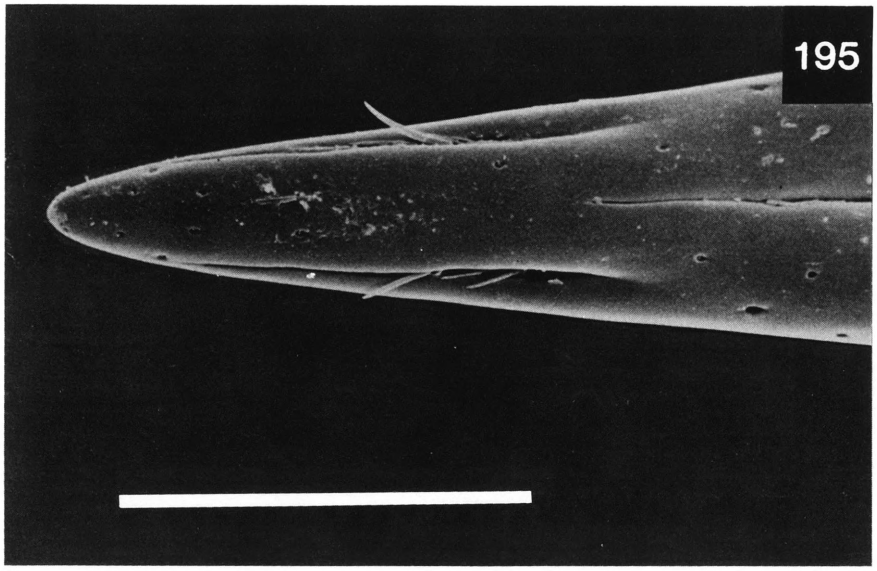
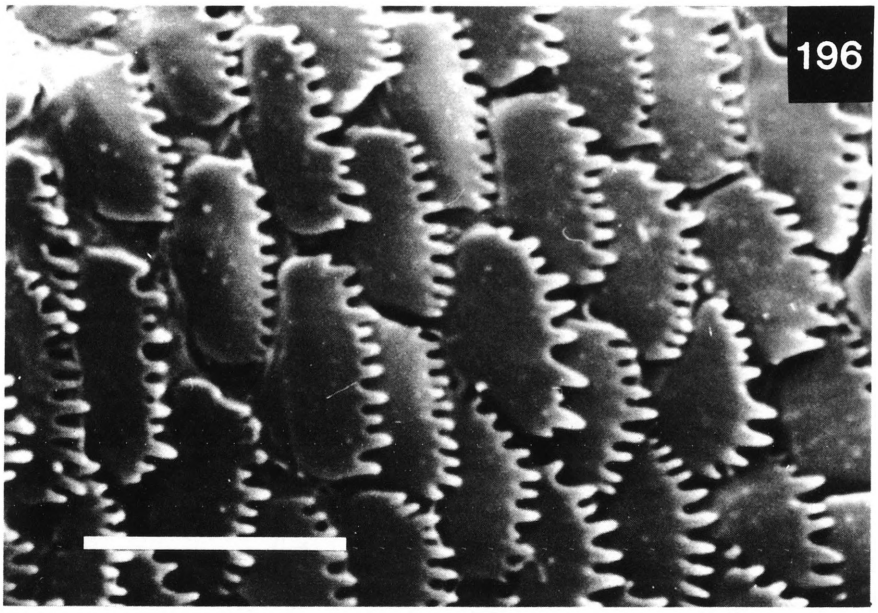


FIG. 193. *Bactrocera* (*Bactrocera*) *neohumeralis* (Hardy), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 194. *Bactrocera* (*Bactrocera*) *tryoni* (Froggatt), adult male (x10). A, pale form of abdomen.





FIGS 195–196. *Bactrocera* (*Bactrocera*) *tryoni* (Froggatt): 195, apex of aculeus (scale 0.1 mm); 196, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

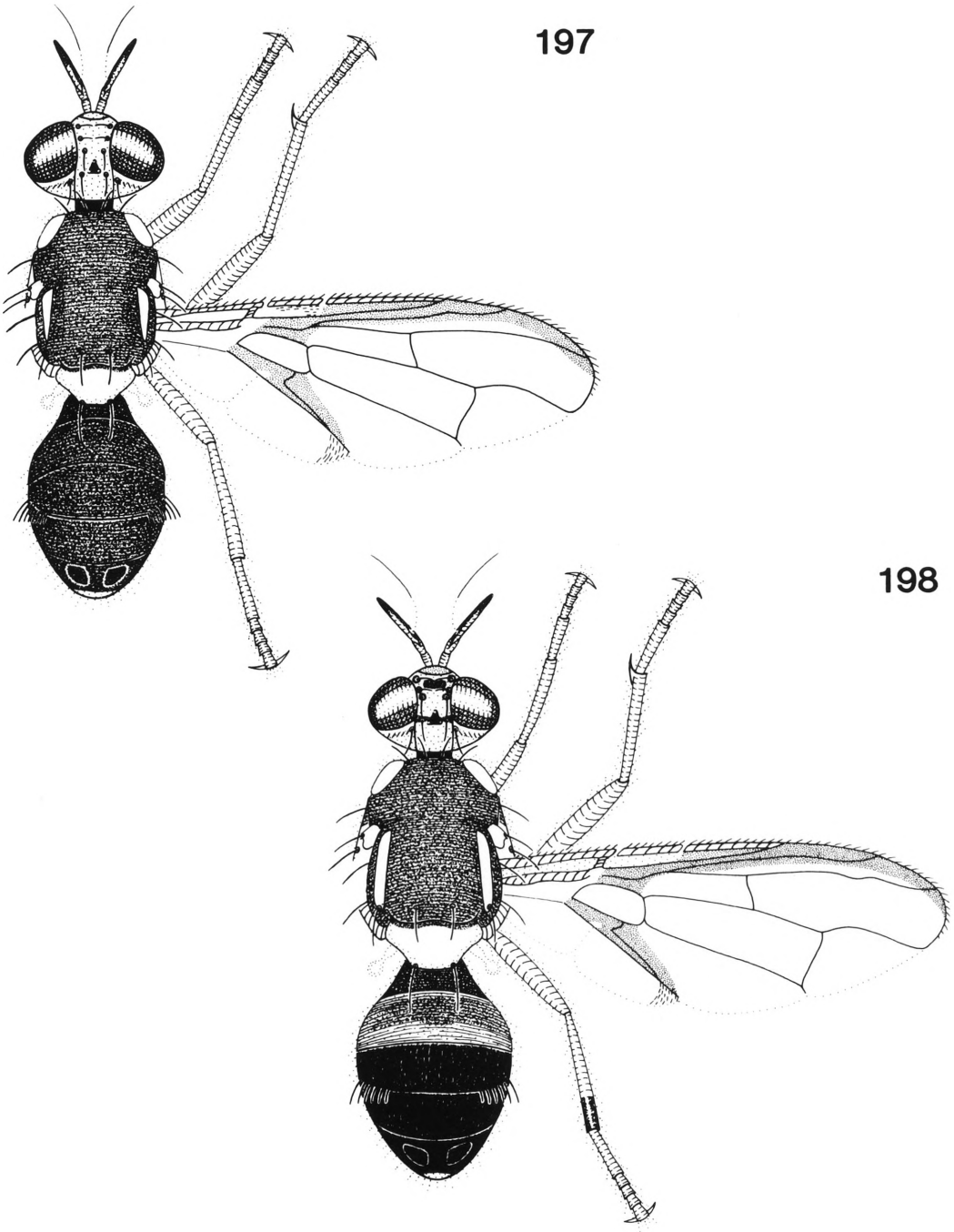


FIG. 197. *Bactrocera* (*Bactrocera*) *abdofuscata* (Drew), adult male (x11). FIG. 198. *Bactrocera* (*Bactrocera*) *abdonigella* (Drew), adult male (x9).

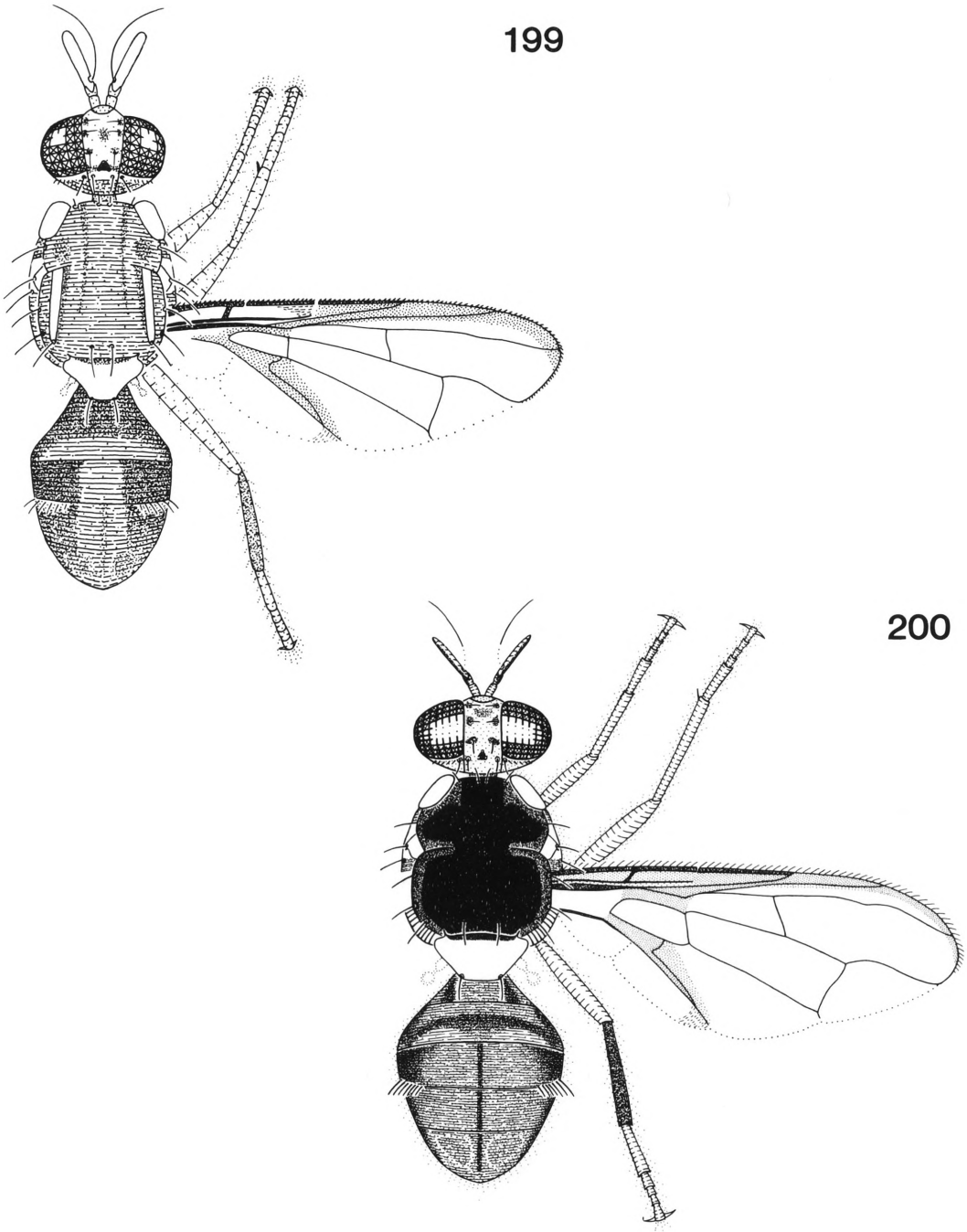


FIG. 199. *Bactrocera* (*Bactrocera*) *aithogaster* n. sp., adult male (x11). FIG. 200. *Bactrocera* (*Bactrocera*) *allwoodi* (Drew), adult male (x12).

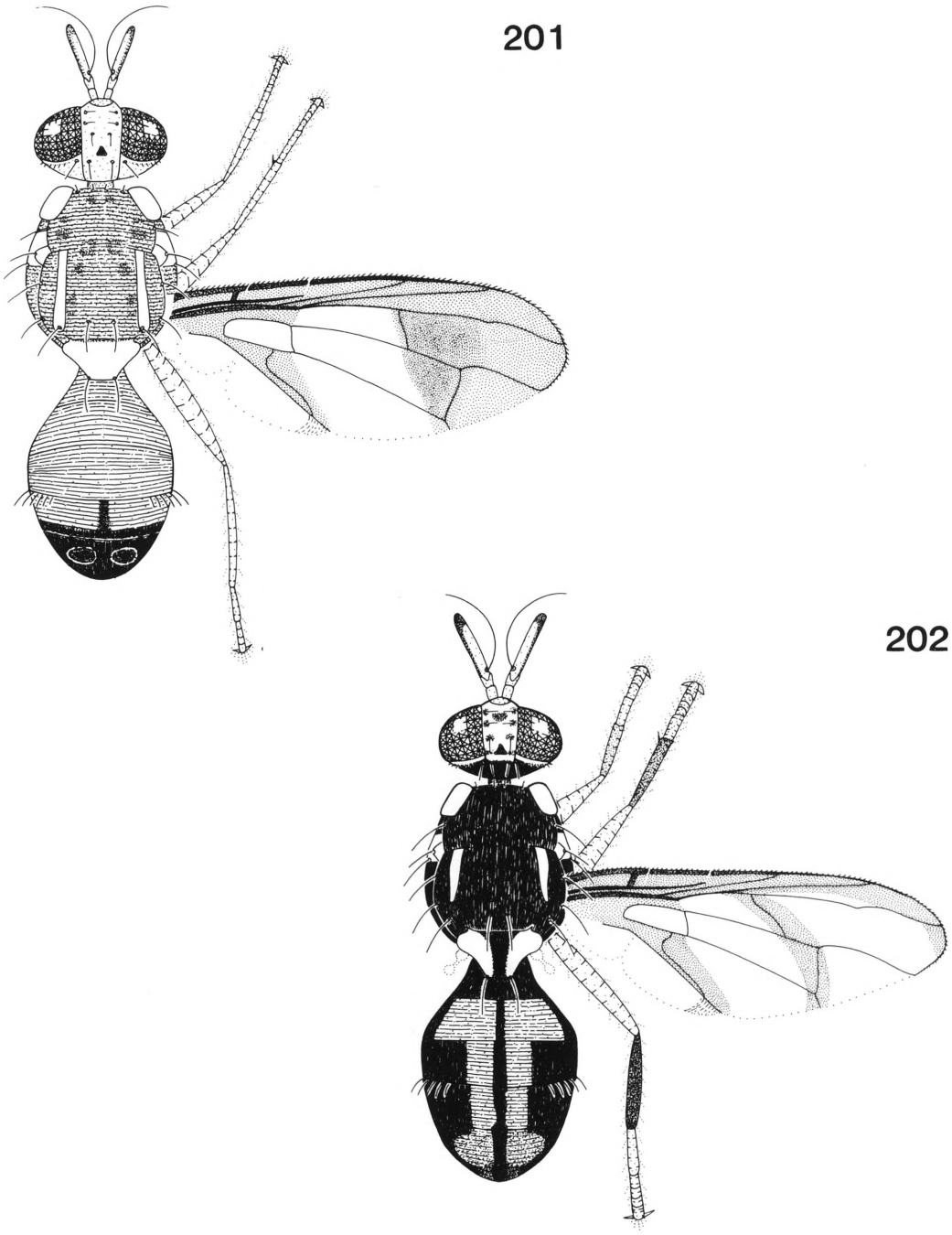
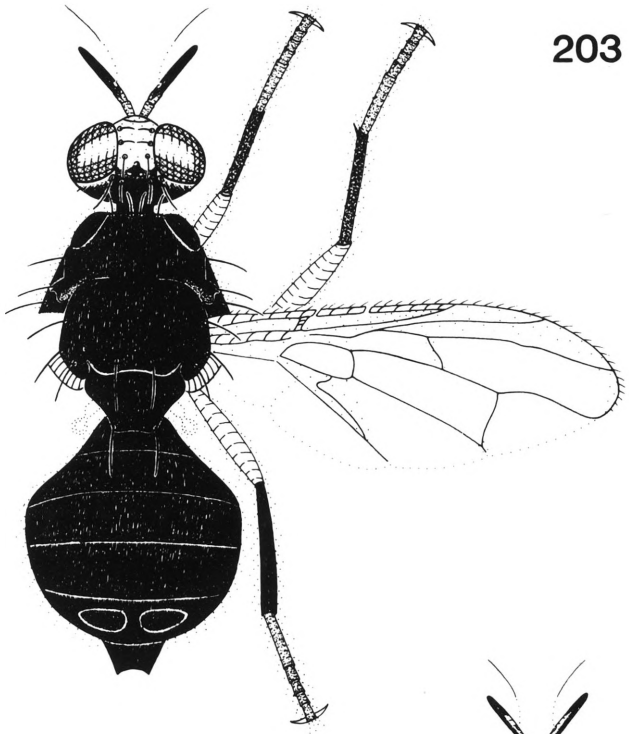


FIG. 201. *Bactrocera* (*Bactrocera*) *amplexiseta* (May), adult male (x9). FIG. 202. *Bactrocera* (*Bactrocera*) *angustifasciata* n. sp., adult male (x8).



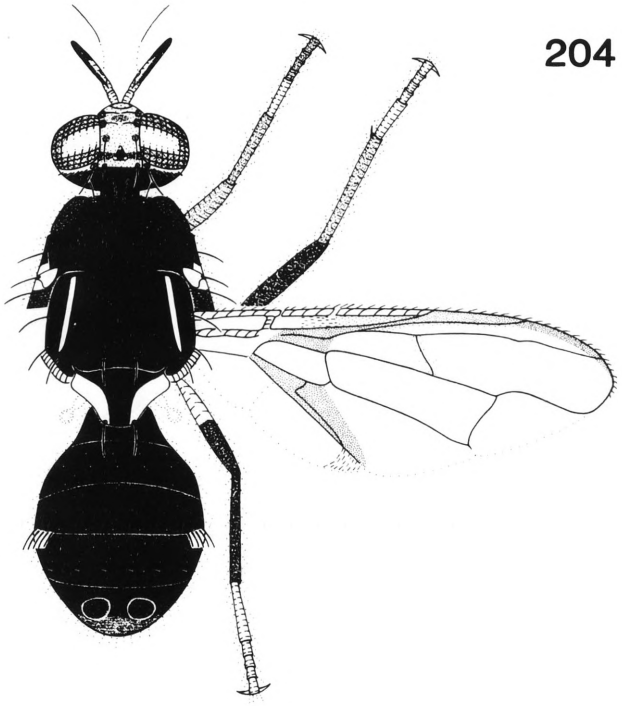
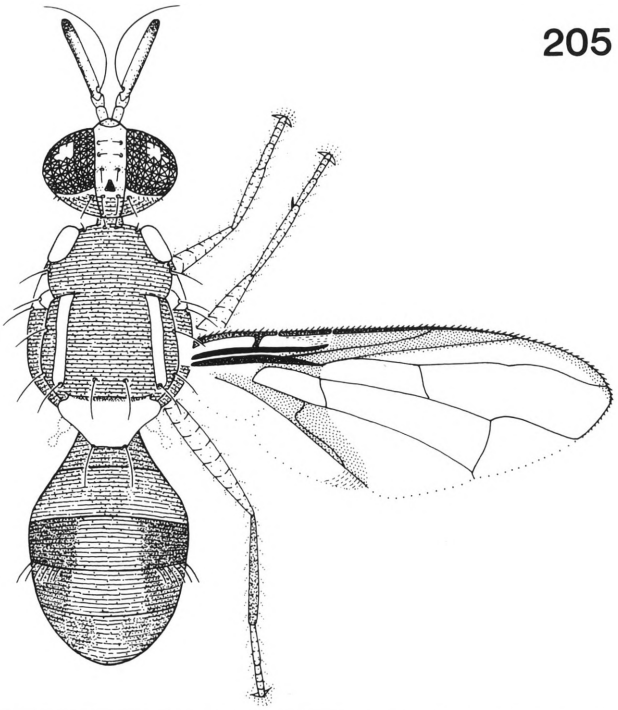
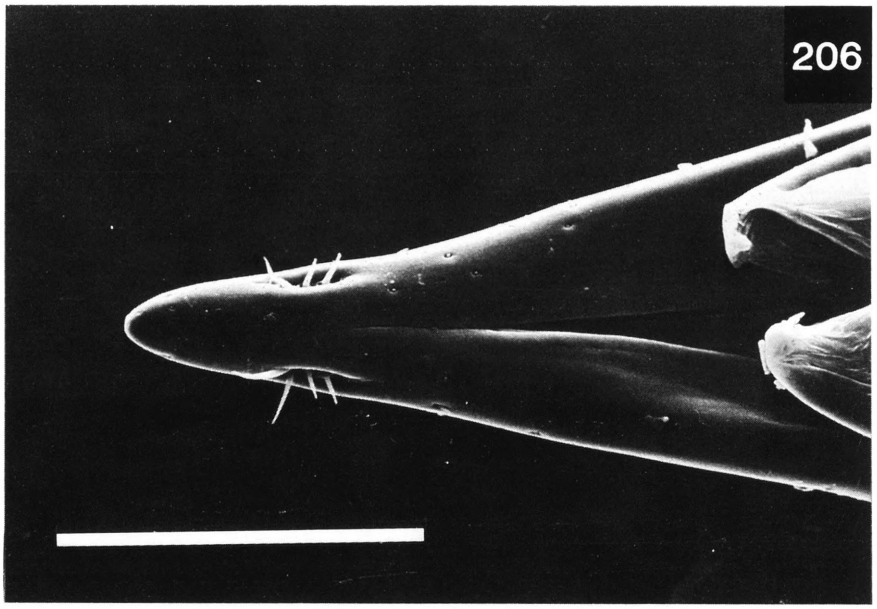
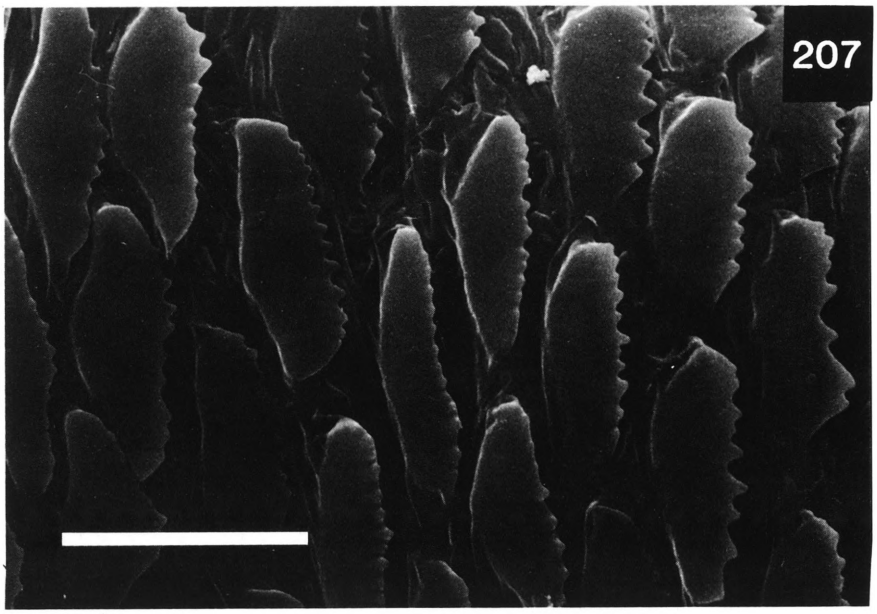


FIG. 203. *Bactrocera* (*Bactrocera*) *atra* (Malloch), adult female (x9). FIG. 204. *Bactrocera* (*Bactrocera*) *atramentata* (Hering), adult male (x8).





FIGS 205–206. *Bactrocera* (*Bactrocera*) *barringtoniae* (Tryon): 205, adult male (x8); 206, apex of aculeus (scale 0.1 mm).



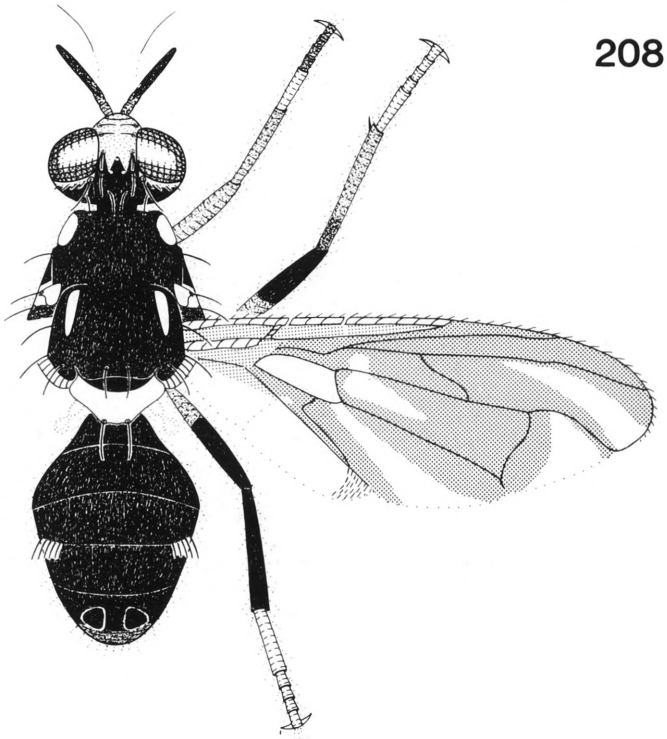
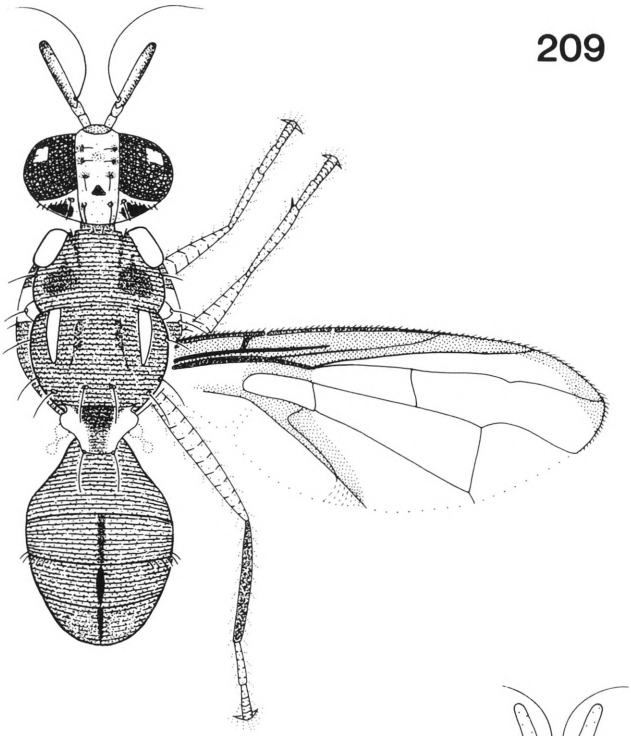


FIG. 207. *Bactrocera* (*Bactrocera*) *barringtoniae* (Tryon), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 208. *Bactrocera* (*Bactrocera*) *biarcuata* (Walker), adult male (x9).



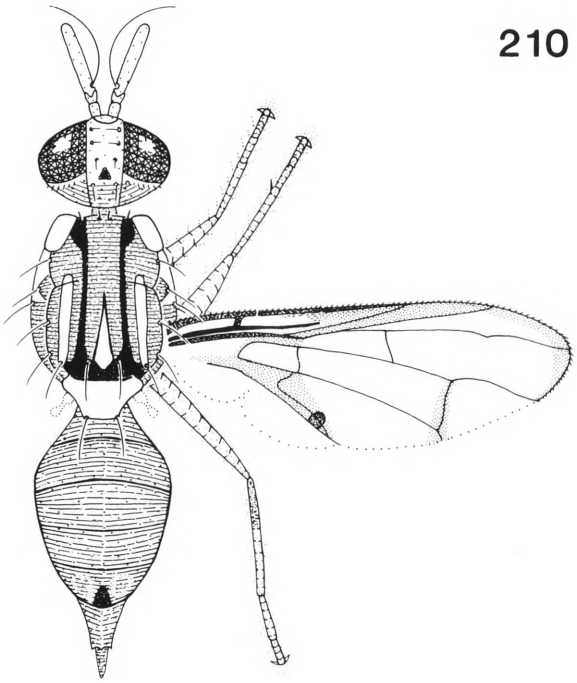
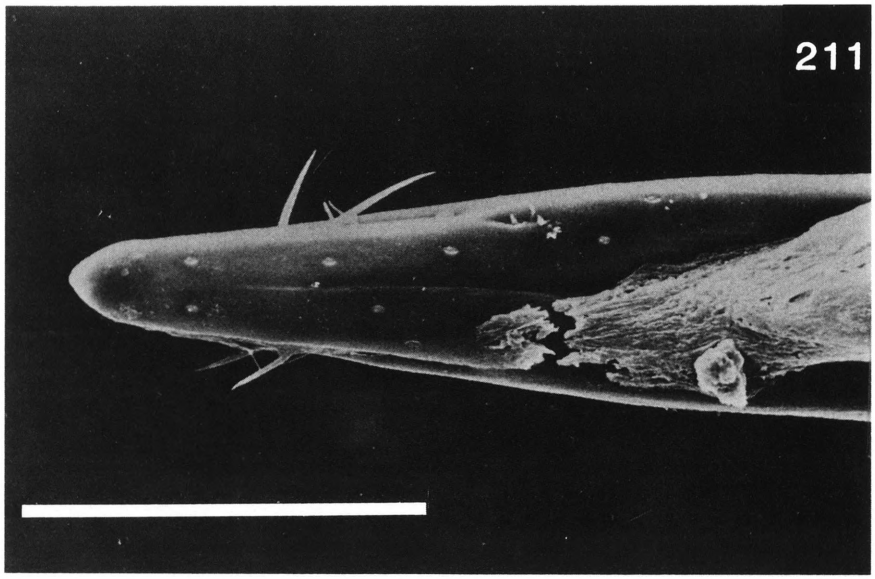
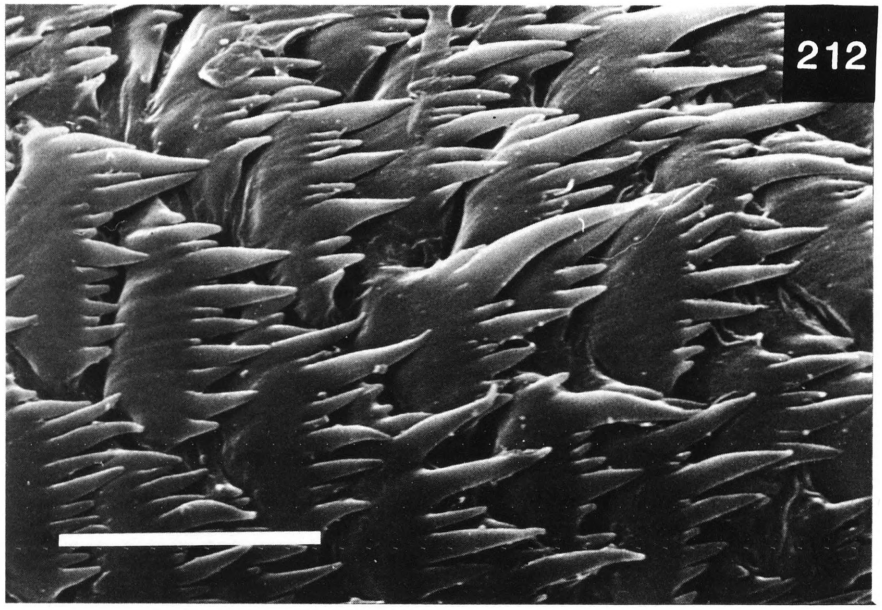


FIG. 209. *Bactrocera* (*Bactrocera*) *buinensis* n. sp., adult male (x11). FIG. 210. *Bactrocera* (*Bactrocera*) *bullata* n. sp., adult female (x9).





FIGS 211–212. *Bactrocera* (*Bactrocera*) *bullata* n. sp.: 211, apex of aculeus (scale 0.1 mm); 212, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

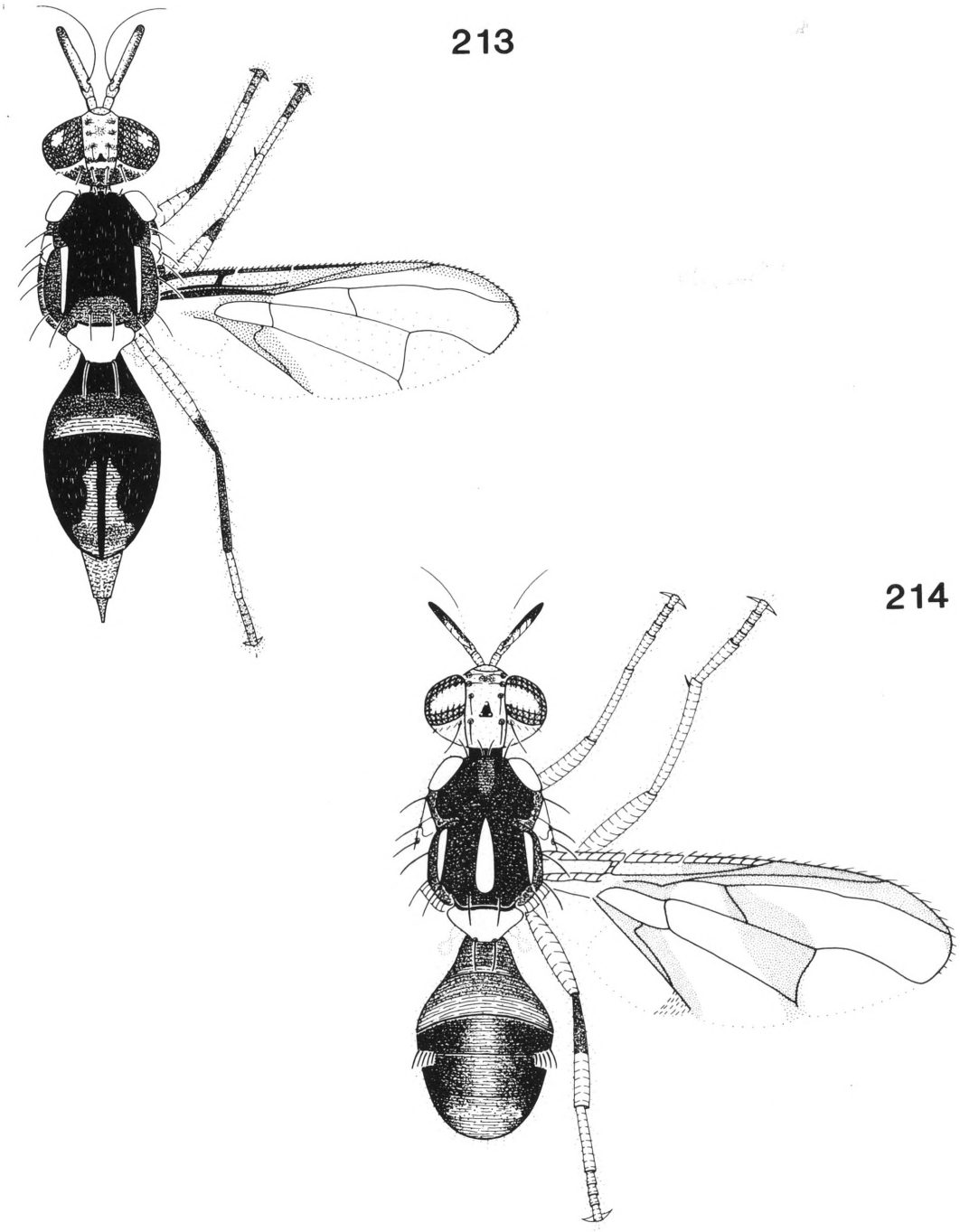


FIG. 213. *Bactrocera* (*Bactrocera*) *buloloensis* n. sp., adult female (x11). FIG. 214. *Bactrocera* (*Bactrocera*) *cheesmanae* (Perkins), adult male (x10).

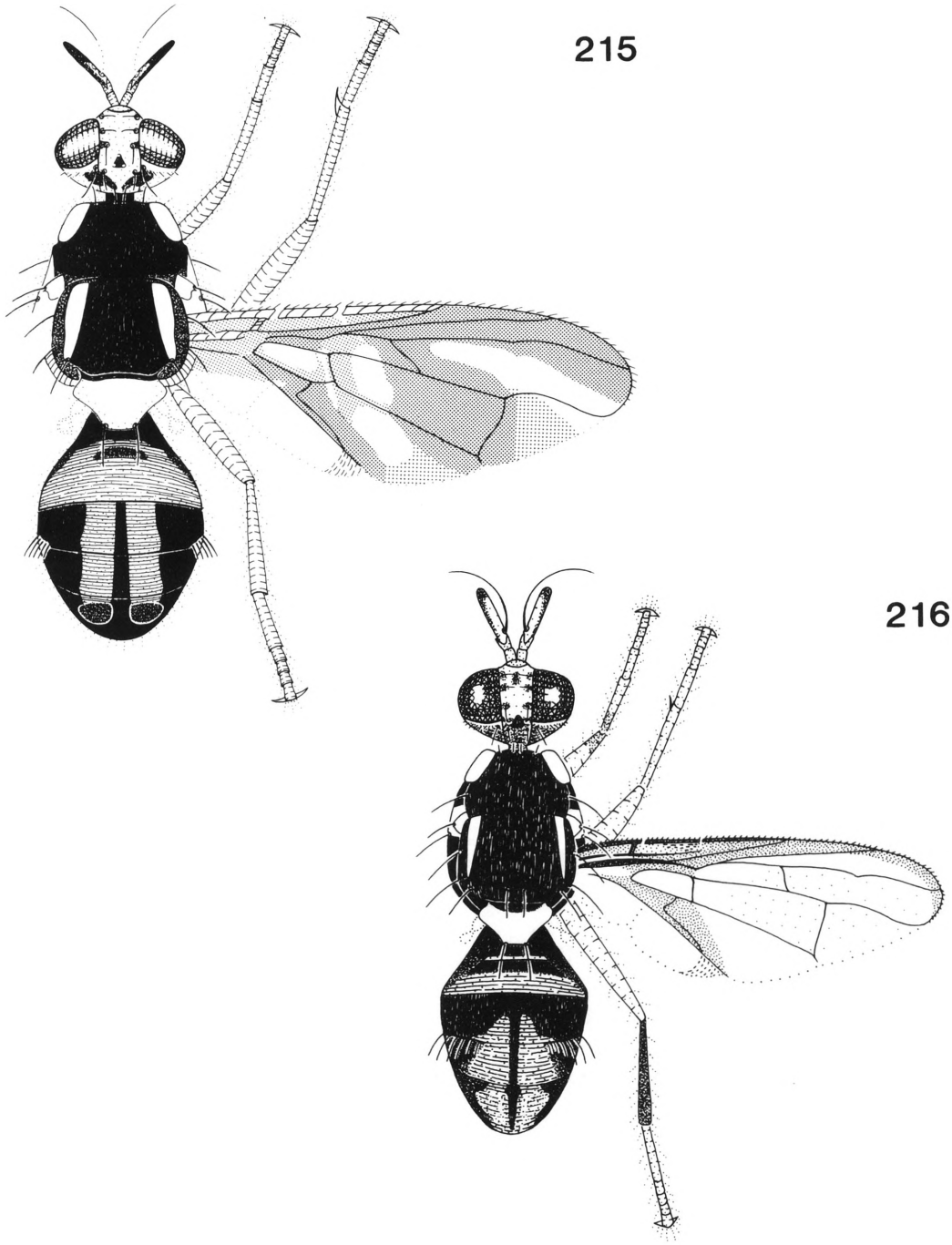


FIG. 215. *Bactrocera* (*Bactrocera*) *confluens* (Drew), adult male (x8). FIG. 216. *Bactrocera* (*Bactrocera*) *congener* n. sp., adult male (x9).

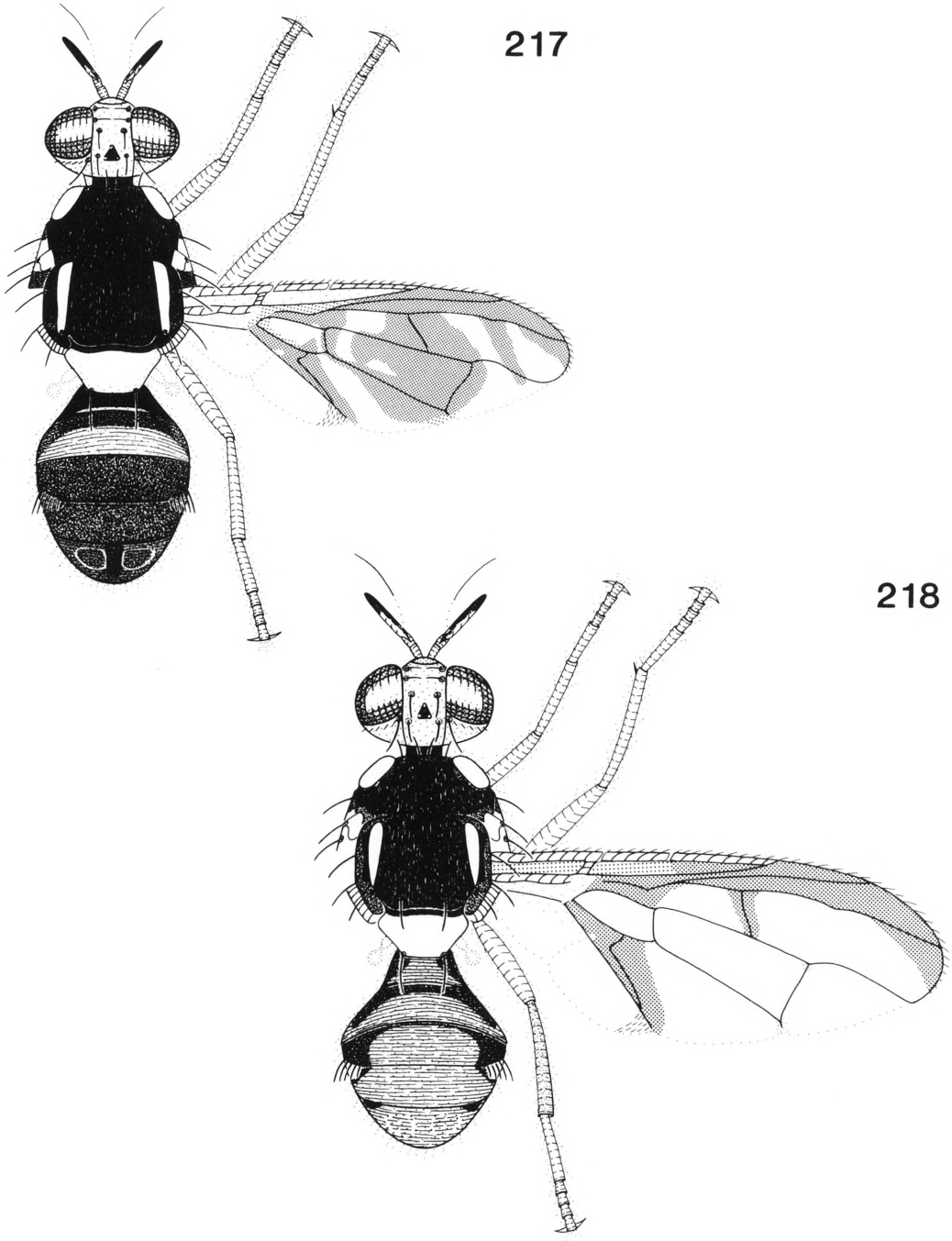
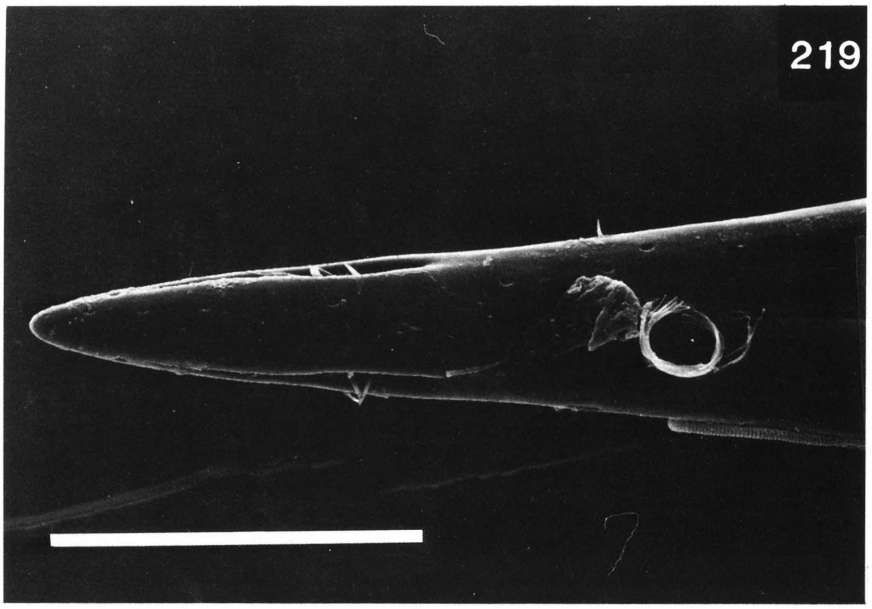
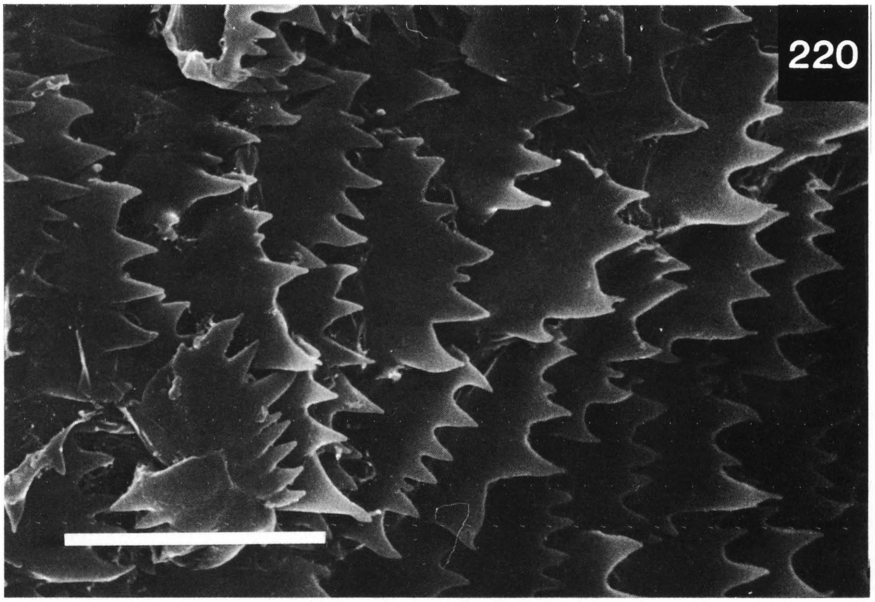


FIG. 217. *Bactrocera* (*Bactrocera*) *curvifera* (Walker), adult male (x6). FIG. 218. *Bactrocera* (*Bactrocera*) *curvipennis* (Froggatt), adult male (x13).





FIGS 219–220. *Bactrocera* (*Bactrocera*) *curvipennis* (Froggatt): 219, apex of aculeus (scale 0.1 mm); 220, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

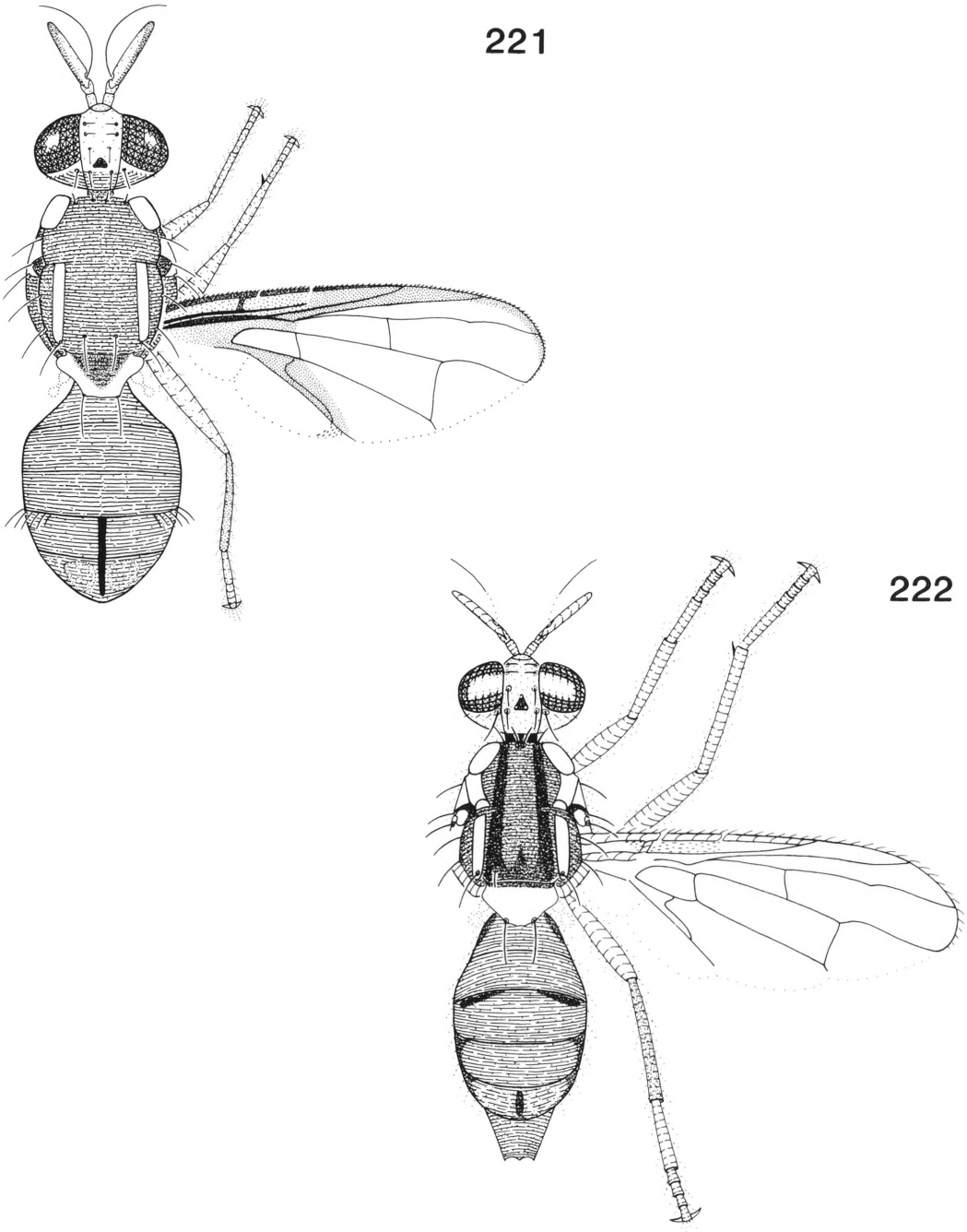
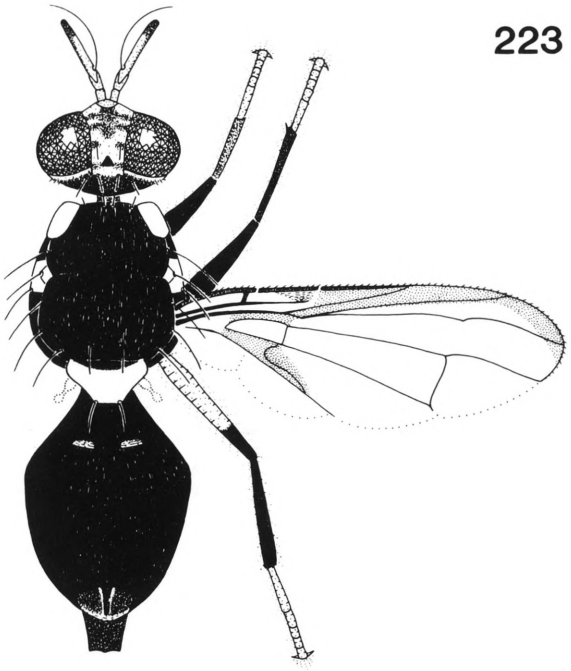
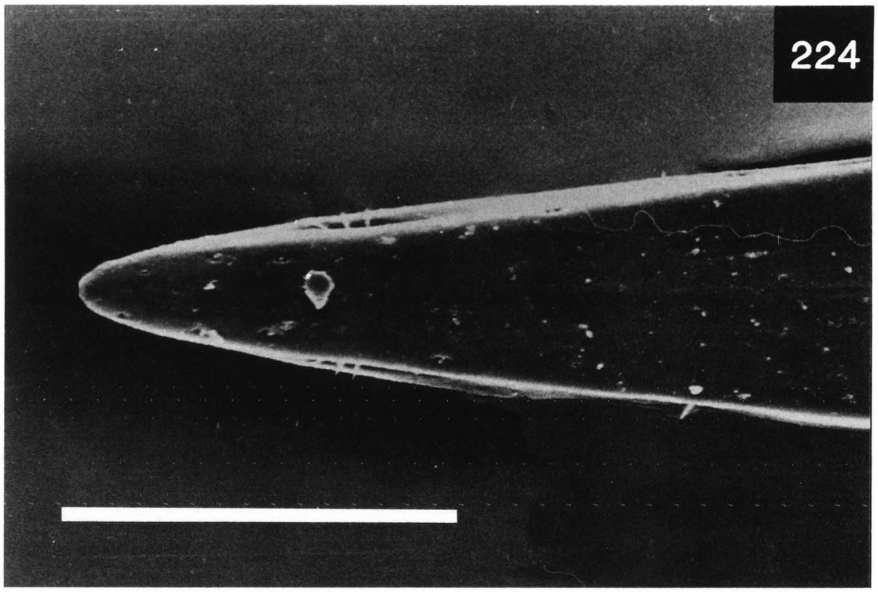
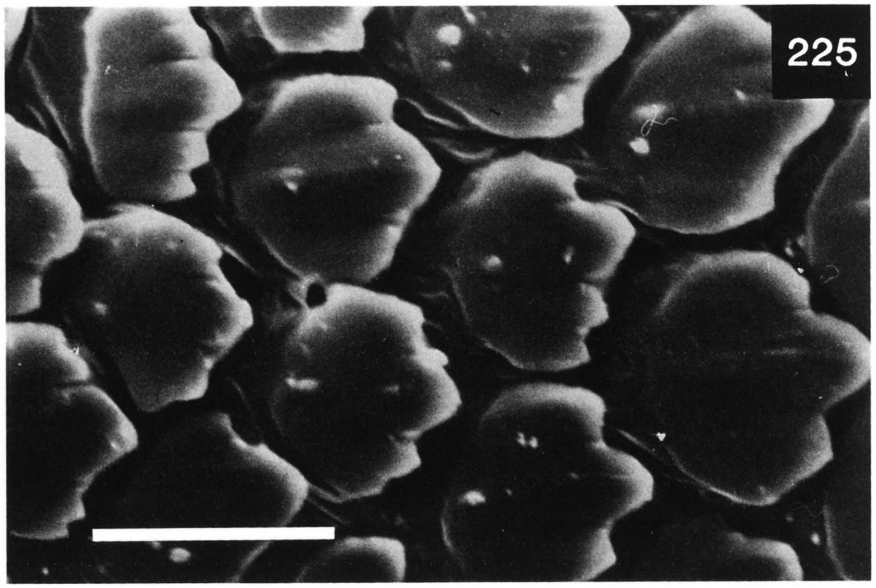


FIG. 221. *Bactrocera* (*Bactrocera*) *daruensis* n. sp., adult male (x10). FIG. 222. *Bactrocera* (*Bactrocera*) *diaphana* (Hering), adult female (x10).





FIGS 223–224. *Bactrocera* (*Bactrocera*) *diospyri* n. sp.: 223, adult female (x11); 224, apex of aculeus (scale 0.1 mm).



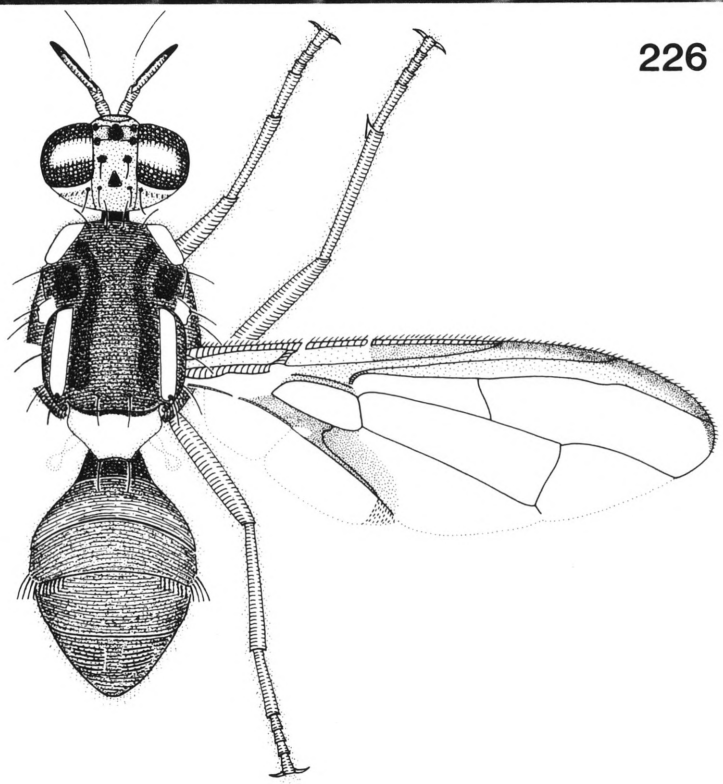


FIG. 225. *Bactrocera* (*Bactrocera*) *diospyri* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 226. *Bactrocera* (*Bactrocera*) *dyscrita* (Drew), adult male (x10).

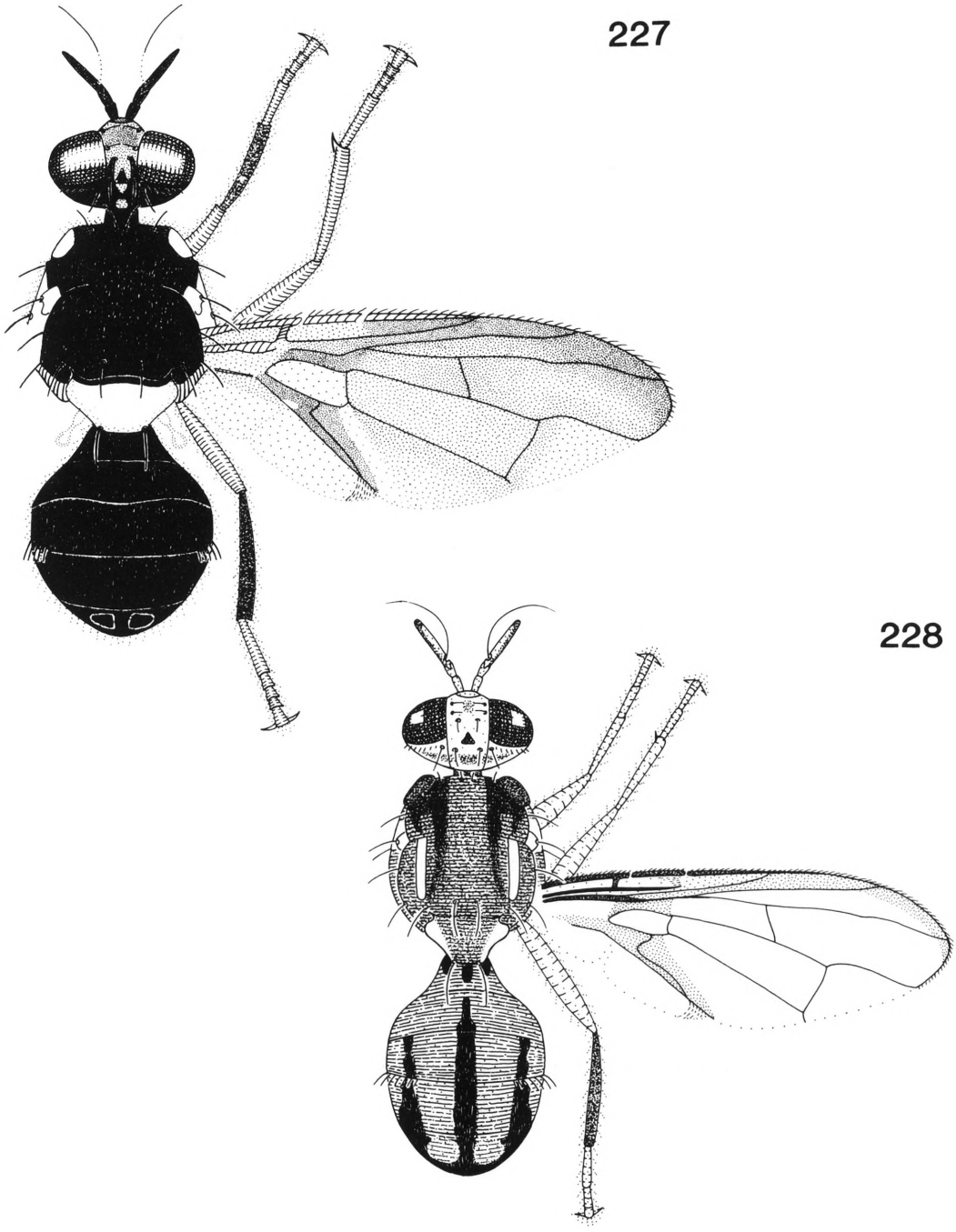


FIG. 227. *Bactrocera* (*Bactrocera*) *ebenea* (Drew), adult male (x10). FIG. 228. *Bactrocera* (*Bactrocera*) *enochra* (Drew), adult male (x9).

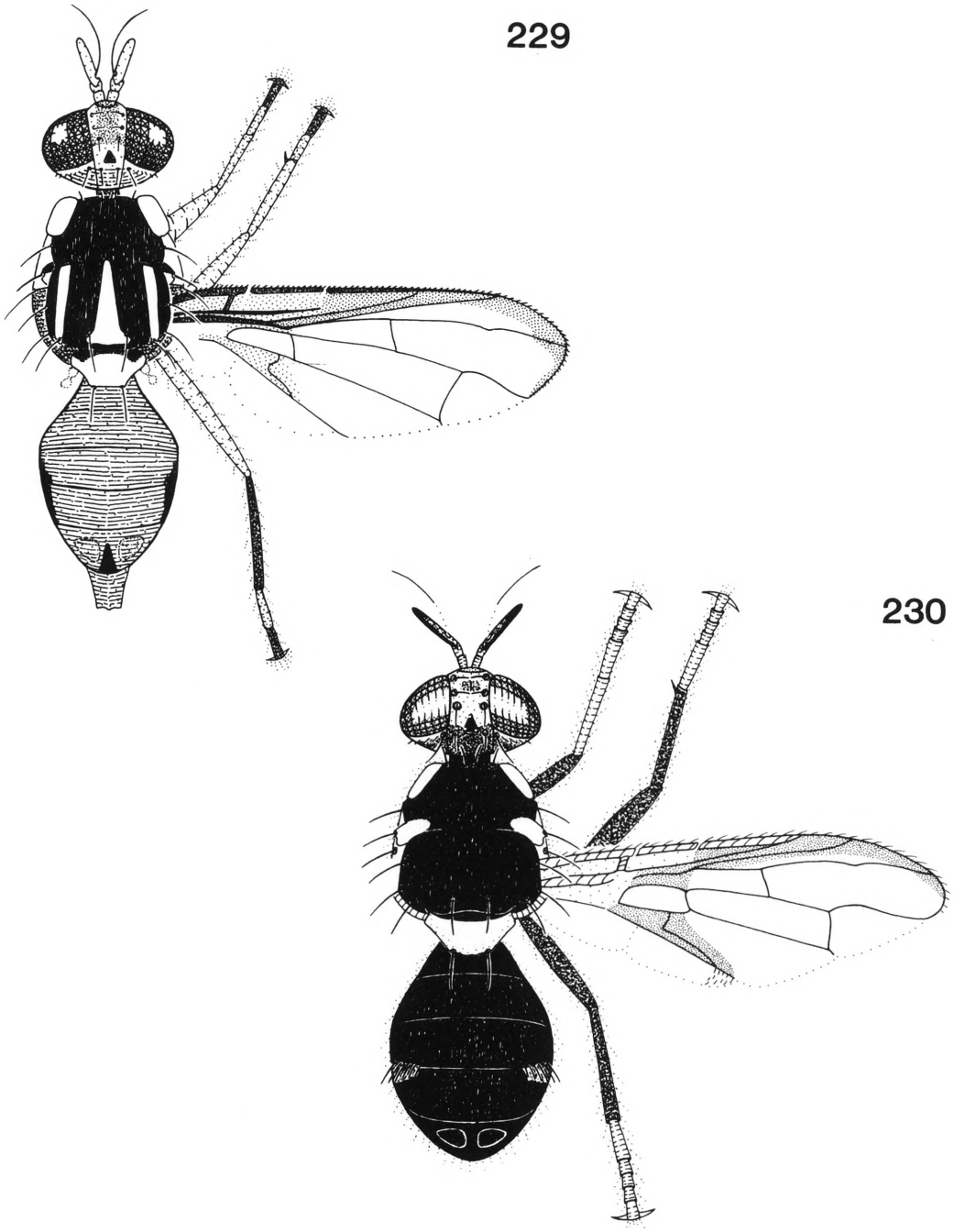
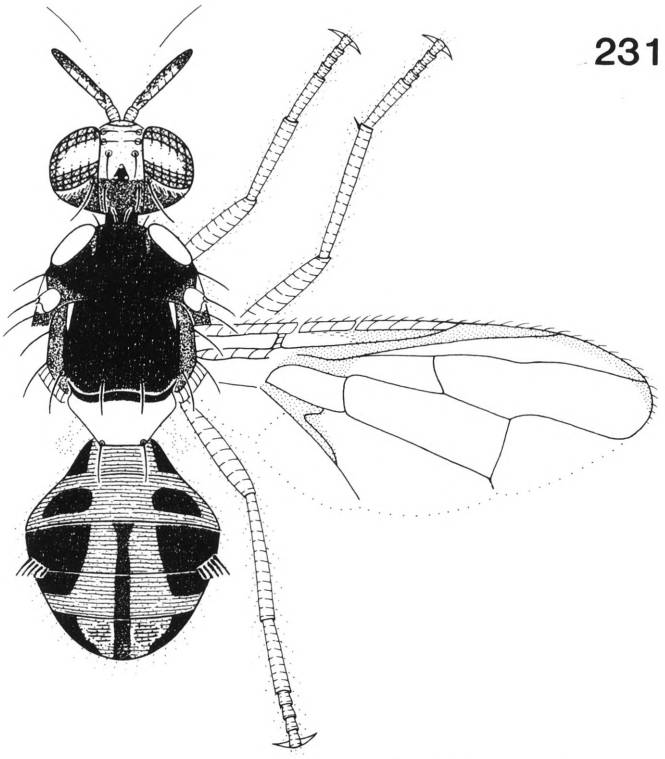
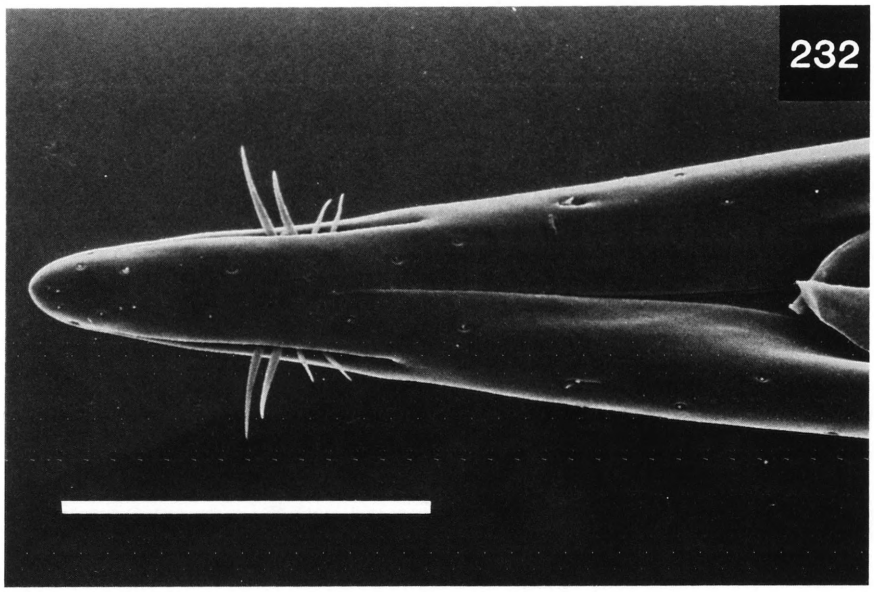
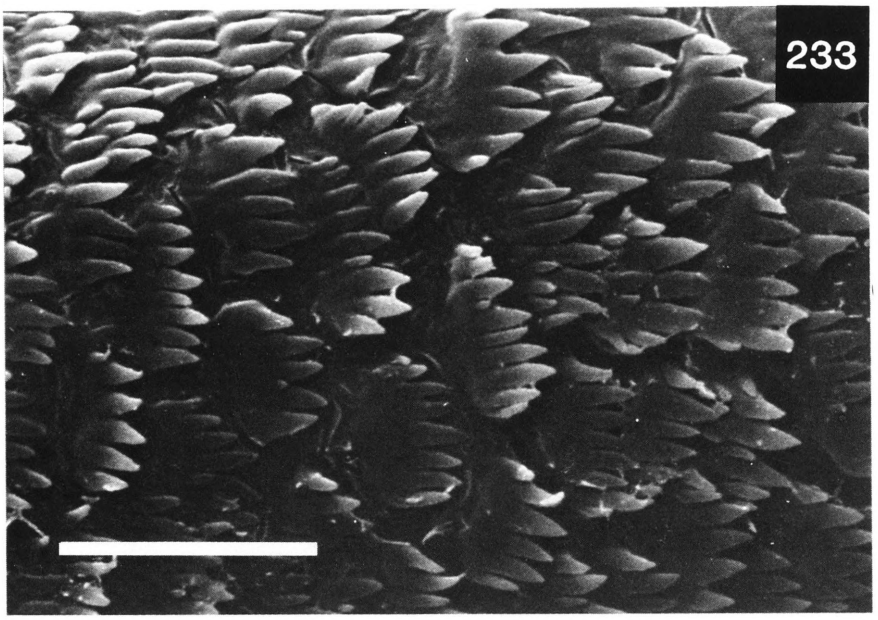


FIG. 229. *Bactrocera* (*Bactrocera*) *eximia* n. sp., adult female (x12). FIG. 230. *Bactrocera* (*Bactrocera*) *exspoliata* (Hering), adult male (x11).





FIGS 231–232. *Bactrocera* (*Bactrocera*) *facialis* (Coquillett): 231, adult male (x14); 232, apex of aculeus (scale 0.1 mm).



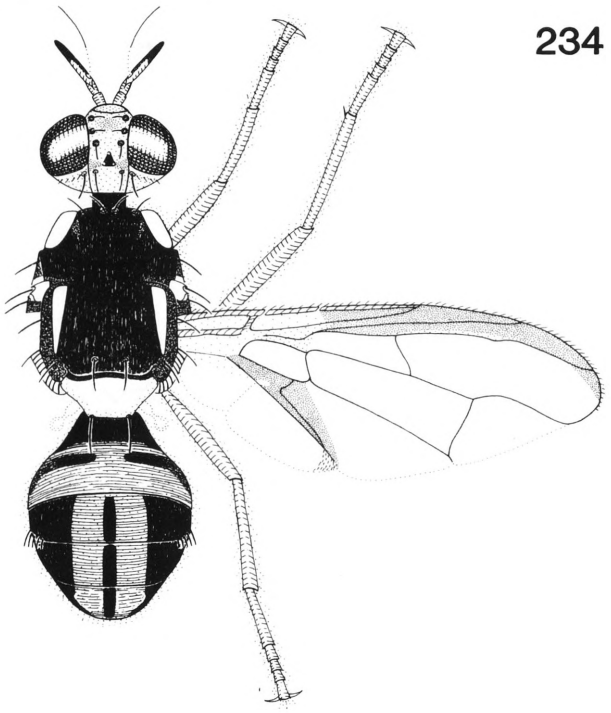
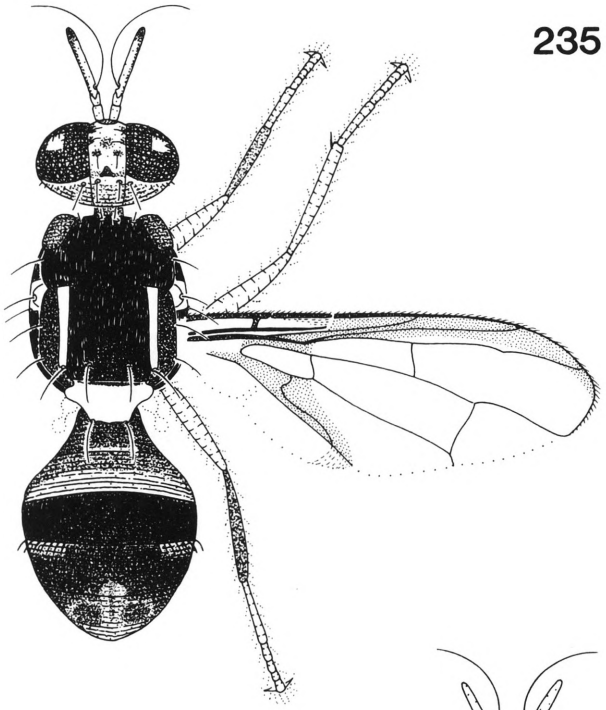


FIG 233. *Bactrocera* (*Bactrocera*) *facialis* (Coquillett), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 234. *Bactrocera* (*Bactrocera*) *froggatti* (Bezzi), adult male (x9).



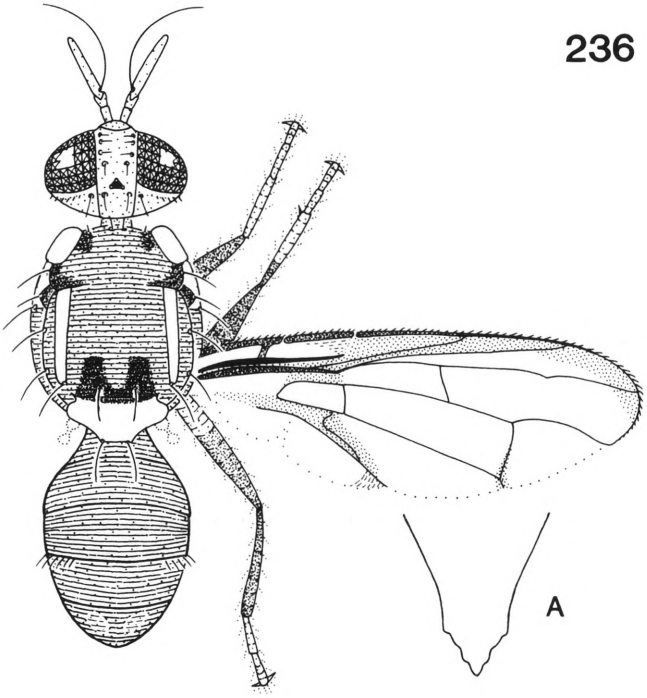
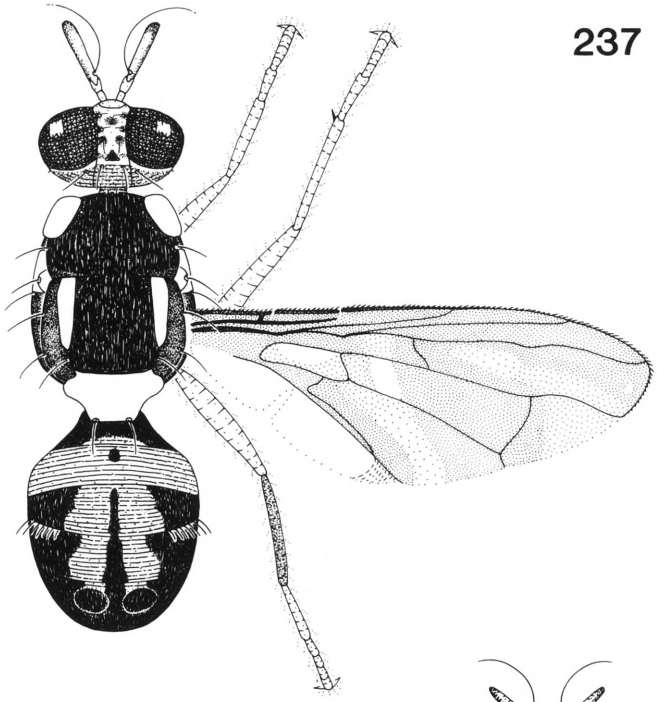


FIG. 235. *Bactrocera* (*Bactrocera*) *furvescens* n. sp., adult male (x10). FIG. 236. *Bactrocera* (*Bactrocera*) *hispidula* (May), adult male (x12). A, apex of aculeus.



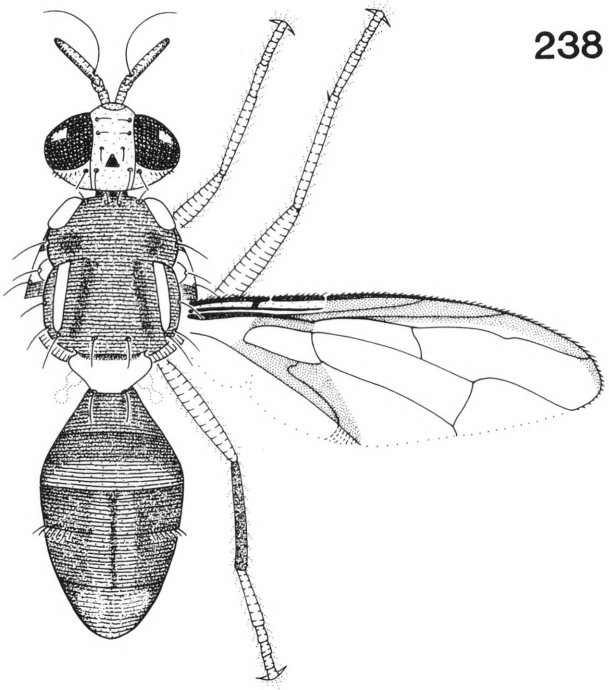
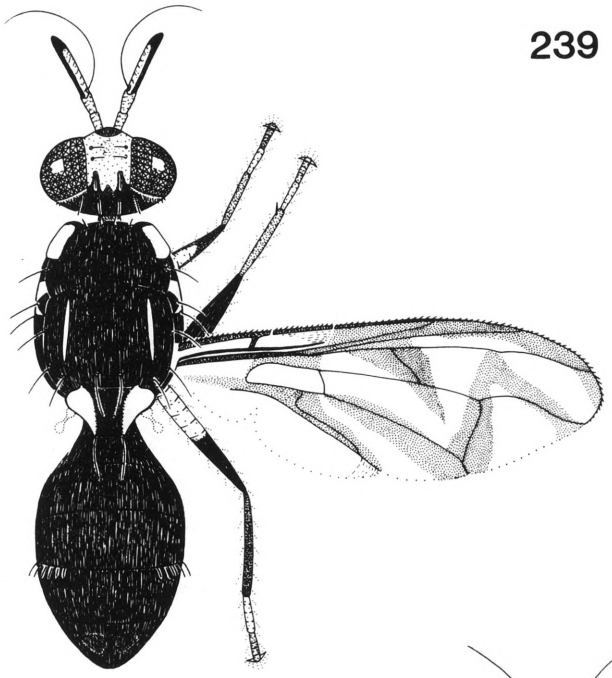


FIG. 237. *Bactrocera* (*Bactrocera*) *honiarae* n. sp., adult male (x7). FIG. 238. *Bactrocera* (*Bactrocera*) *humilis* (Drew and Hancock), adult male (x16).



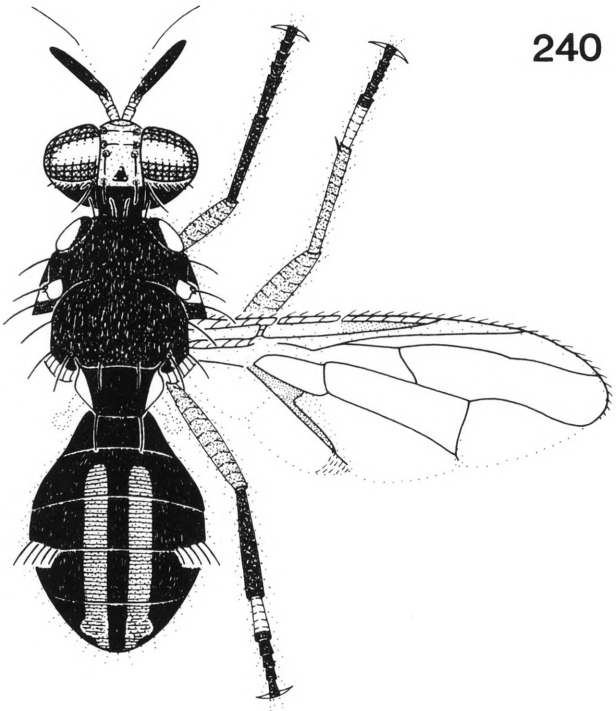
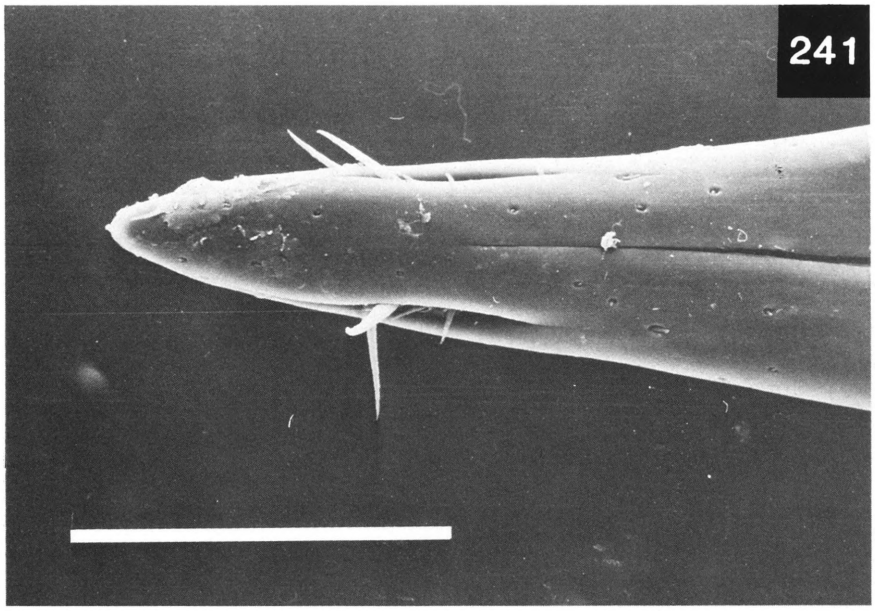
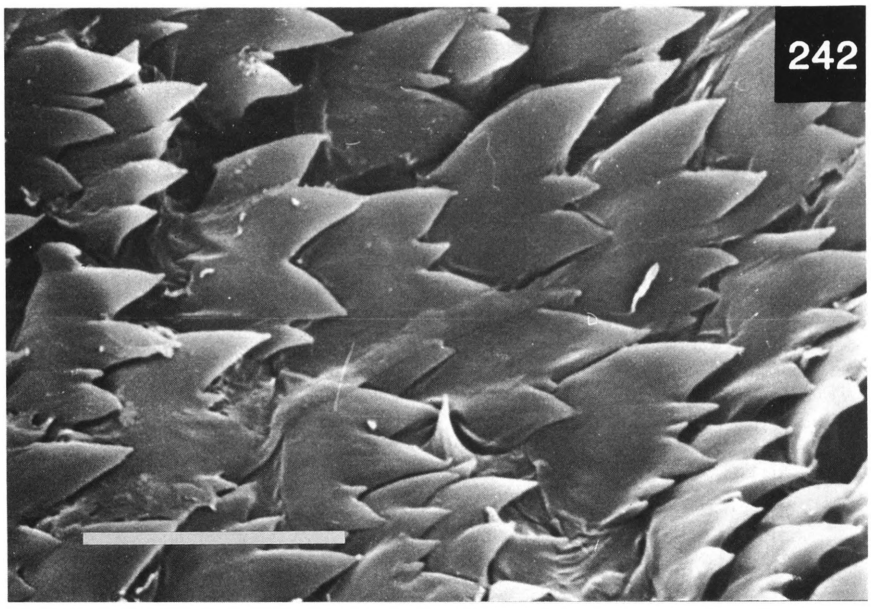
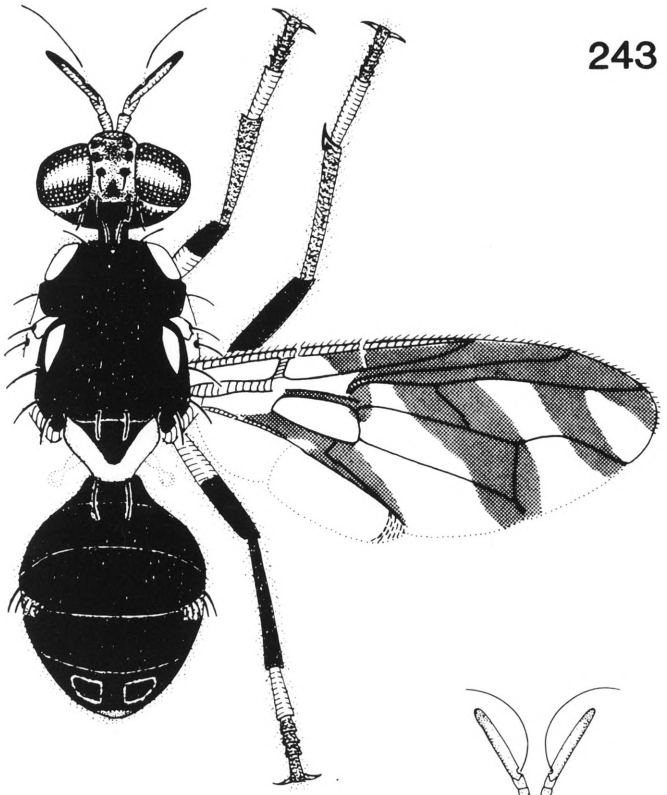


FIG. 239. *Bactrocera* (*Bactrocera*) *ismayi* n. sp., adult male (x9). FIG. 240. *Bactrocera* (*Bactrocera*) *kirki* (Froggatt), adult male (x9).





FIGS 241–242. *Bactrocera* (*Bactrocera*) *kirki* (Froggatt): 241, apex of aculeus (scale 0.1 mm); 242, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



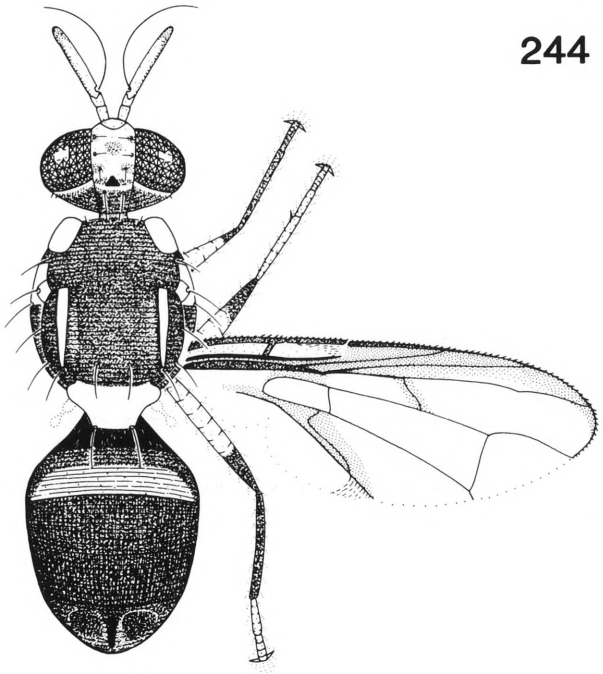
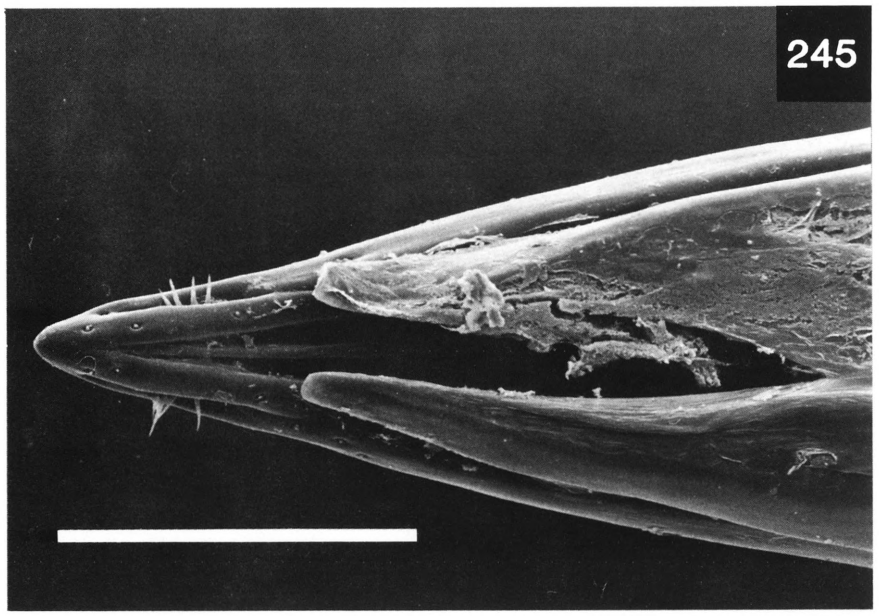
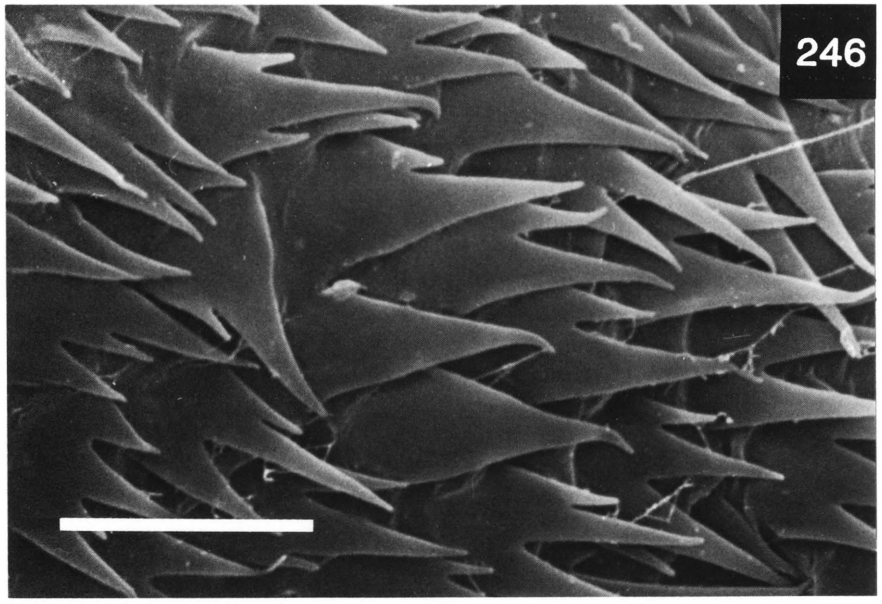
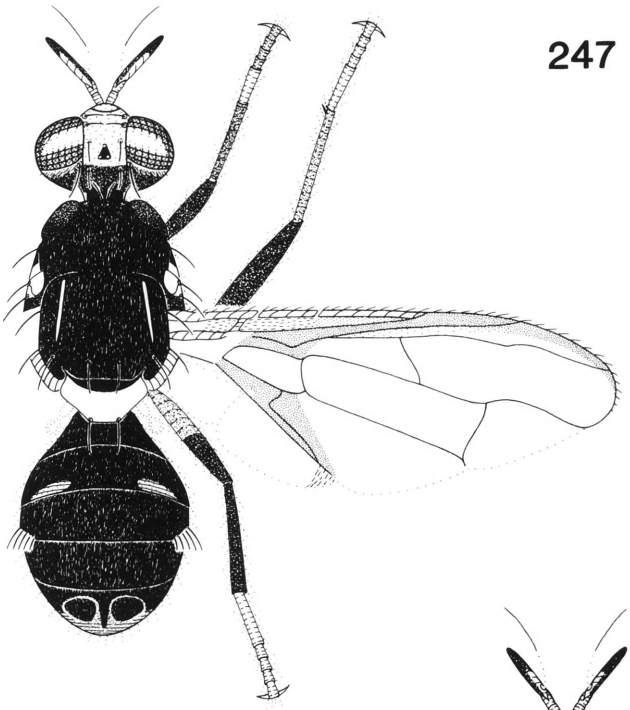


FIG. 243. *Bactrocera* (*Bactrocera*) *lampabilis* (Drew), adult male (x13). FIG. 244. *Bactrocera* (*Bactrocera*) *laticaudus* (Hardy), adult male (x11).





FIGS. 245–246. *Bactrocera* (*Bactrocera*) *laticaudus* (Hardy): 245, apex of aculeus (scale 0.1 mm); 246, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



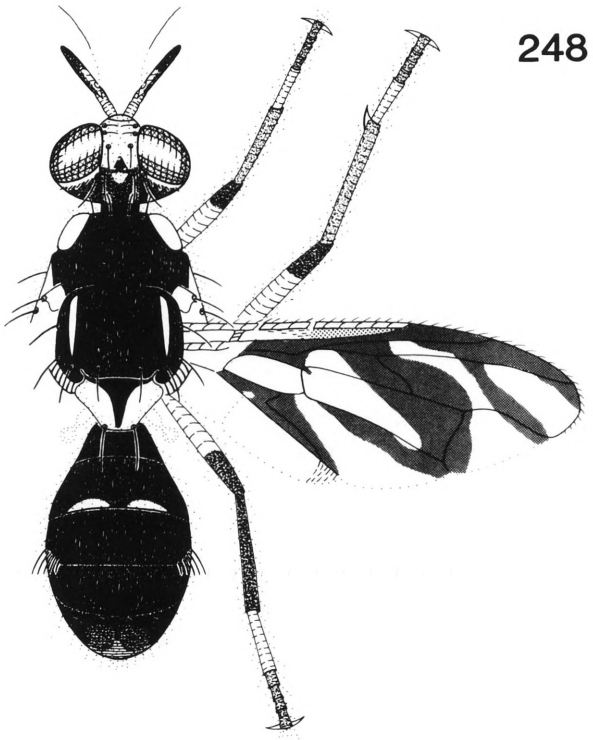
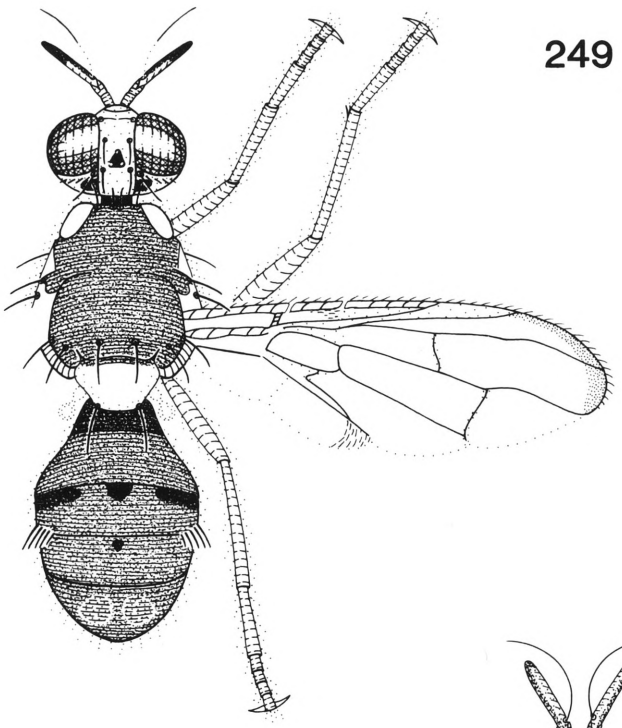


FIG. 247. *Bactrocera* (*Bactrocera*) *lineata* (Perkins), adult male (x9). FIG. 248. *Bactrocera* (*Bactrocera*) *longicornis* (Macquart), adult male (x9).



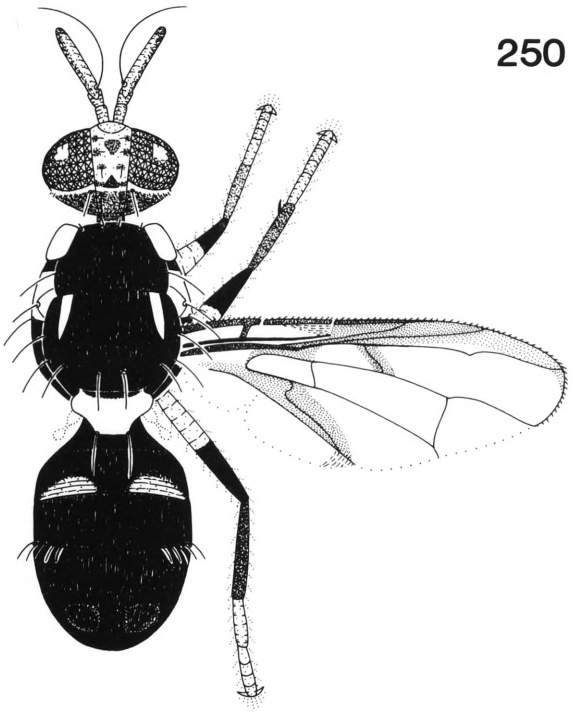
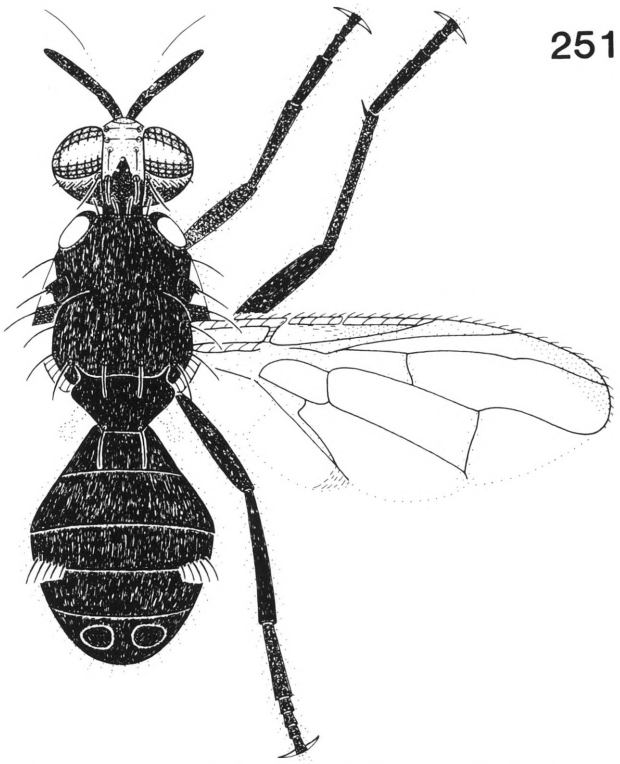
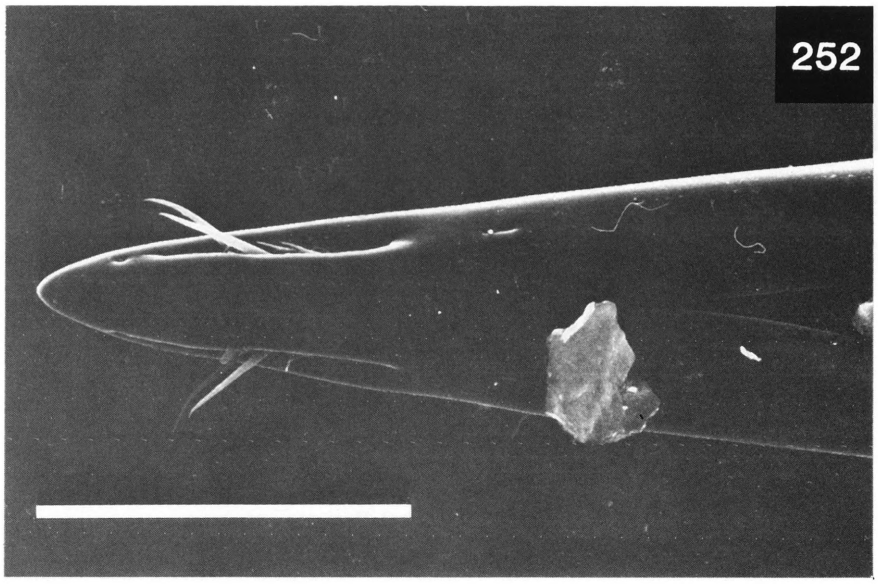
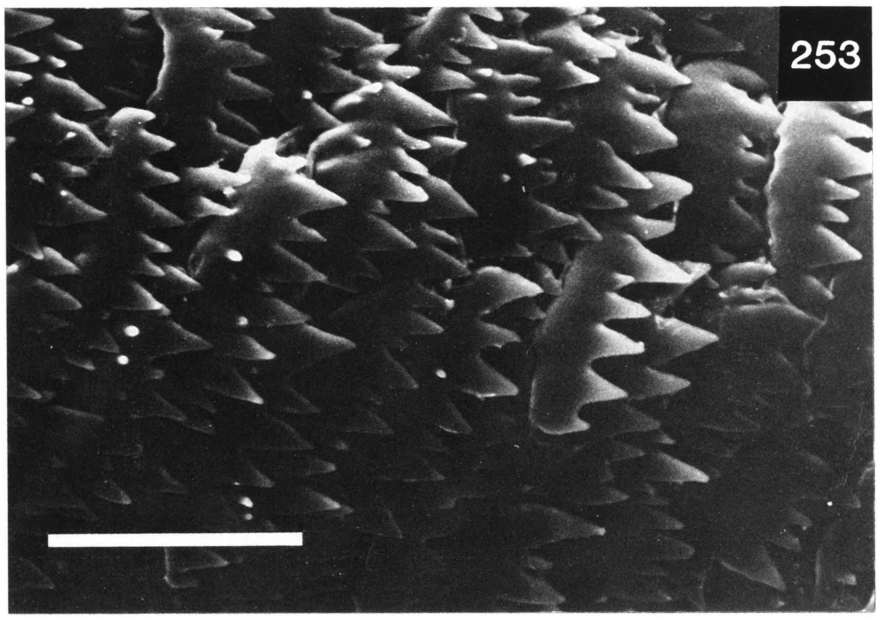


FIG. 249. *Bactrocera* (*Bactrocera*) *luteola* (Malloch), adult male (x11). FIG. 250. *Bactrocera* (*Bactrocera*) *melanogaster* n. sp., adult male (x10).





FIGS 251–252. *Bactrocera* (*Bactrocera*) *melanotus* (Coquillett): 251, adult male (x10); 252, apex of aculeus (scale 0.1 mm).



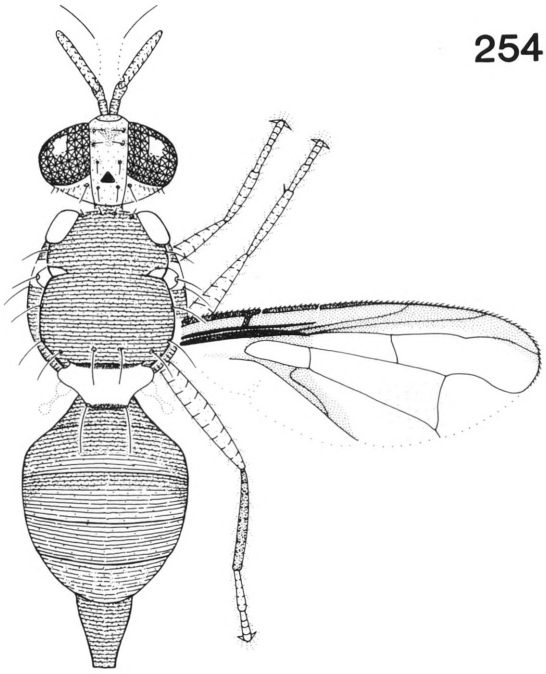
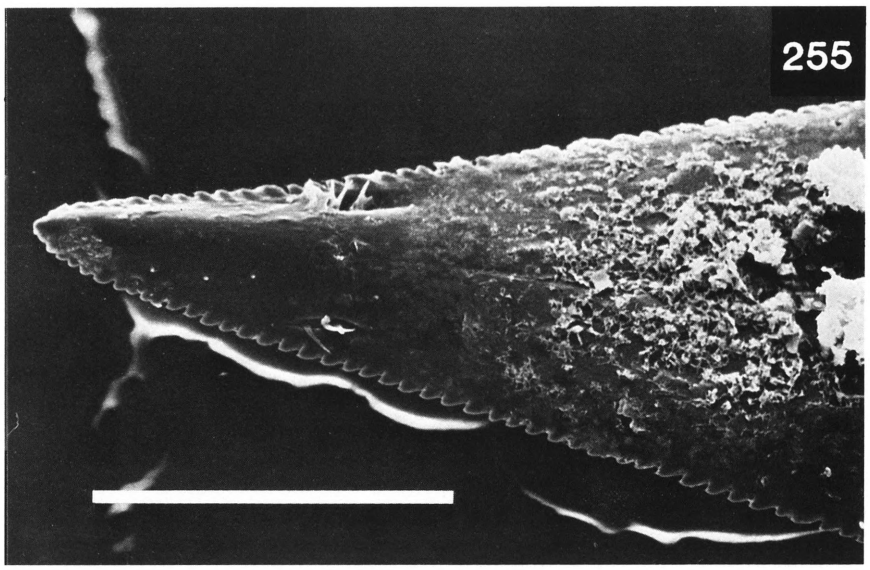
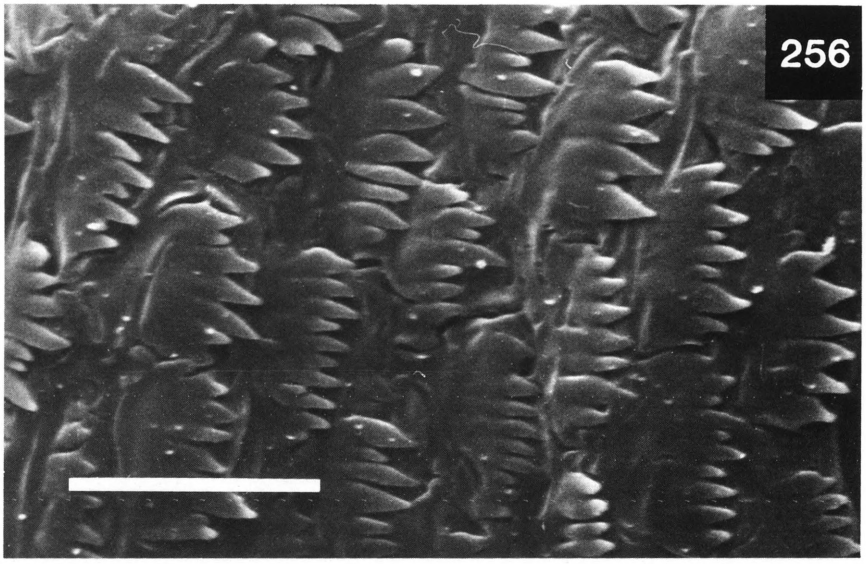
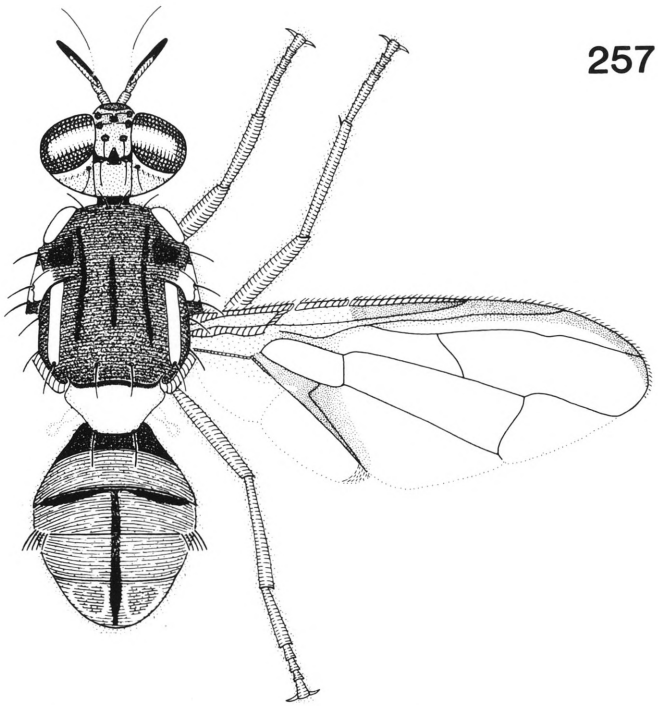


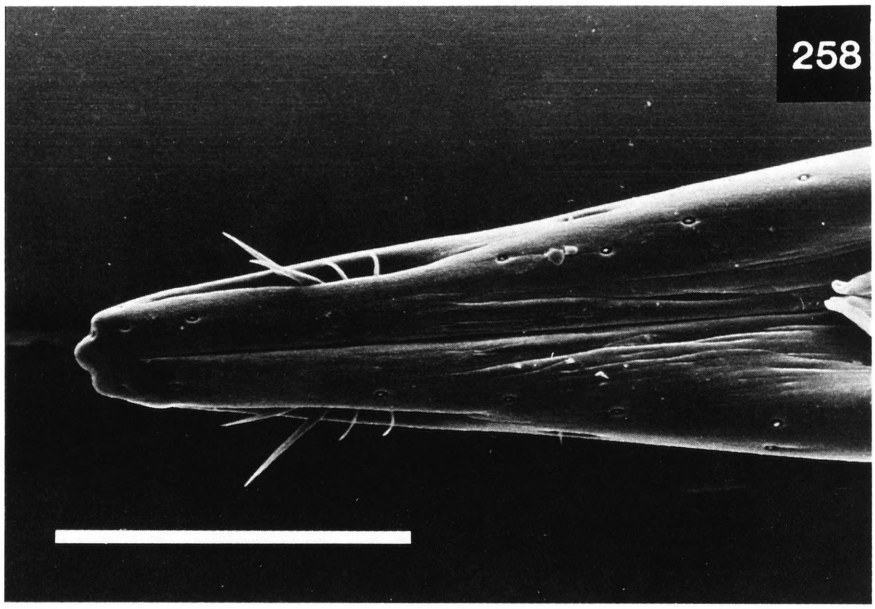
FIG. 253. *Bactrocera* (*Bactrocera*) *melanotus* (Coquillett), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 254. *Bactrocera* (*Bactrocera*) *mendosa* (May), adult female (x9).



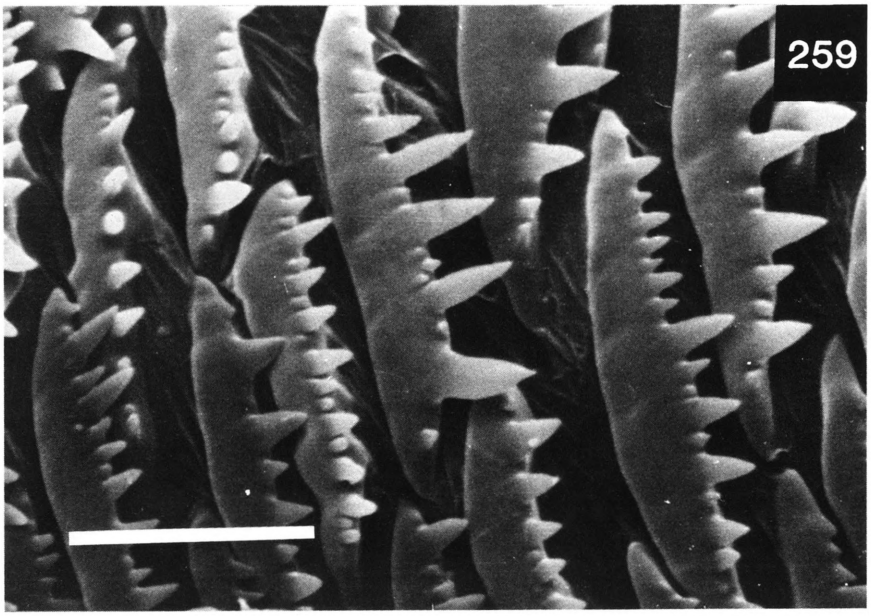


FIGS 255–256. *Bactrocera* (*Bactrocera*) *mendosa* (May): 255, apex of aculeus (scale 0.1 mm); 256, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).





FIGS 257–258. *Bactrocera* (*Bactrocera*) *moluccensis* (Perkins): 257, adult male (x8); 258, apex of aculeus (scale 0.1 mm).



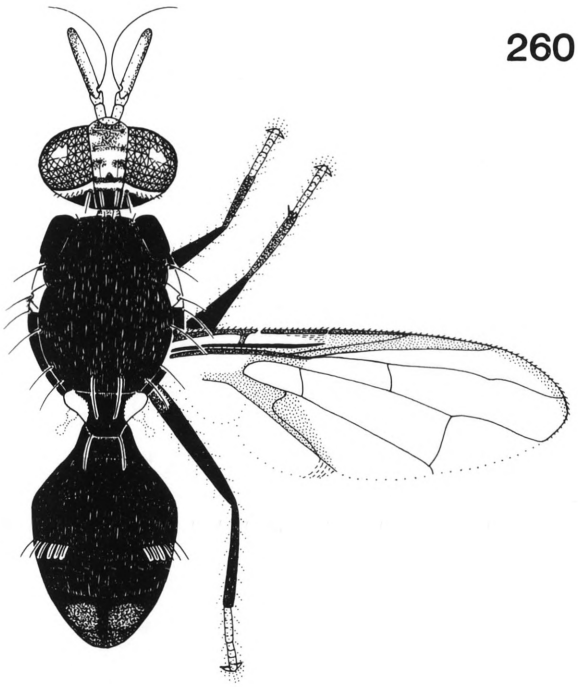


FIG. 259. *Bactrocera* (*Bactrocera*) *moluccensis* (Perkins), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 260. *Bactrocera* (*Bactrocera*) *morula* n. sp., adult male (x11).

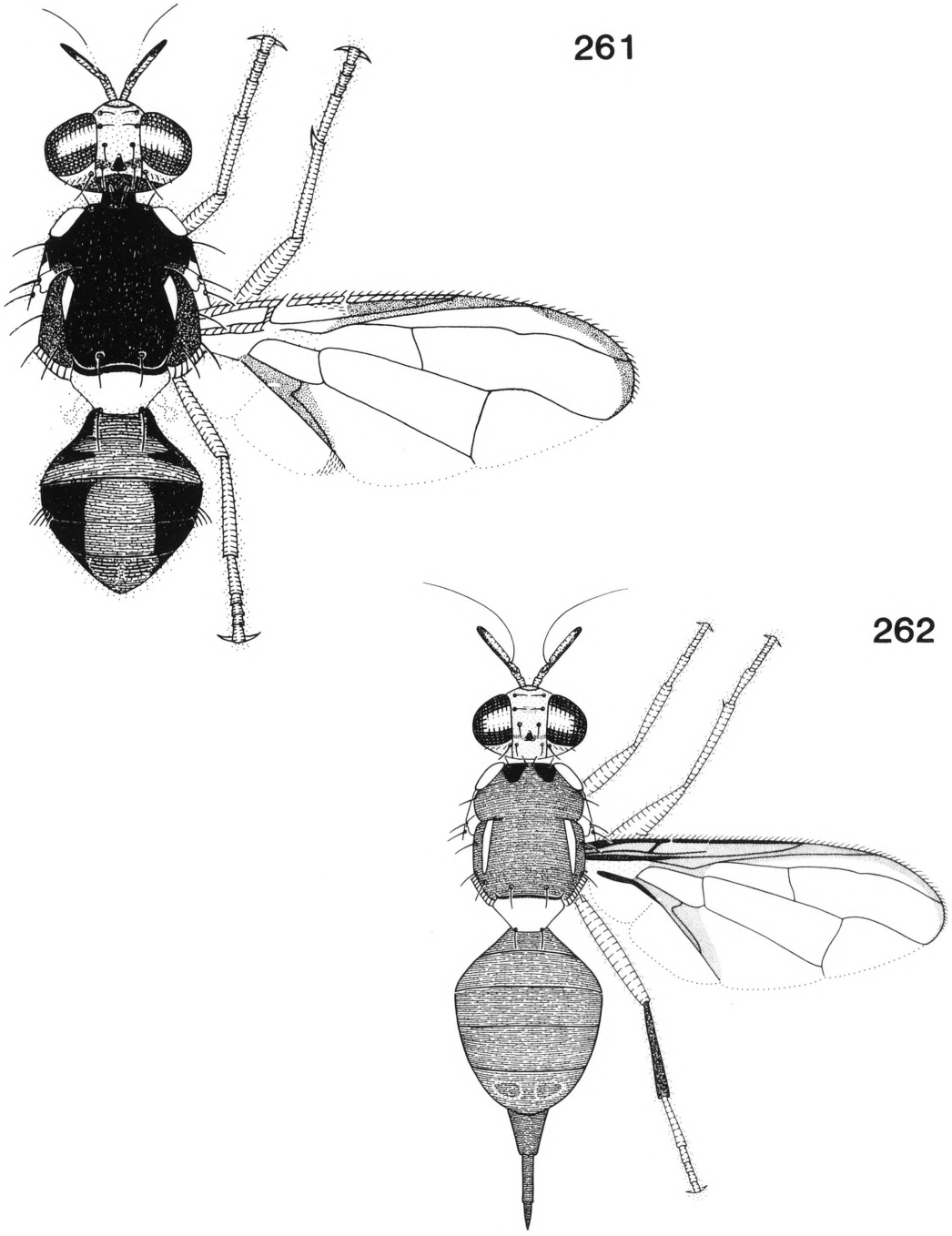
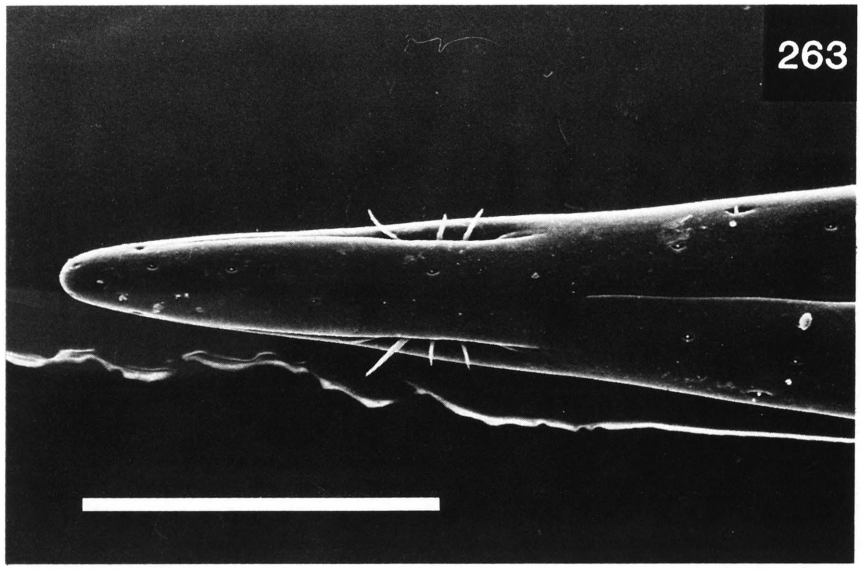
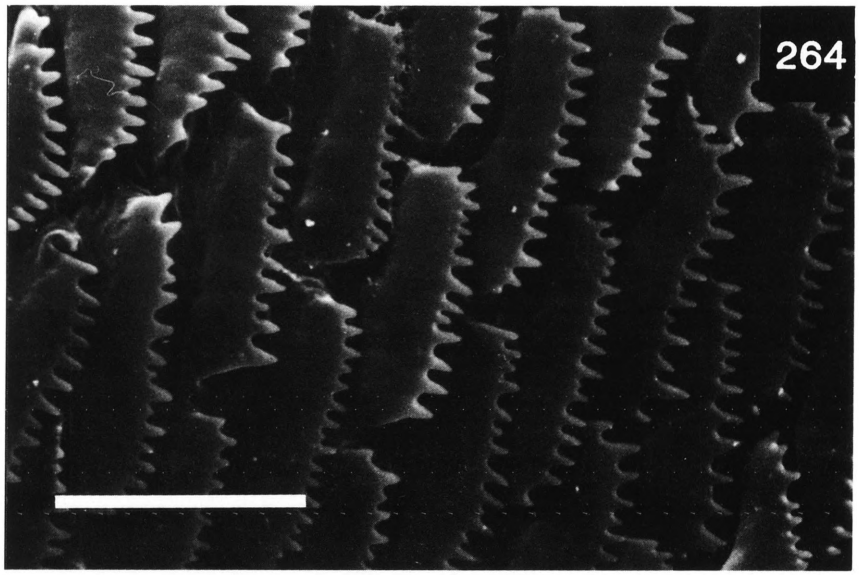


FIG. 261. *Bactrocera* (*Bactrocera*) *mucronis* (Drew), adult male (x14). FIG. 262. *Bactrocera* (*Bactrocera*) *mutabilis* (May), adult female (x9).





FIGS 263–264. *Bactrocera* (*Bactrocera*) *mutabilis* (May): 263, apex of aculeus (scale 0.1 mm); 264, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

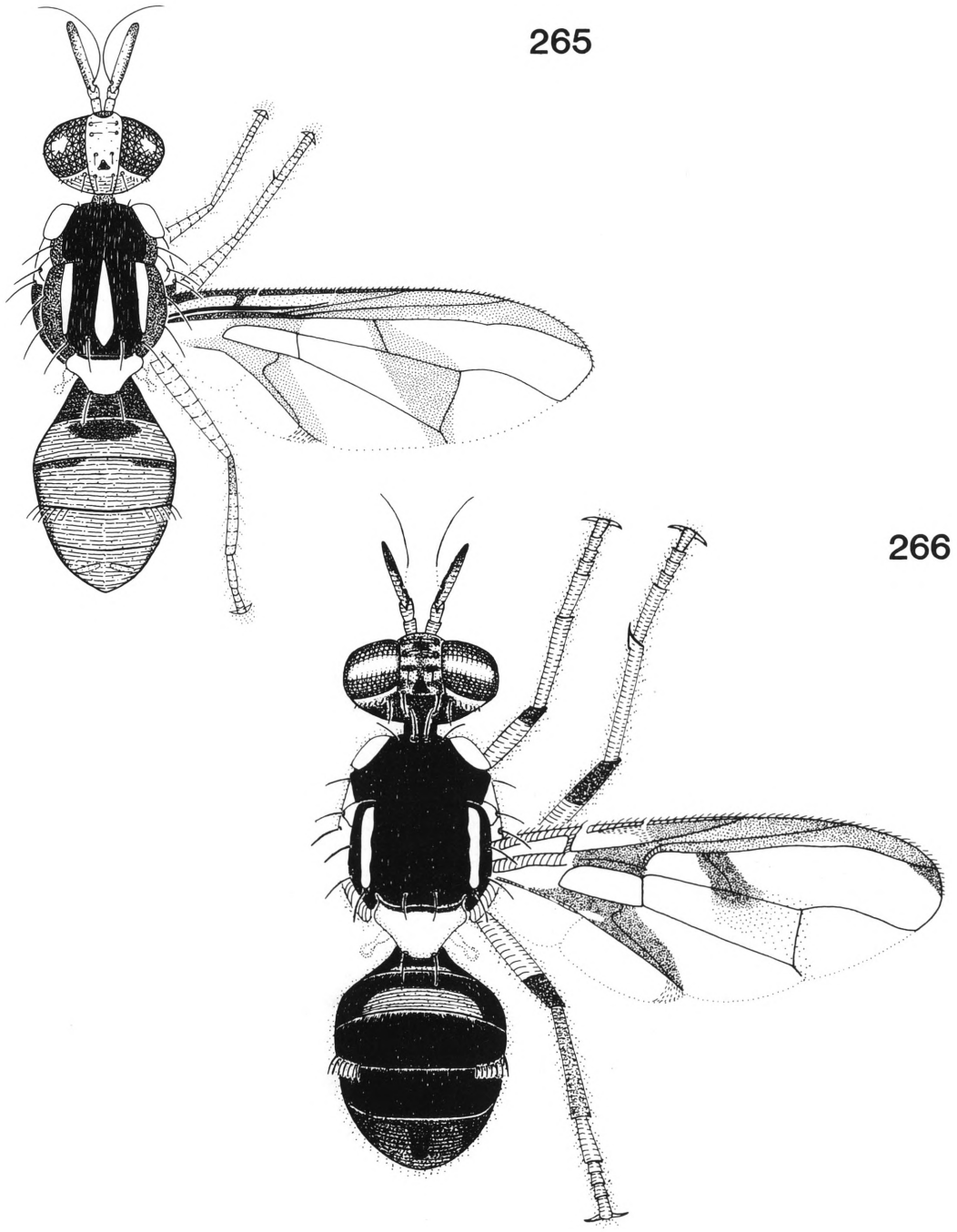
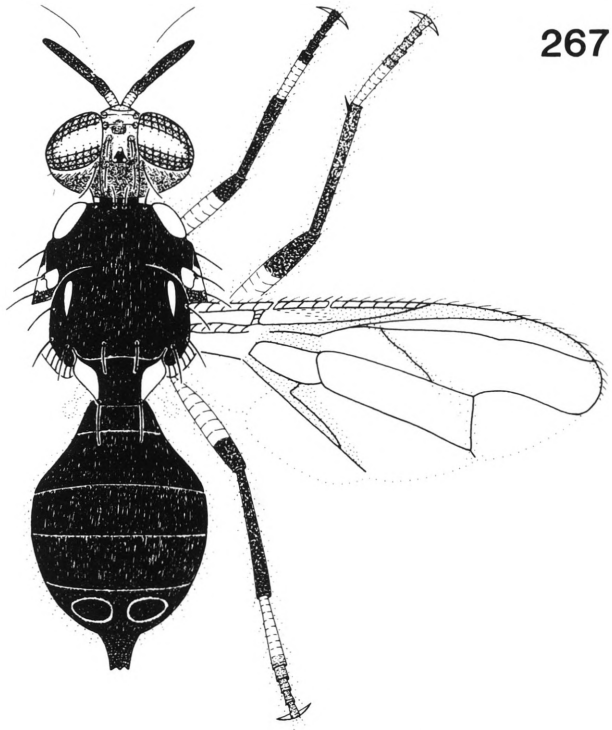
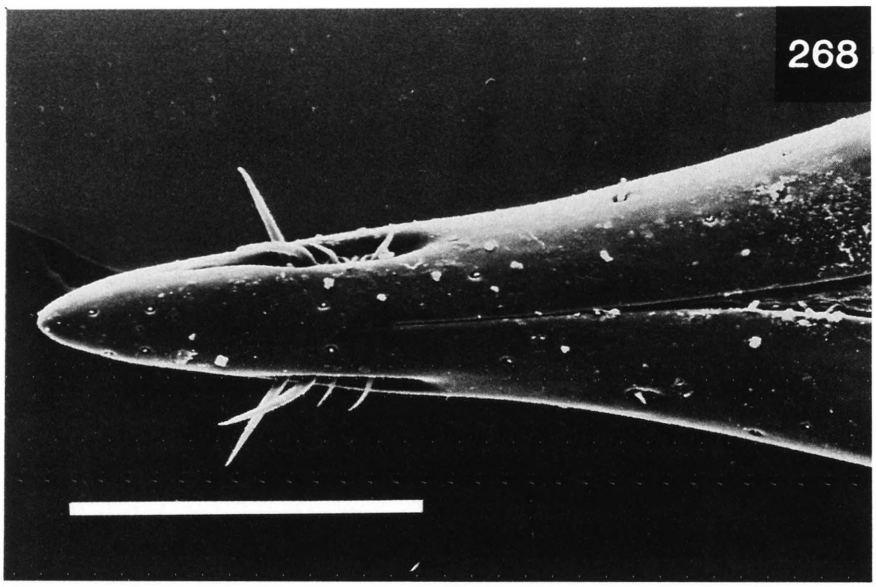
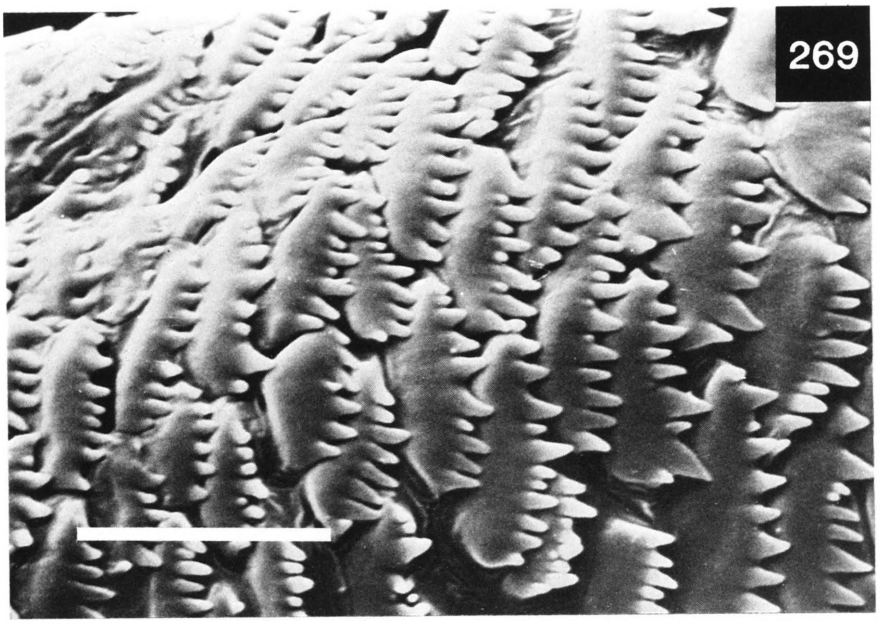


FIG. 265. *Bactrocera* (*Bactrocera*) *neocheesmanae* n. sp., adult male (x10). FIG. 266. *Bactrocera* (*Bactrocera*) *neonigrita* n. nom., adult male (x13).





FIGS 267–268. *Bactrocera* (*Bactrocera*) *obliqua* (Malloch): 267, adult female (x10); 268, apex of aculeus (scale 0.1 mm).



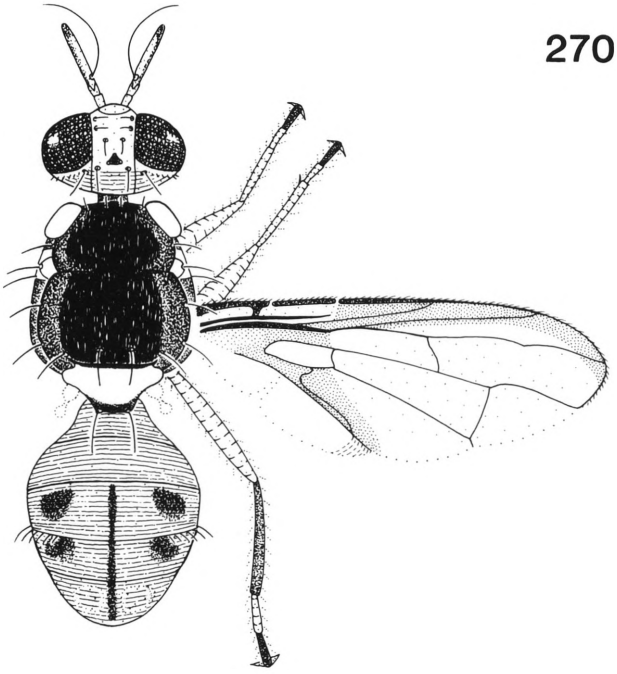


FIG. 269. *Bactrocera* (*Bactrocera*) *obliqua* (Malloch), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 270. *Bactrocera* (*Bactrocera*) *obscura* (Malloch), adult male (x9).

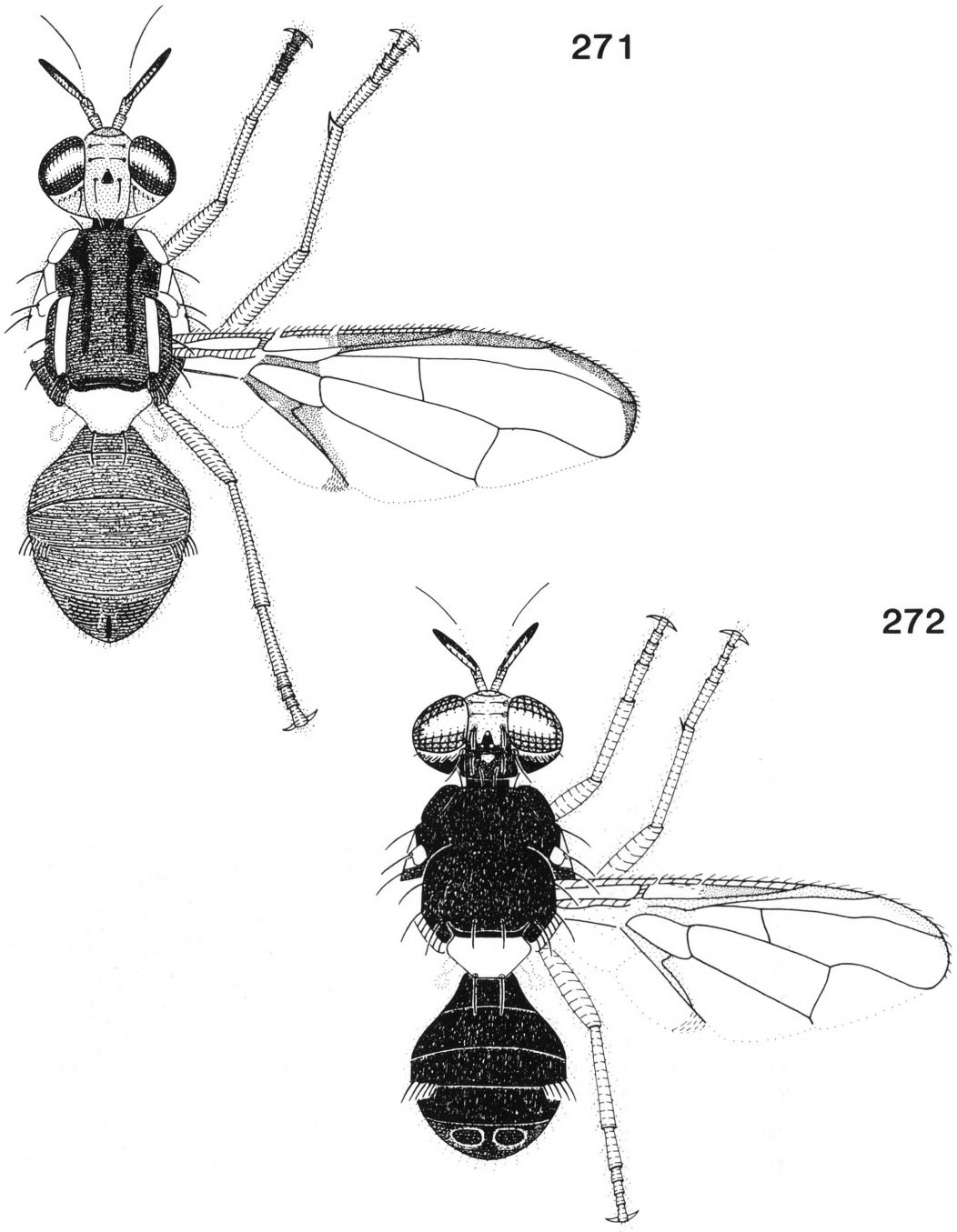
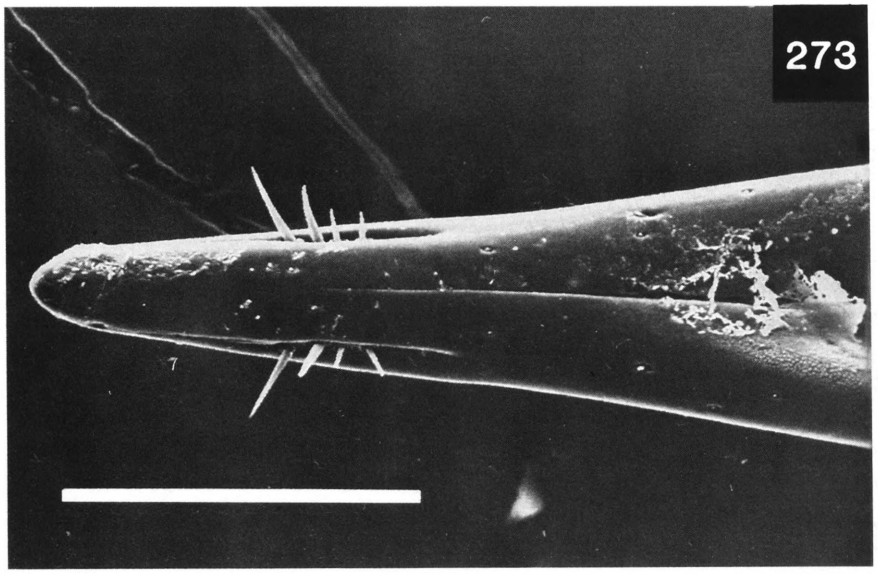
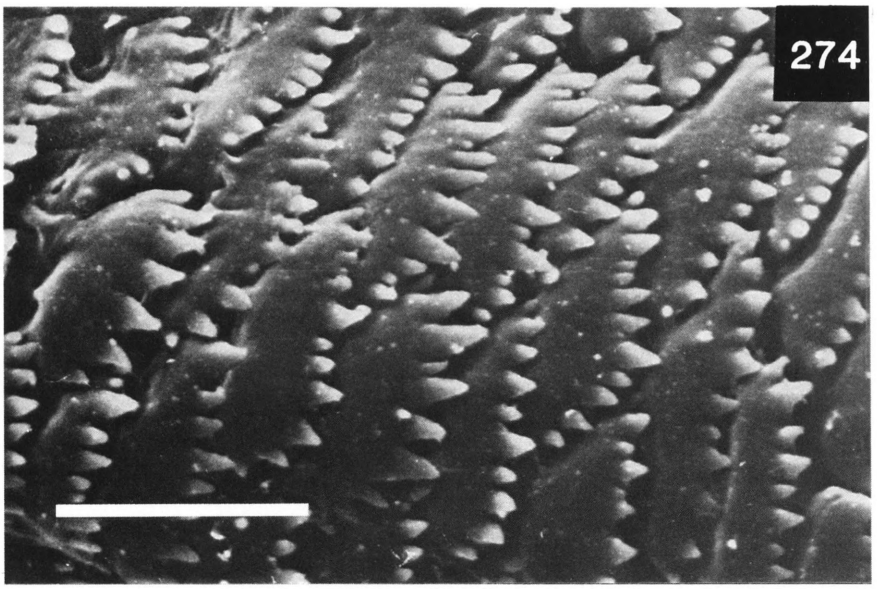
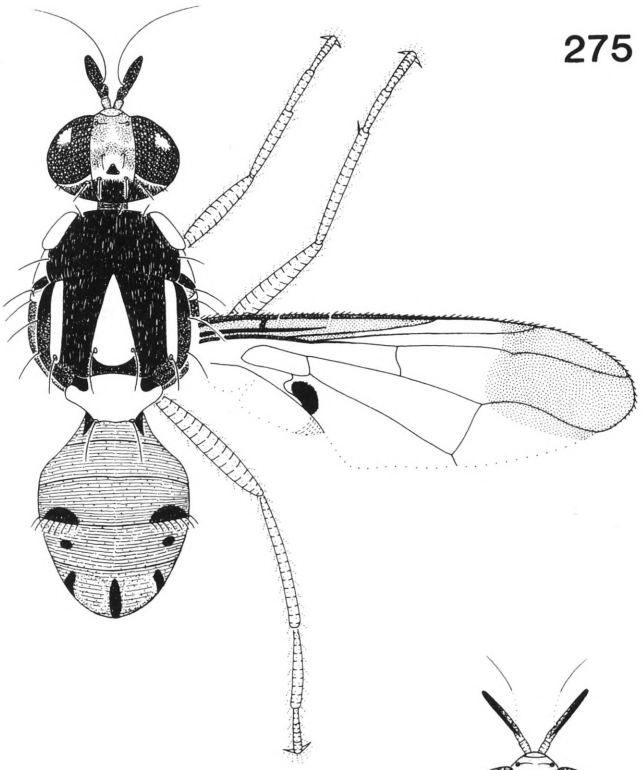


FIG. 271. *Bactrocera* (*Bactrocera*) *ochromarginis* (Drew), adult male (x12). FIG. 272. *Bactrocera* (*Bactrocera*) *passiflorae* (Froggatt), adult male (x13).





FIGS 273—274. *Bactrocera* (*Bactrocera*) *passiflorae* (Froggatt): 273, apex of aculeus (scale 0.1 mm); 274, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



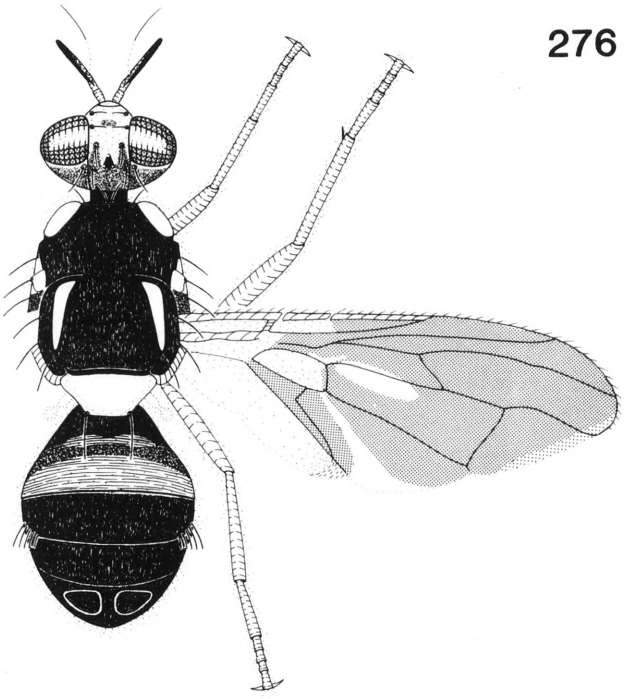


FIG. 275. *Bactrocera* (*Bactrocera*) *penefurva* n. sp., adult male (x14). FIG. 276. *Bactrocera* (*Bactrocera*) *pepisalae* (Froggatt), adult male (x6).

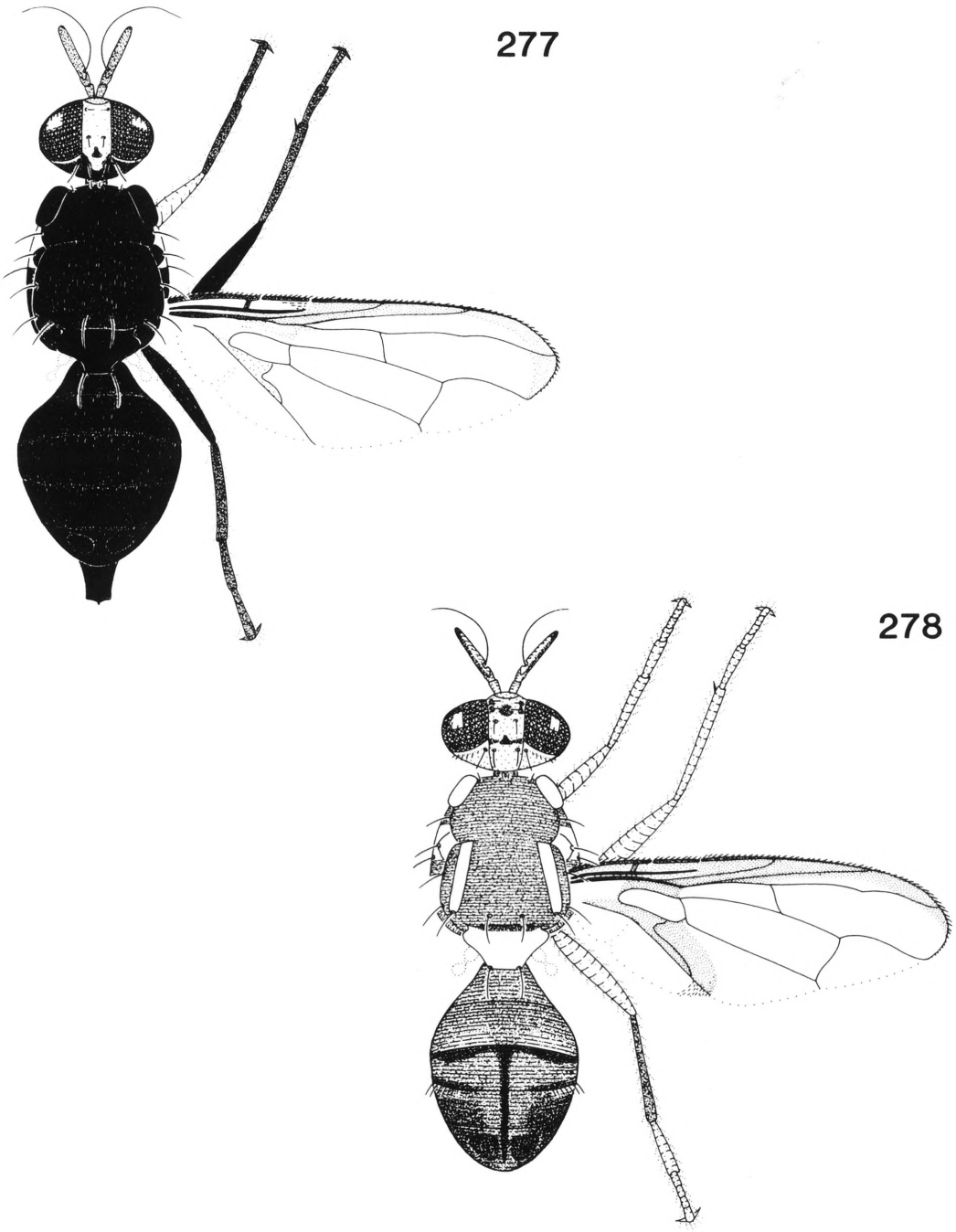
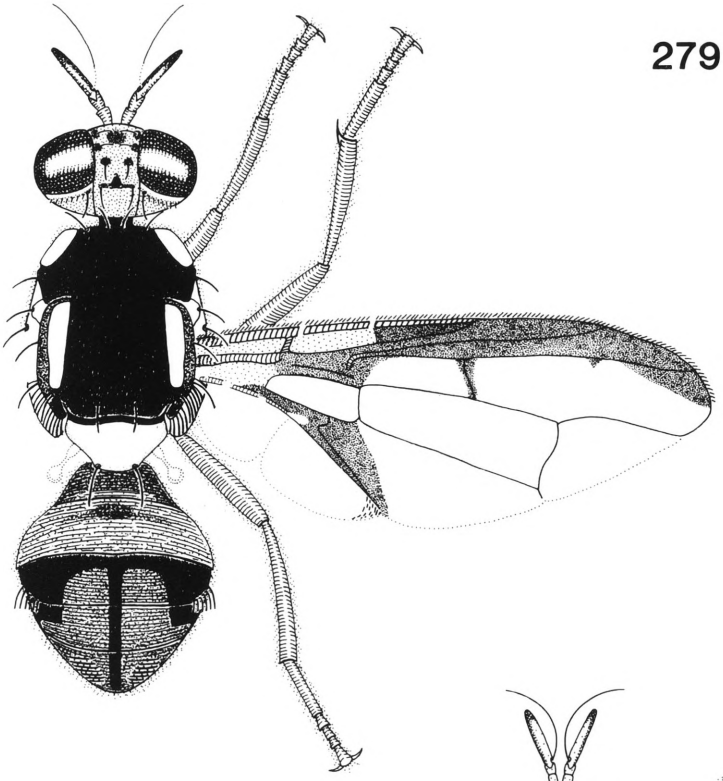


FIG. 277. *Bactrocera* (*Bactrocera*) *perfusca* (Aubertin), adult female (x8). FIG. 278. *Bactrocera* (*Bactrocera*) *perkinsi* (Drew and Hancock), adult male (x8).



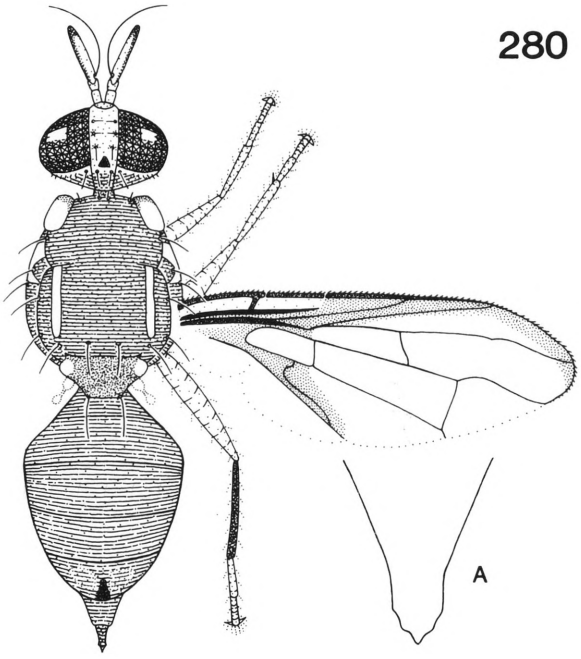


FIG. 279. *Bactrocera* (*Bactrocera*) *phaea* (Drew), adult male (x10). FIG. 280. *Bactrocera* (*Bactrocera*) *phaleriae* (May), adult female (x10). A, apex of aculeus.

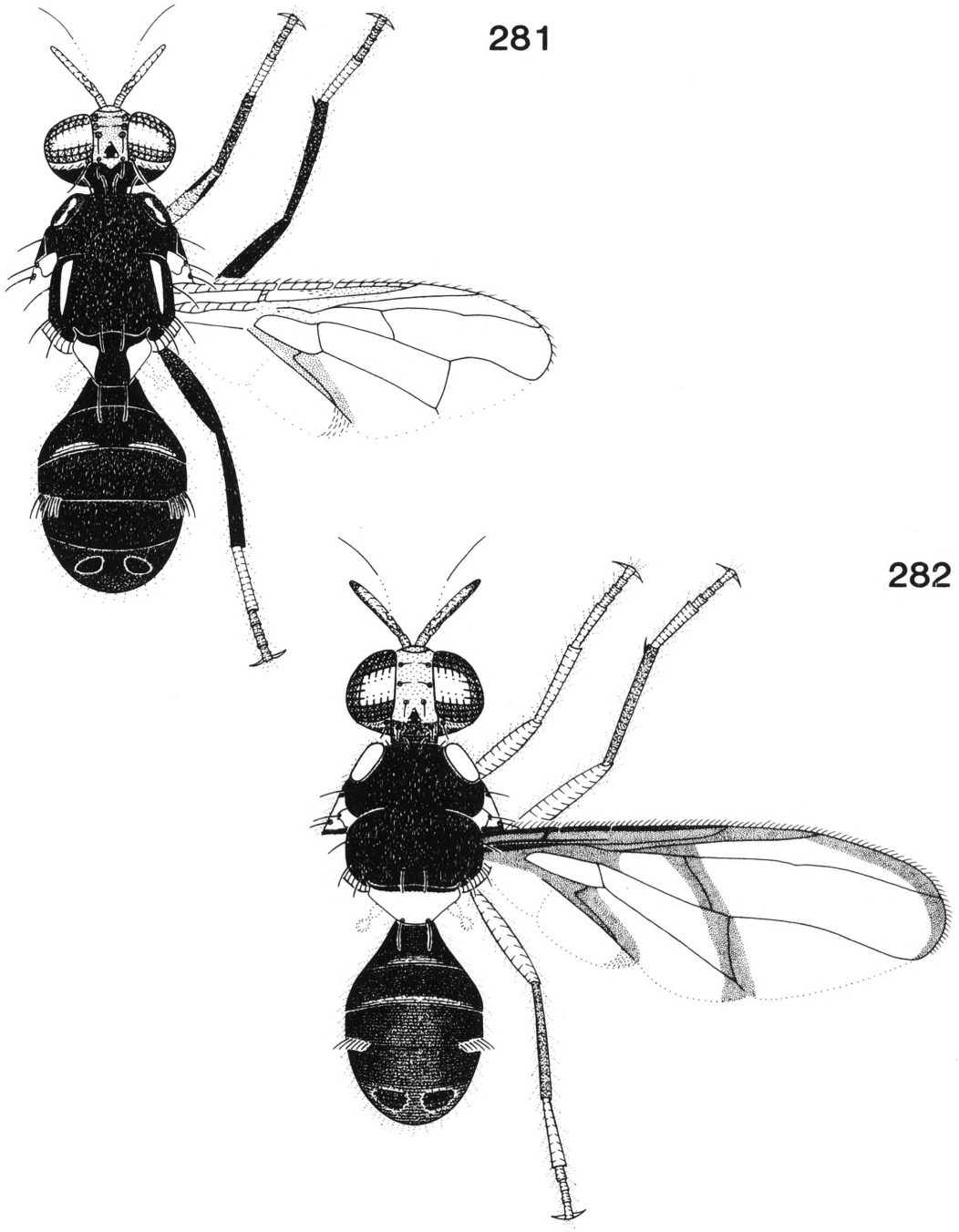
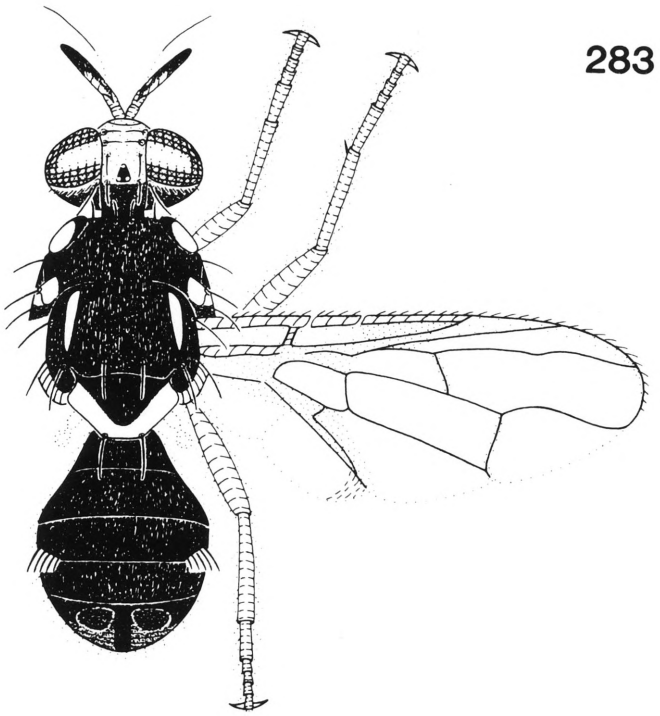
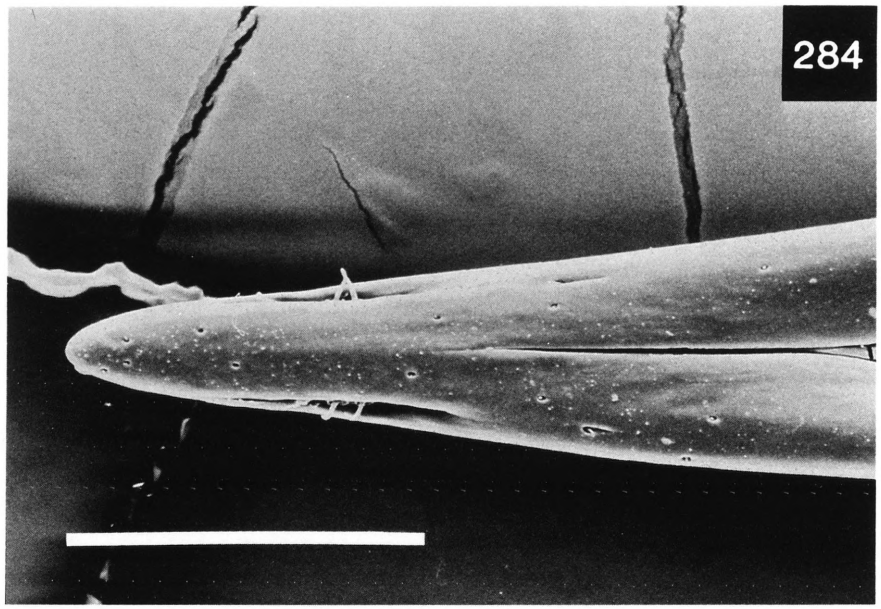
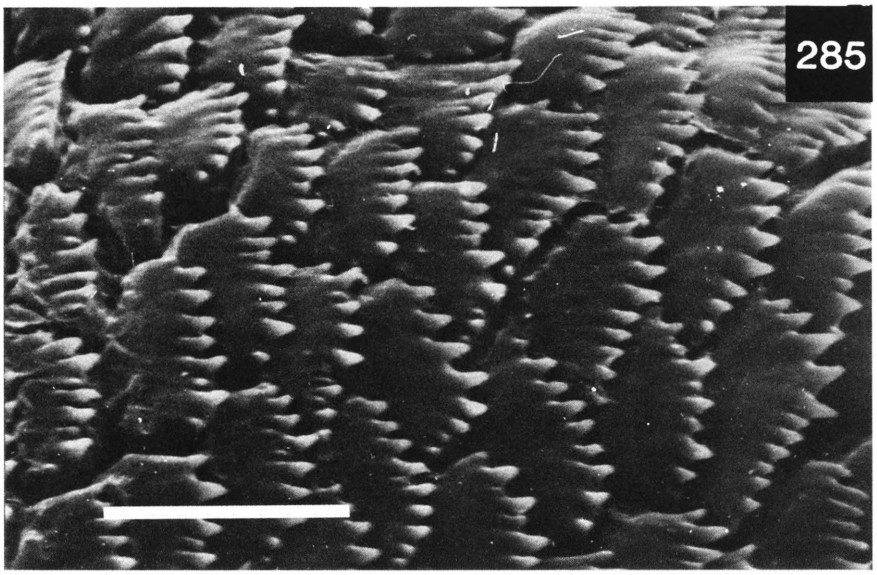


FIG. 281. *Bactrocera* (*Bactrocera*) *picea* (Drew), adult male (x11). FIG. 282. *Bactrocera* (*Bactrocera*) *pisinna* n. sp., adult male (x19).





FIGS 283–284. *Bactrocera* (*Bactrocera*) *psidii* (Froggatt): 283, adult male (x11); 284, apex of aculeus (scale 0.1 mm).



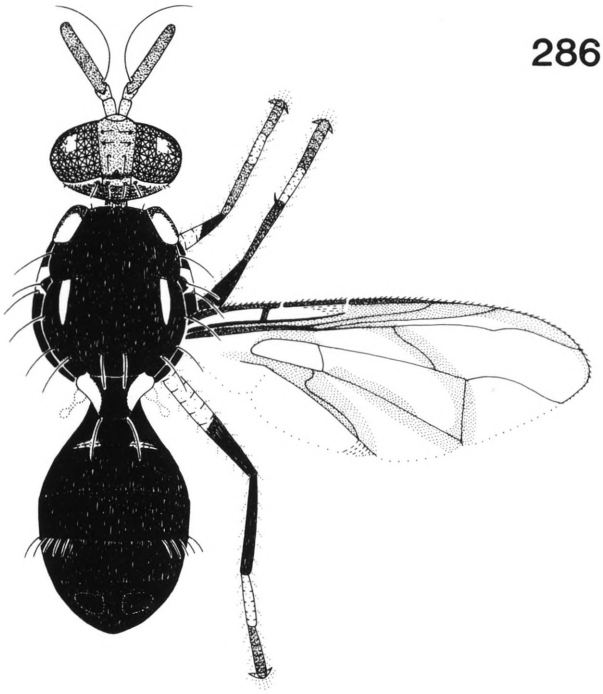


FIG. 285. *Bactrocera* (*Bactrocera*) *psidii* (Froggatt), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 286. *Bactrocera* (*Bactrocera*) *reclinata* n. sp., adult male (x8).

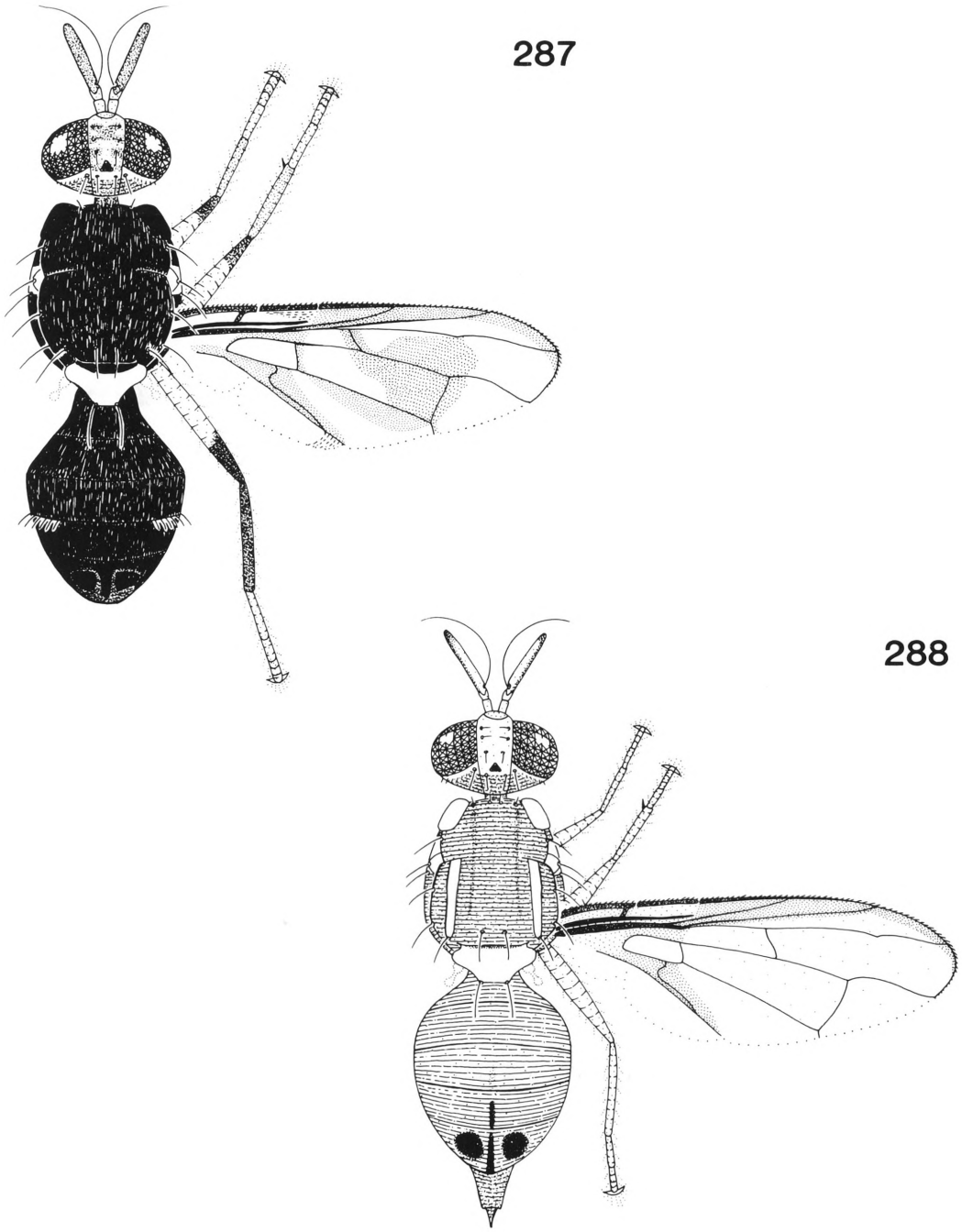
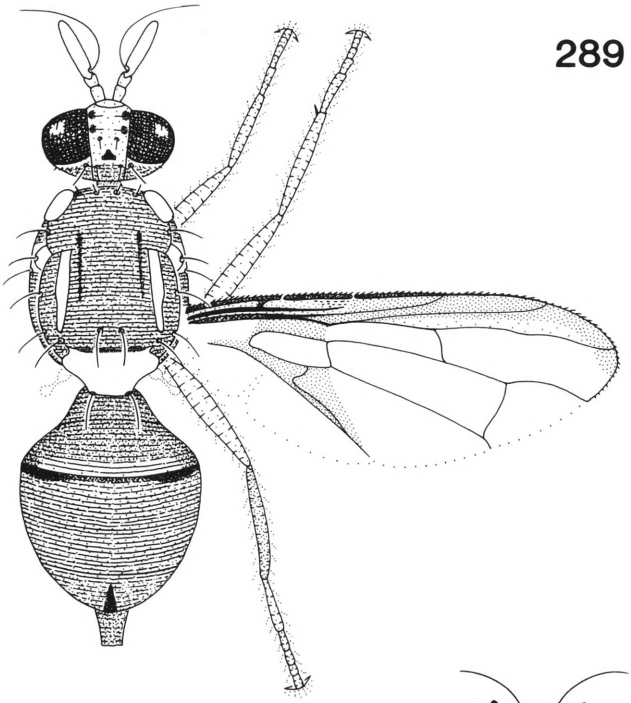


FIG. 287. *Bactrocera* (*Bactrocera*) *retrorsa* n. sp., adult male (x8). FIG. 288. *Bactrocera* (*Bactrocera*) *robiginosa* (May), adult female (x9).



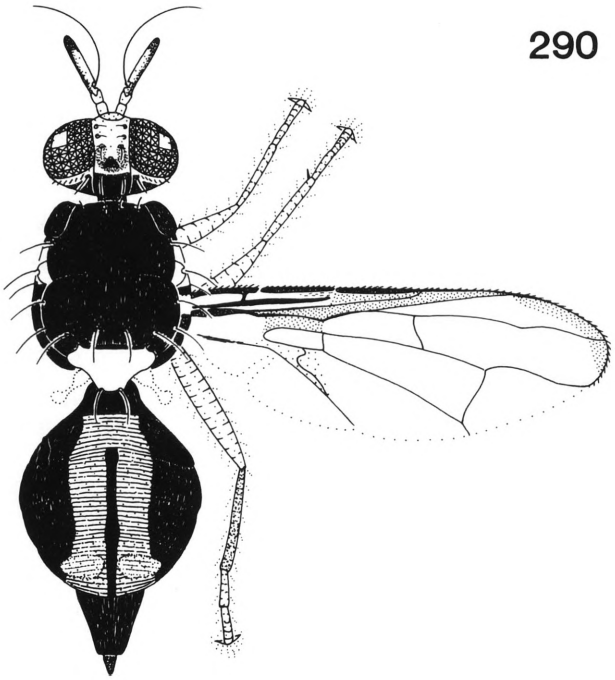


FIG. 289. *Bactrocera* (*Bactrocera*) *rutila* (Hering), adult female (x11). FIG. 290. *Bactrocera* (*Bactrocera*) *samoae* n. sp., adult female (x13).

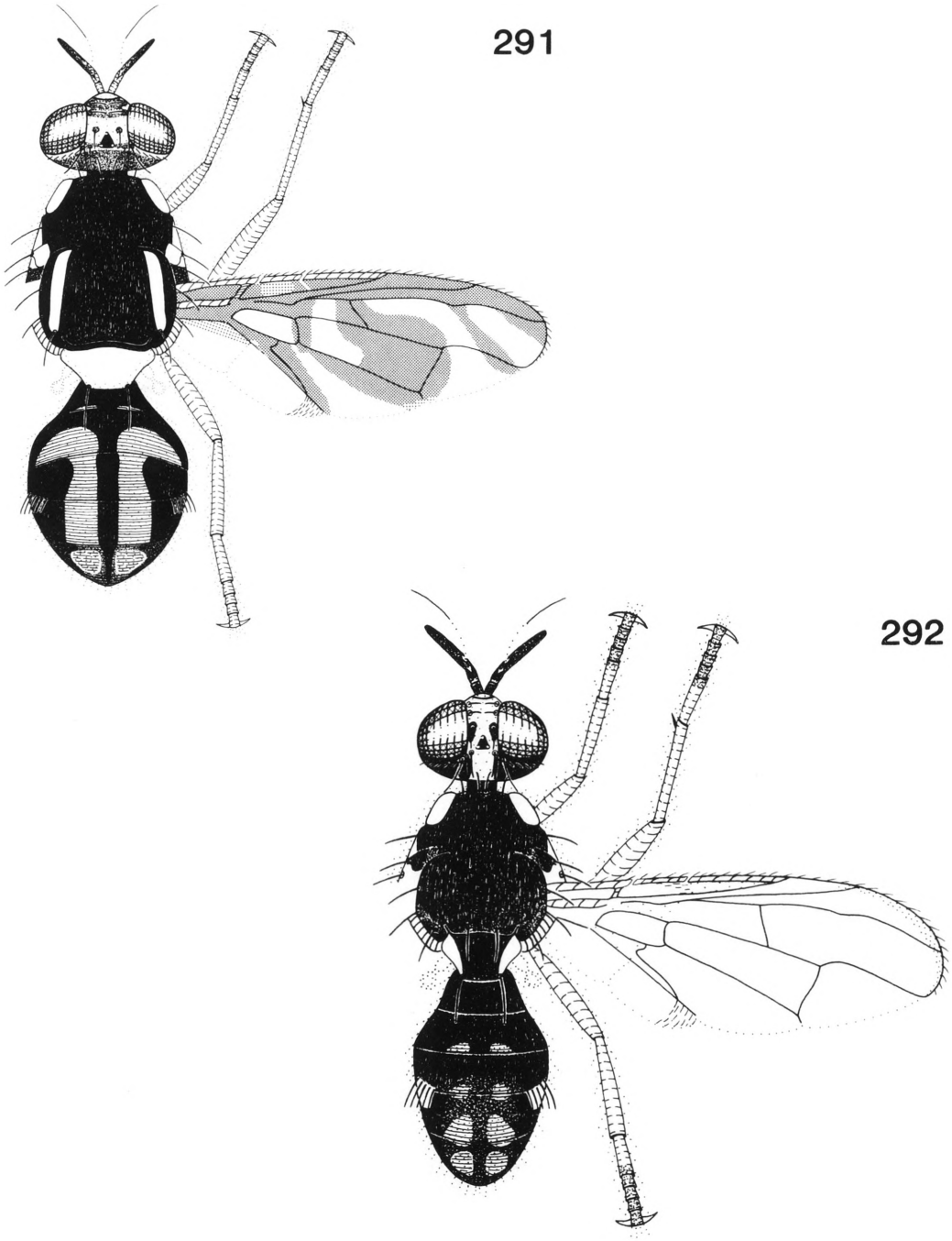
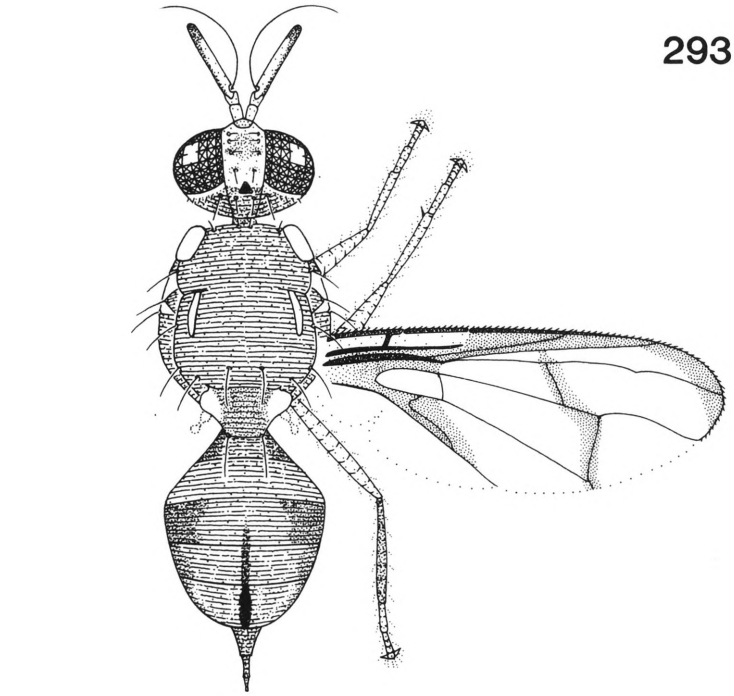
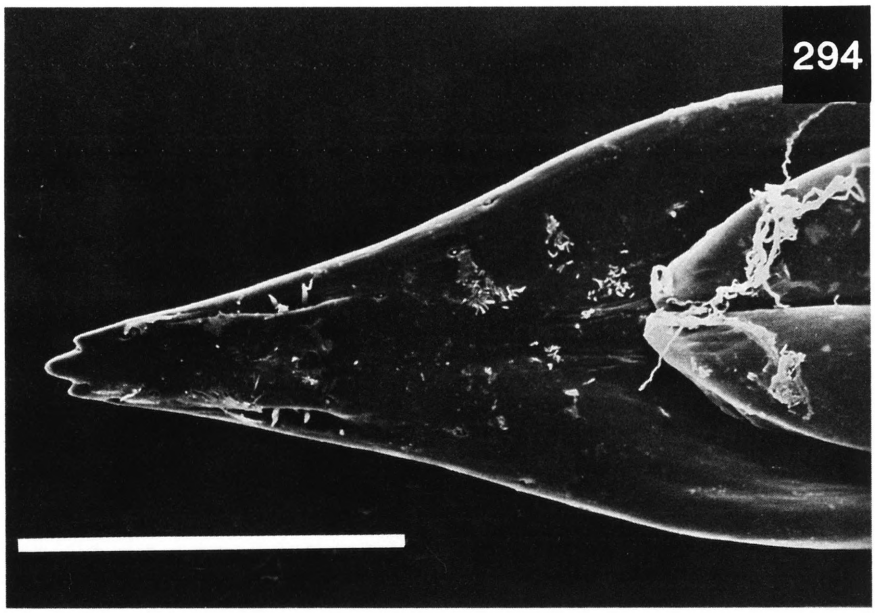
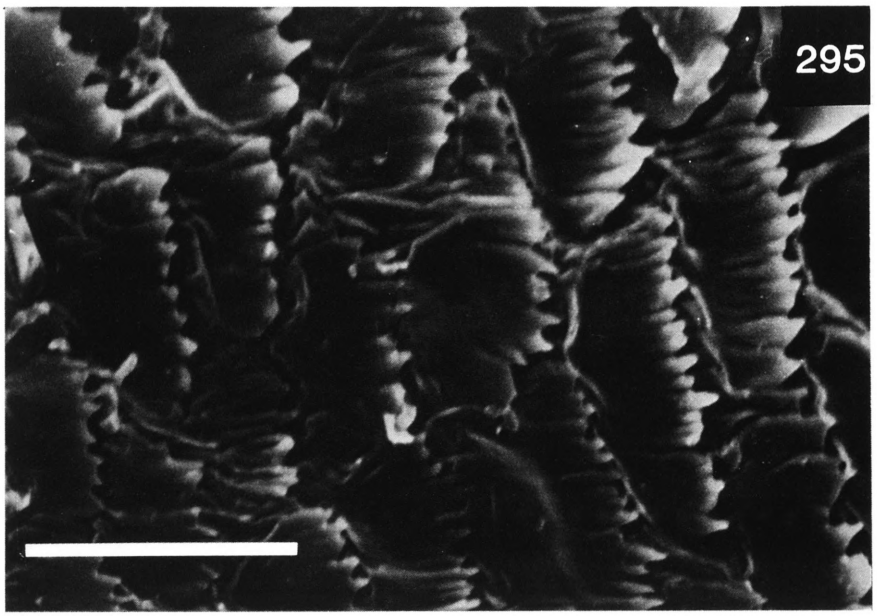


FIG. 291. *Bactrocera* (*Bactrocera*) *seguyi* (Hering), adult male (x7). FIG. 292. *Bactrocera* (*Bactrocera*) *setinervis* (Malloch), adult male (x10).





FIGS 293–294. *Bactrocera* (*Bactrocera*) *strigata* (Perkins): 293, adult female (x10); 294, apex of aculeus (scale 0.1 mm).



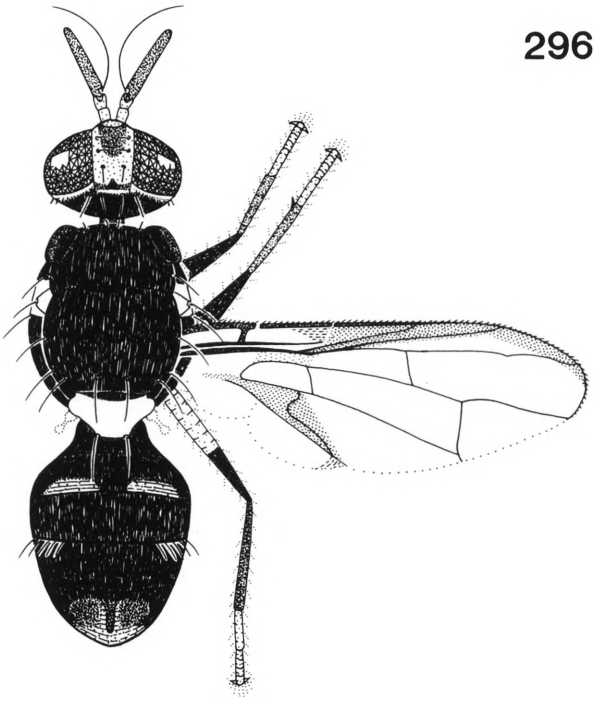


FIG. 295. *Bactrocera* (*Bactrocera*) *strigata* (Perkins), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 296. *Bactrocera* (*Bactrocera*) *thistletoni* n. sp., adult male (x10).

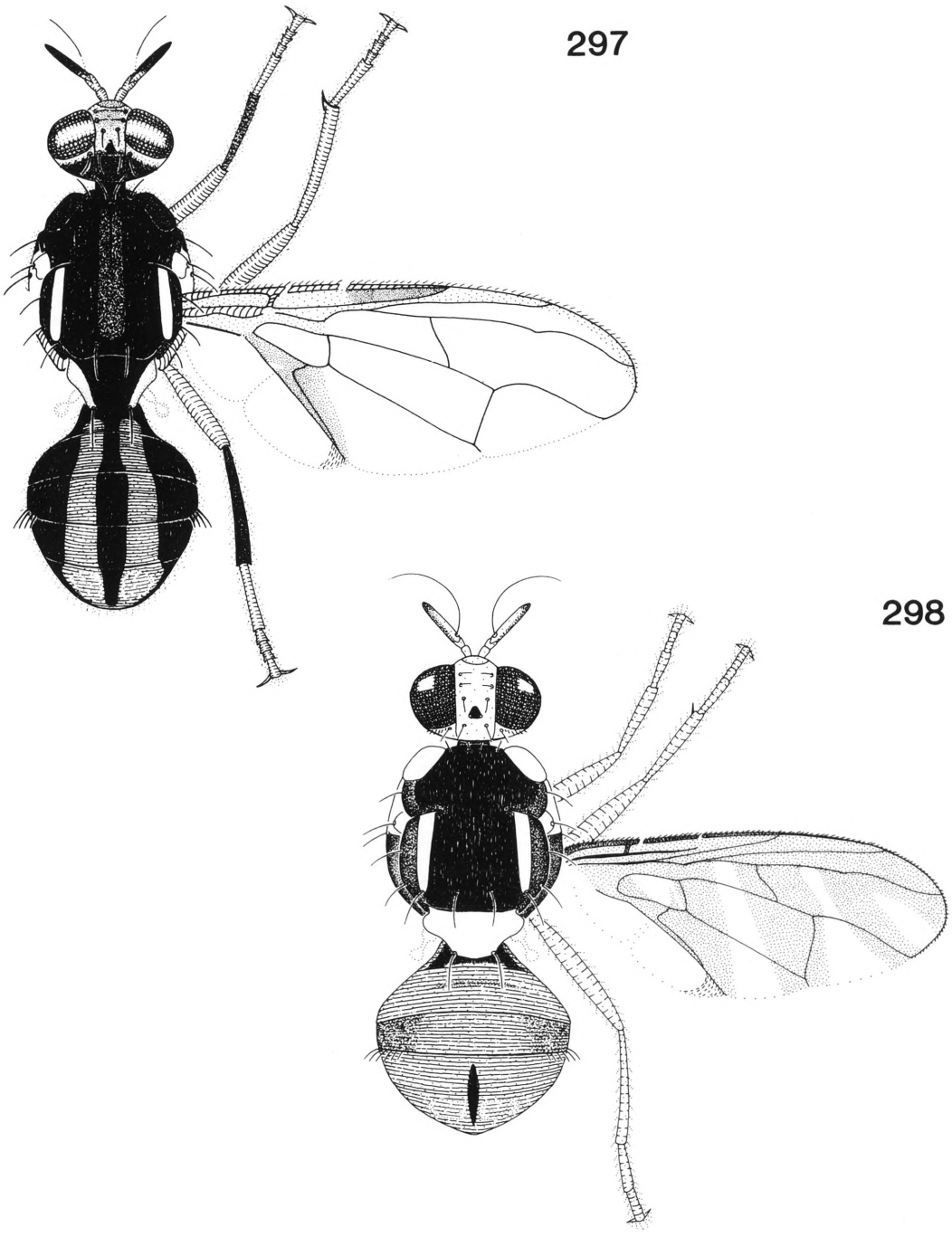
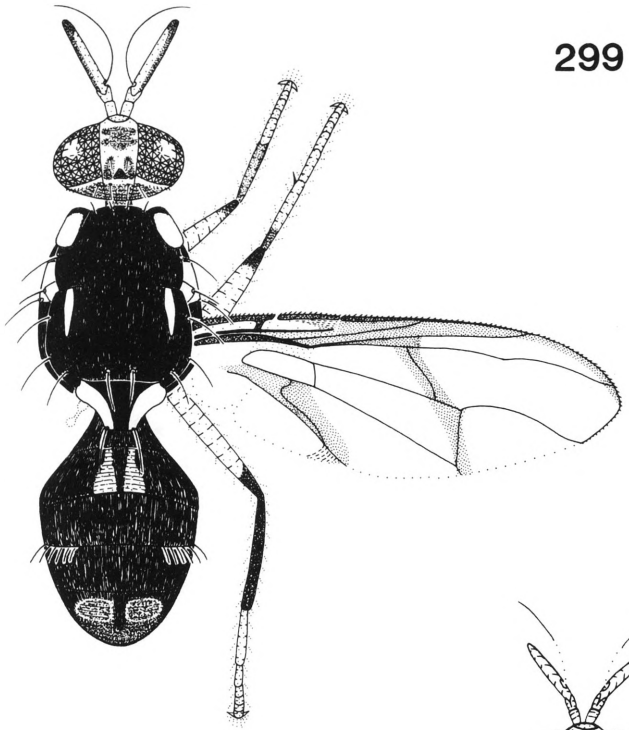


FIG. 297. *Bactrocera* (*Bactrocera*) *trifaria* (Drew), adult male (x12). FIG. 298. *Bactrocera* (*Bactrocera*) *umbrosa* (Fabricius), adult male (x9).



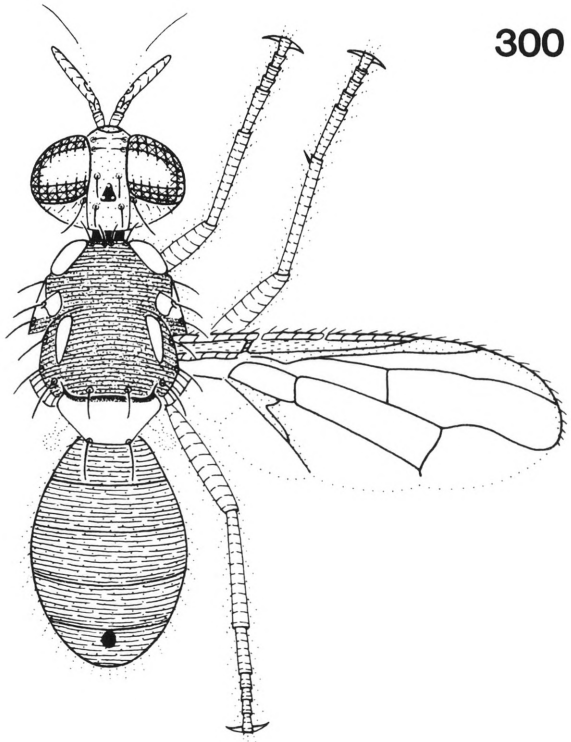
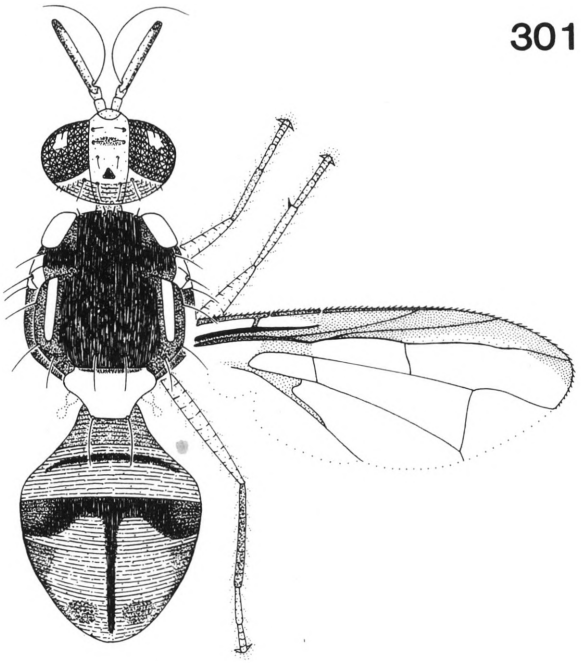
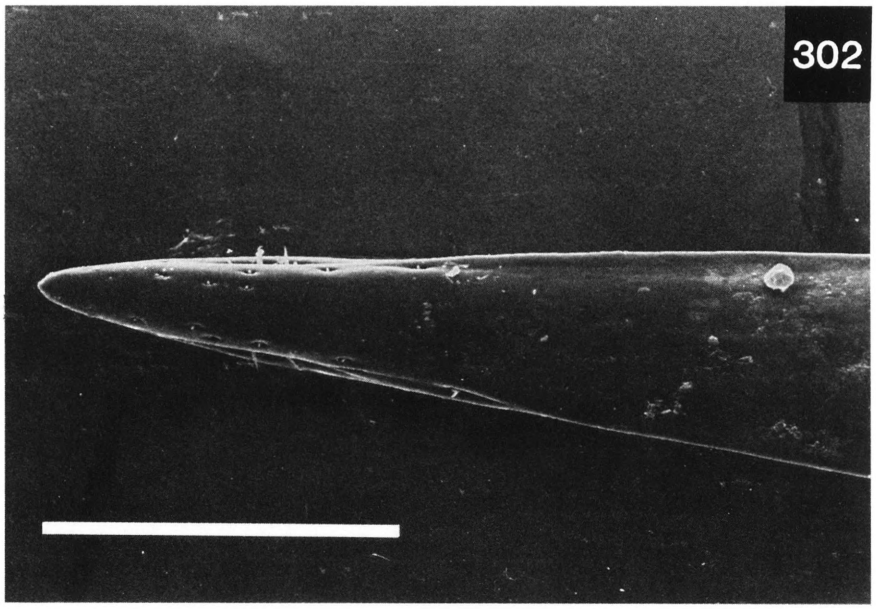
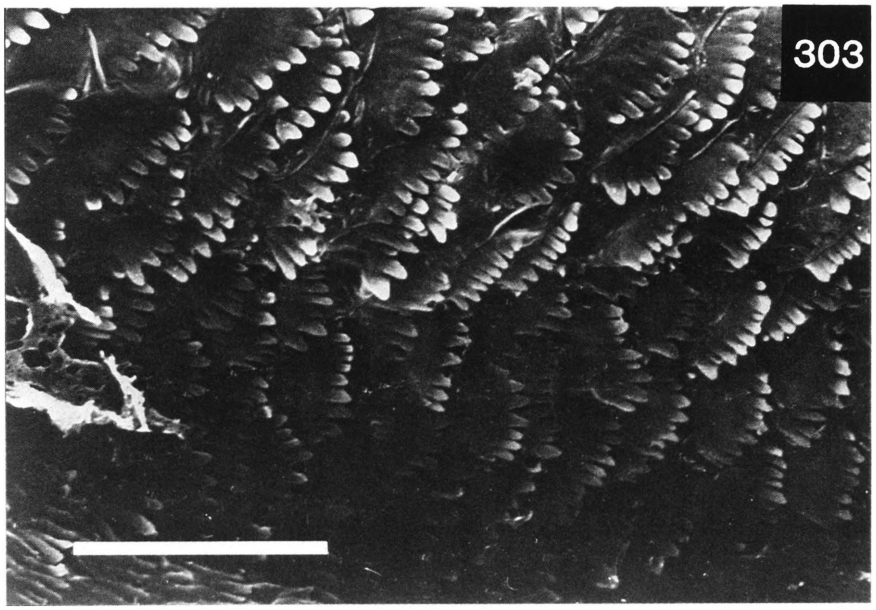


FIG. 299. *Bactrocera* (*Bactrocera*) *unilineata* n. sp., adult male (x10). FIG. 300. *Bactrocera* (*Bactrocera*) *unipunctata* (Malloch), adult male (x14).





FIGS 301–302. *Bactrocera* (*Gymnodacus*) *calophylli* (Perkins and May): 301, adult male (x12); 302, apex of aculeus (scale 0.1 mm).



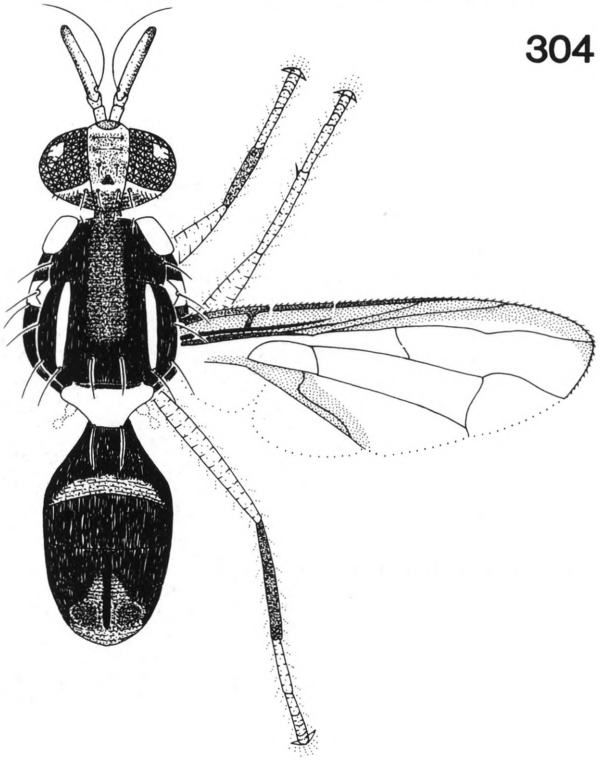
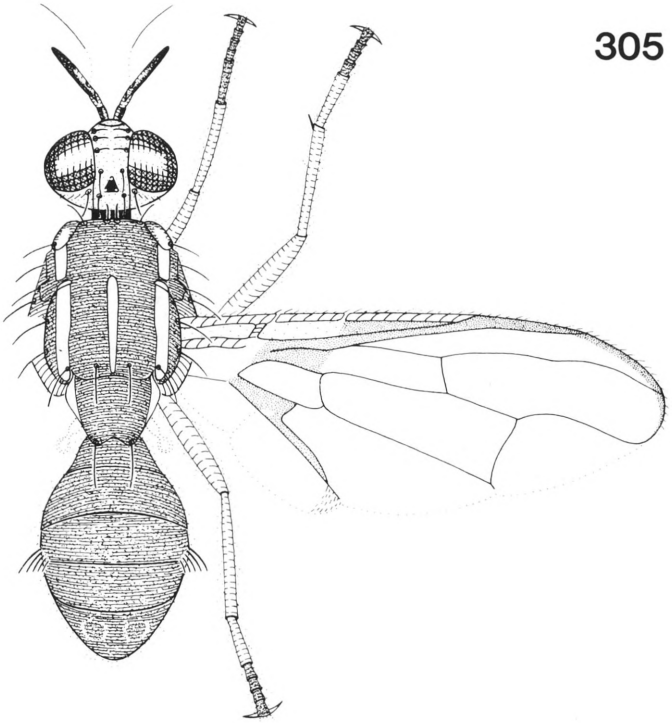
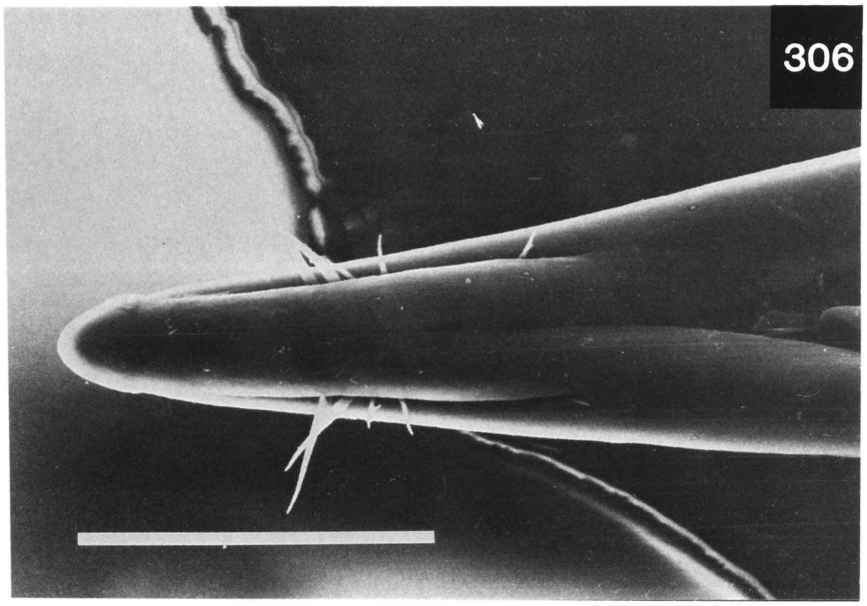
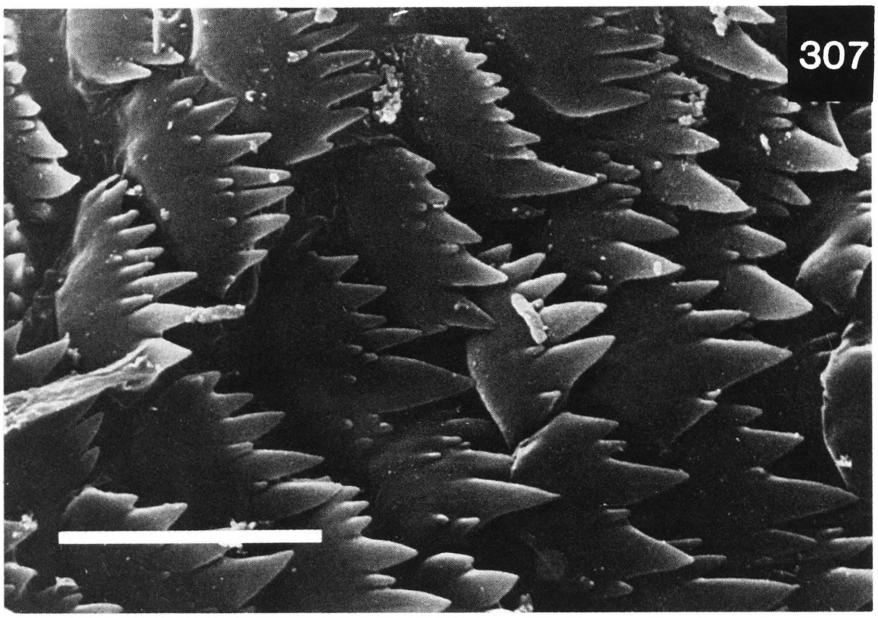


FIG. 303. *Bactrocera* (*Gymnodacus*) *calophylli* (Perkins and May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 304. *Bactrocera* (*Gymnodacus*) *petila* n. sp., adult male (x10).





FIGS 305–306. *Bactrocera* (*Notodacus*) *xanthodes* (Broun): 305, adult male (x10); 306, apex of aculeus (scale 0.1 mm).



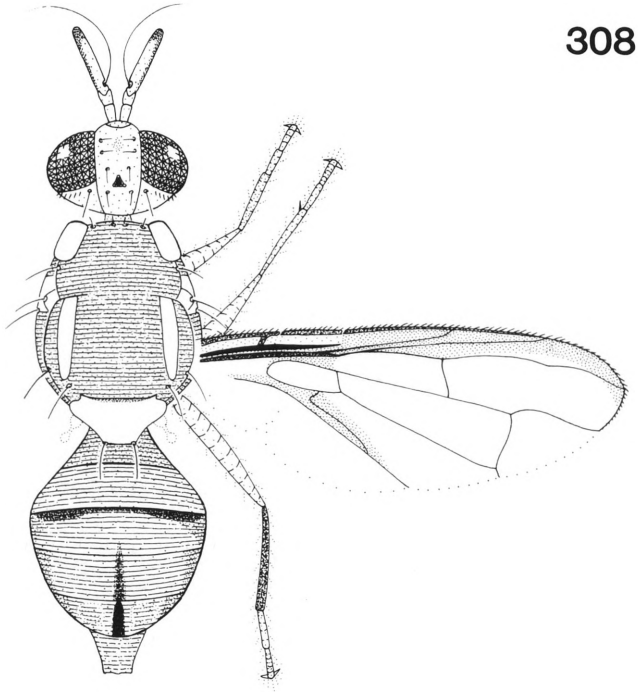
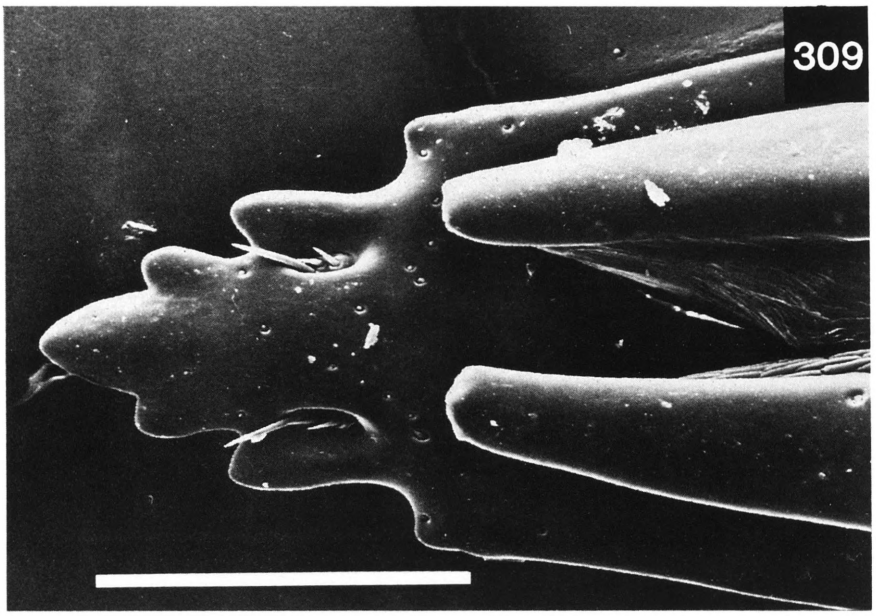
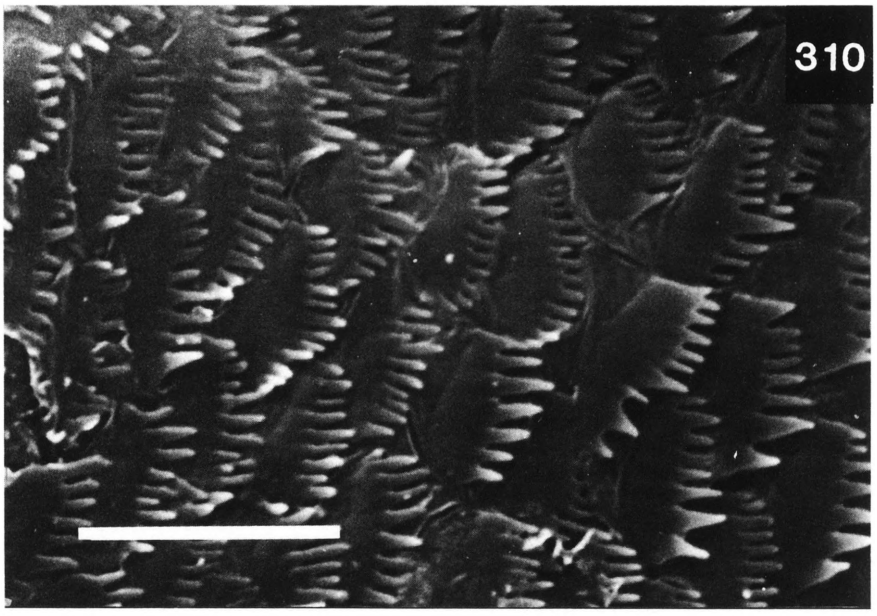
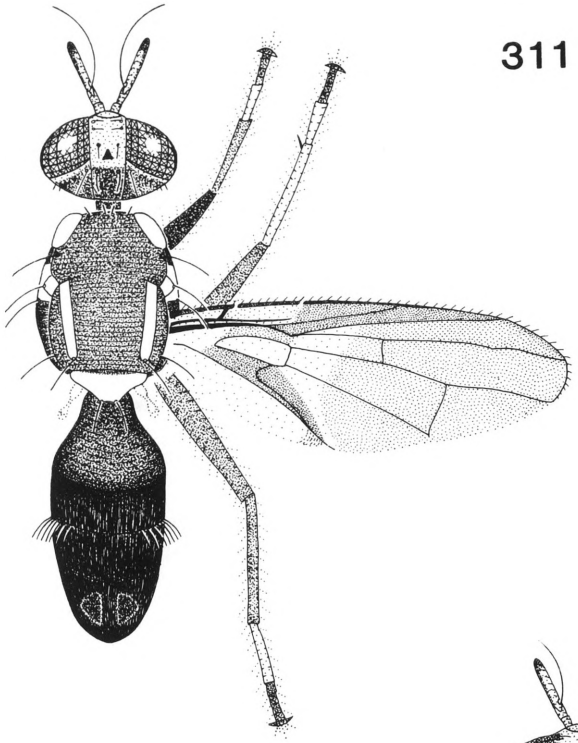


FIG. 307. *Bactrocera* (*Notodacus*) *xanthodes* (Broun), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 308. *Bactrocera* (*Polistomimetes*) *decurtans* (May), adult female (x10).





FIGS 309–310. *Bactrocera* (*Polistomimetes*) *decurtans* (May): 309, apex of aculeus (scale 0.1 mm); 310, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



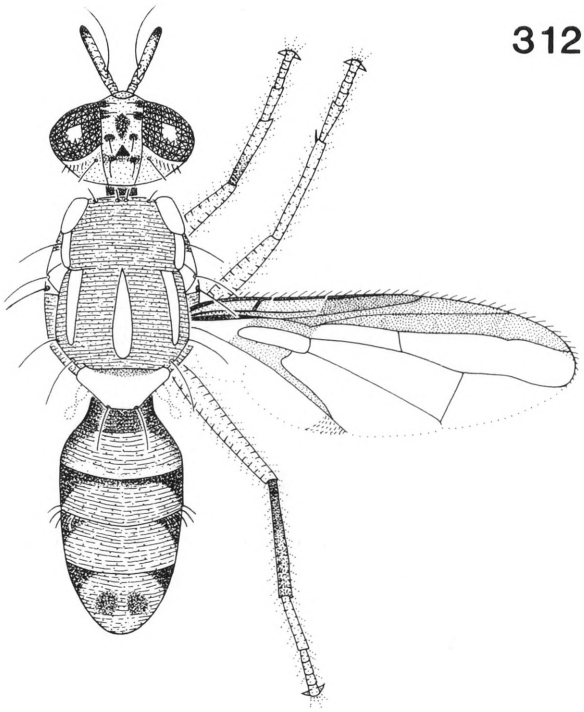
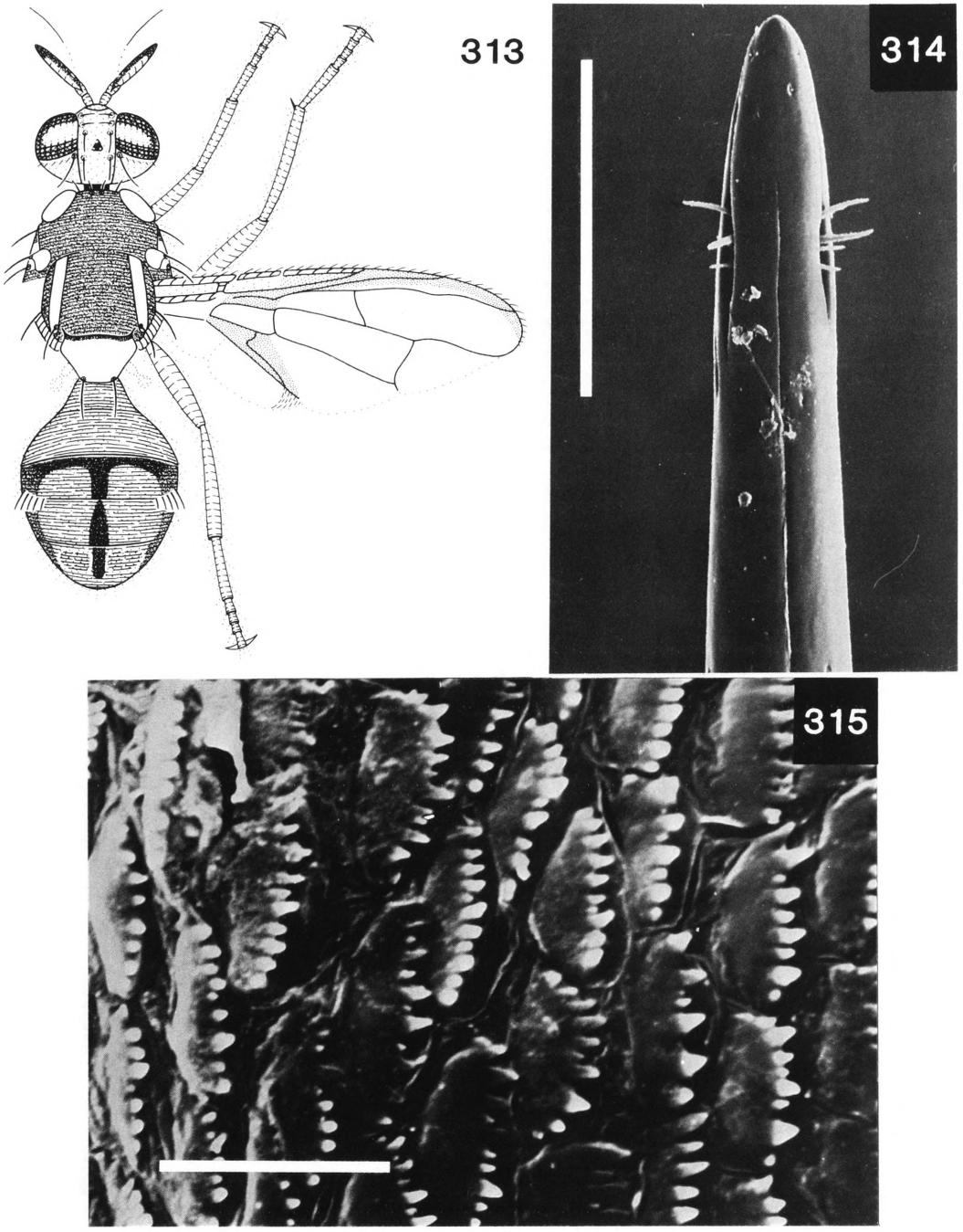


FIG. 311. *Bactrocera* (*Polistomimetes*) *fuscalata* n. sp., adult male (x9). FIG. 312. *Bactrocera* (*Polistomimetes*) *mesonotochra* n. sp., adult male (x8).



FIGS 313–315. *Bactrocera* (*Polistomimetes*) *murrayi* (Perkins): 313, adult male (x8); 314, apex of aculeus (scale 0.1 mm); 315, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

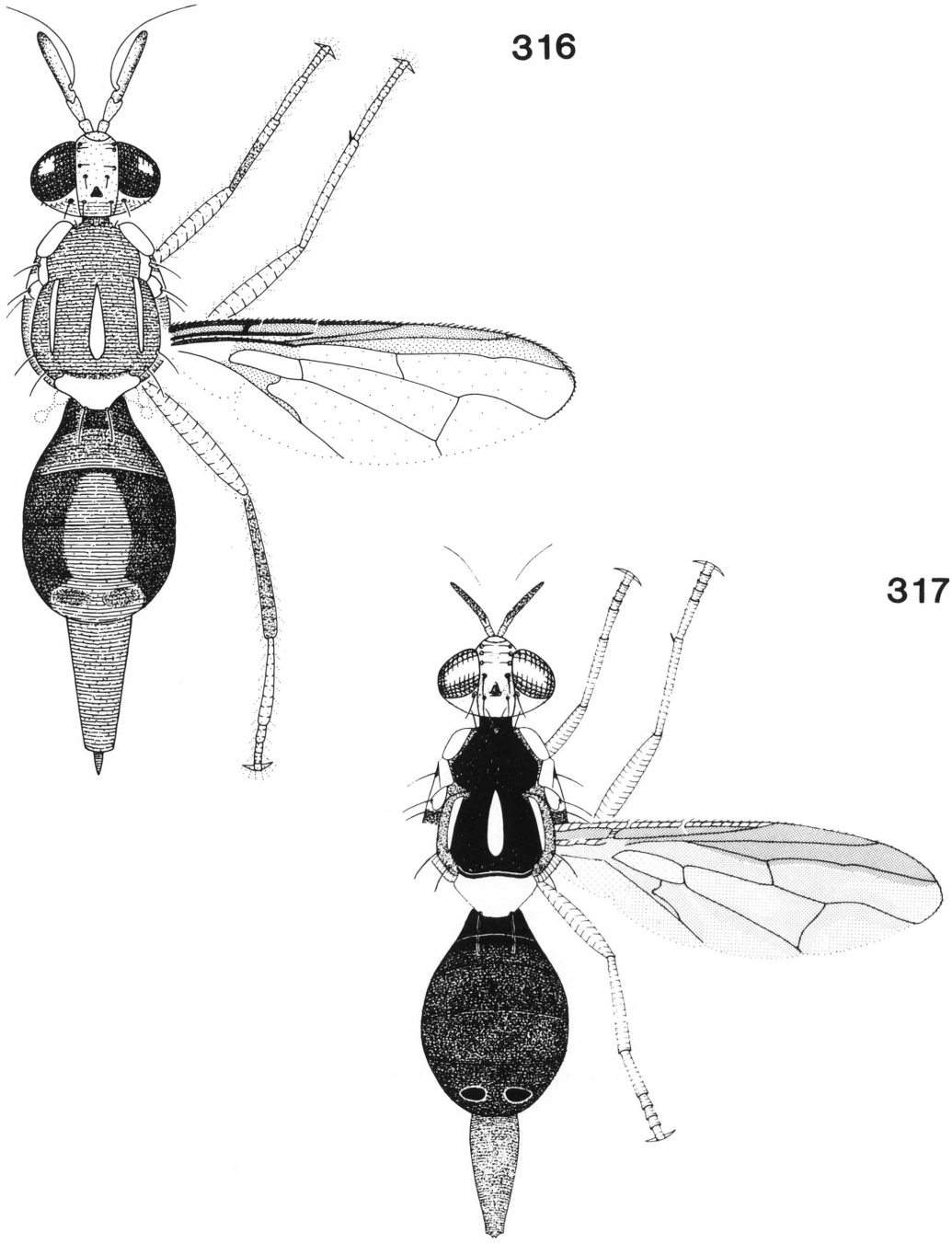


FIG. 316. *Bactrocera* (*Polistomimetes*) *neopagdeni* n. sp., adult female (x9). FIG. 317. *Bactrocera* (*Polistomimetes*) *pagdeni* (Malloch), adult female (x8).

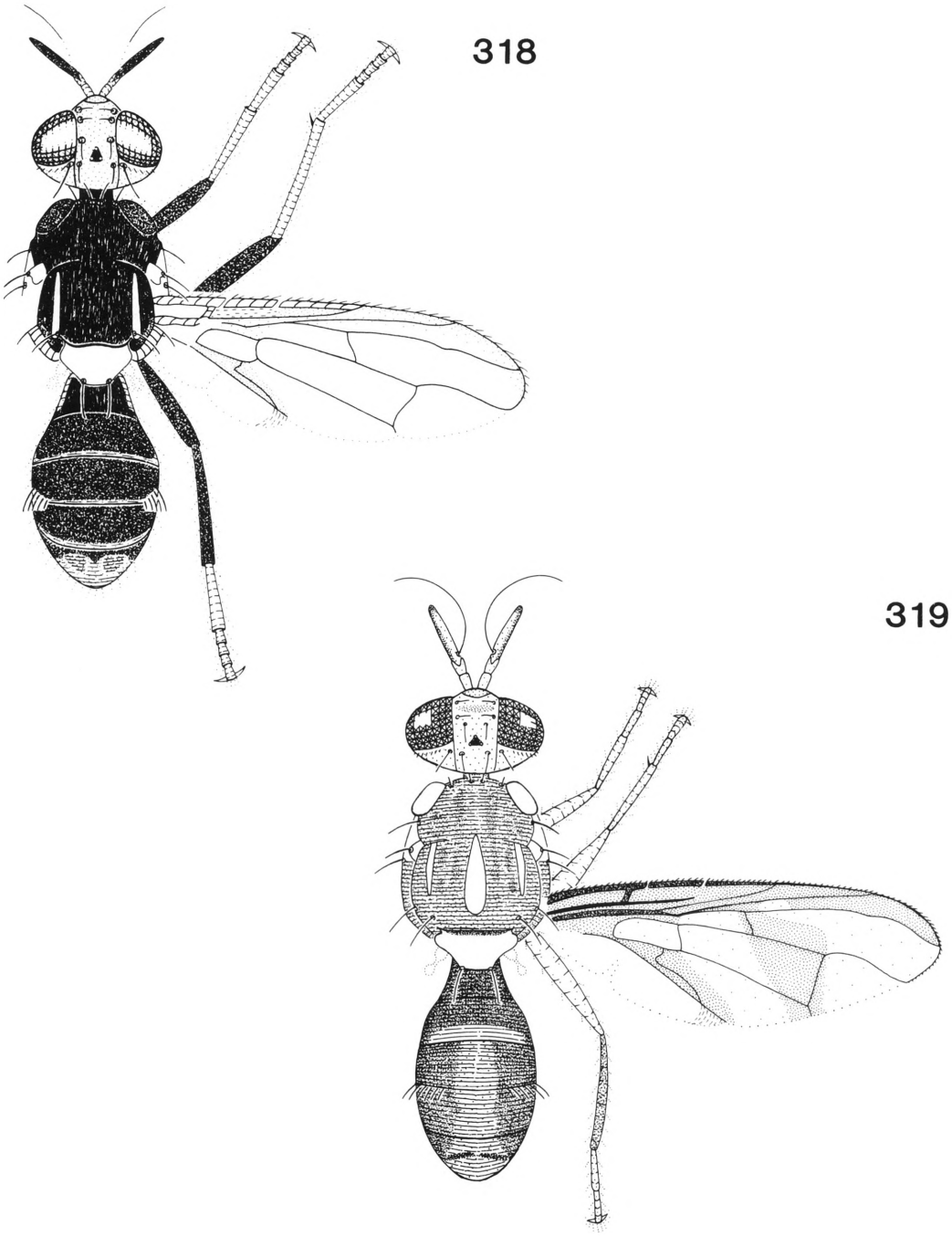
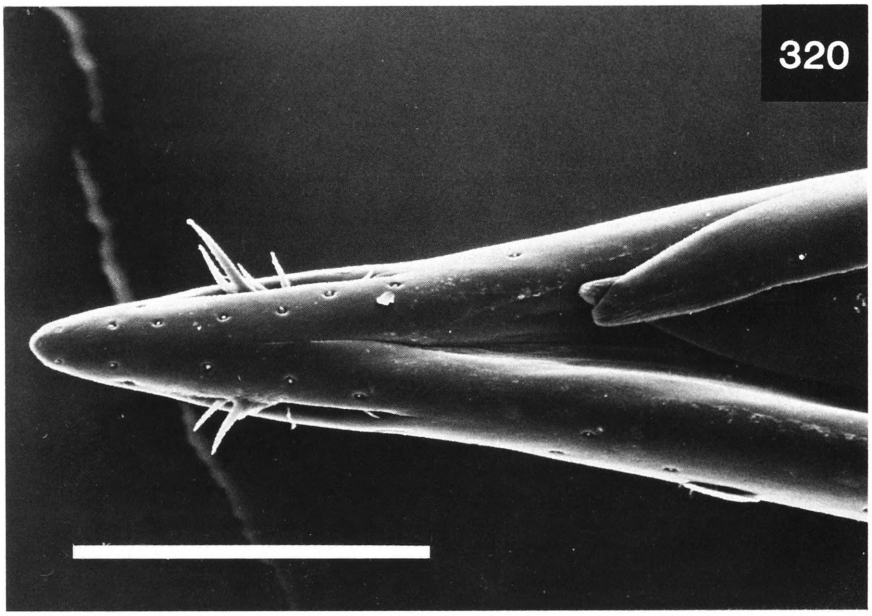
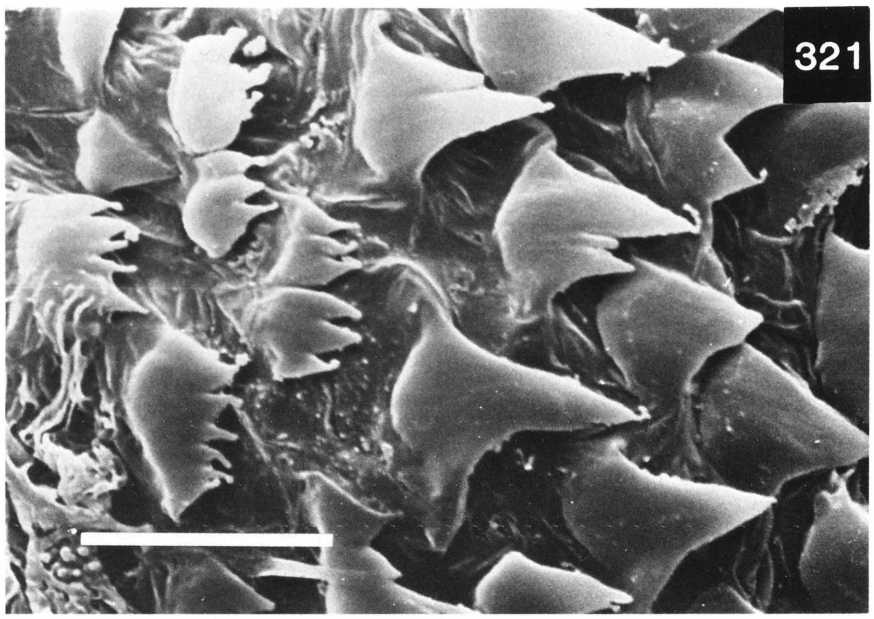


FIG. 318. *Bactrocera* (*Polistomimetes*) *toxopeusi* (Hering), adult male (x8). FIG. 319. *Bactrocera* (*Polistomimetes*) *visenda* (Hardy), adult male (x10).





FIGS 320–321. *Bactrocera* (*Polistomimetes*) *visenda* (Hardy): 320, apex of aculeus (scale 0.1 mm); 321, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

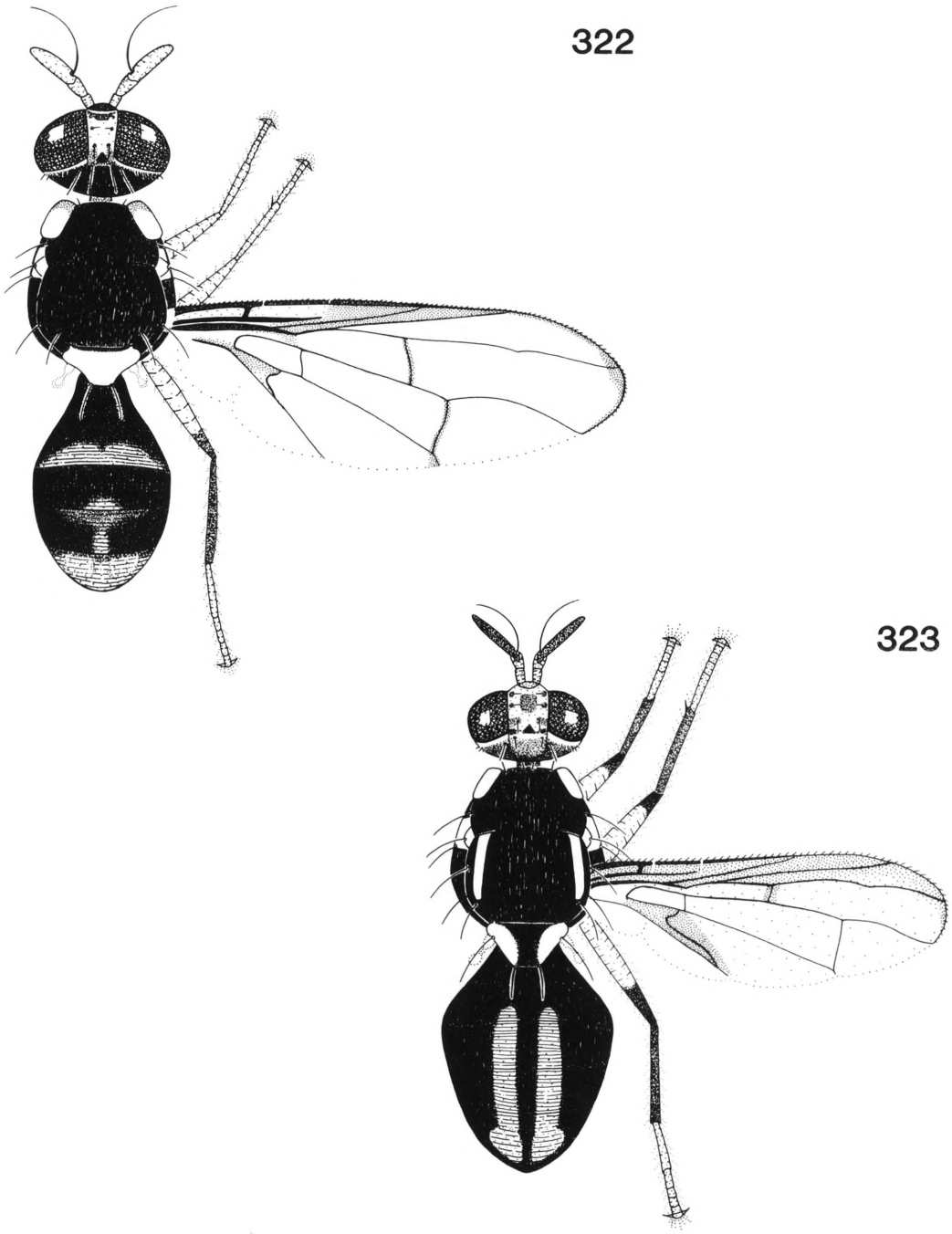
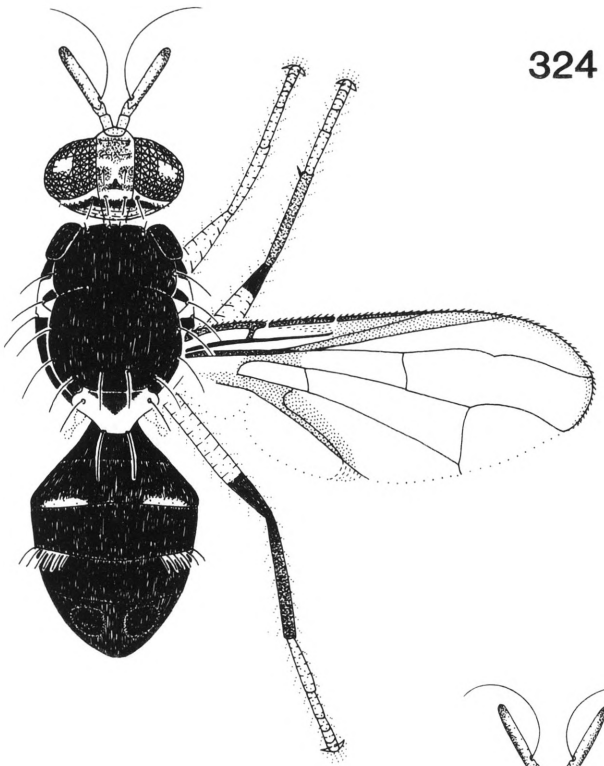


FIG. 322. *Bactrocera* (*Trypetidacus*) *invisitata* n. sp., adult male (x14). FIG. 323. *Bactrocera* (*Hemisurstylus*) *melanoscutata* n. sp., adult male (x7).



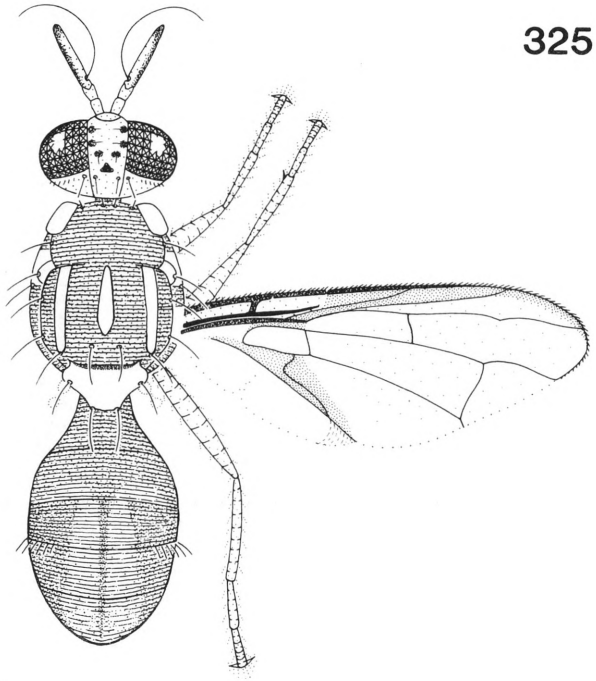
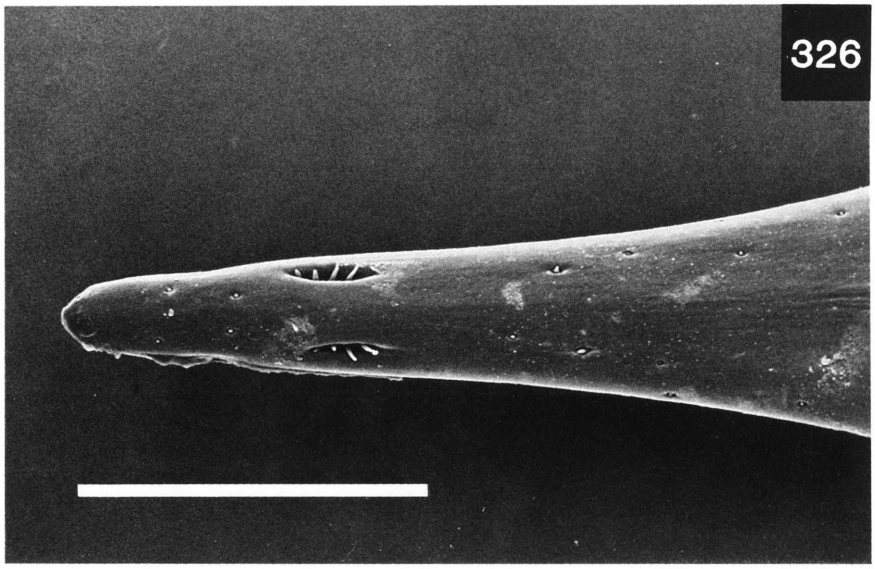
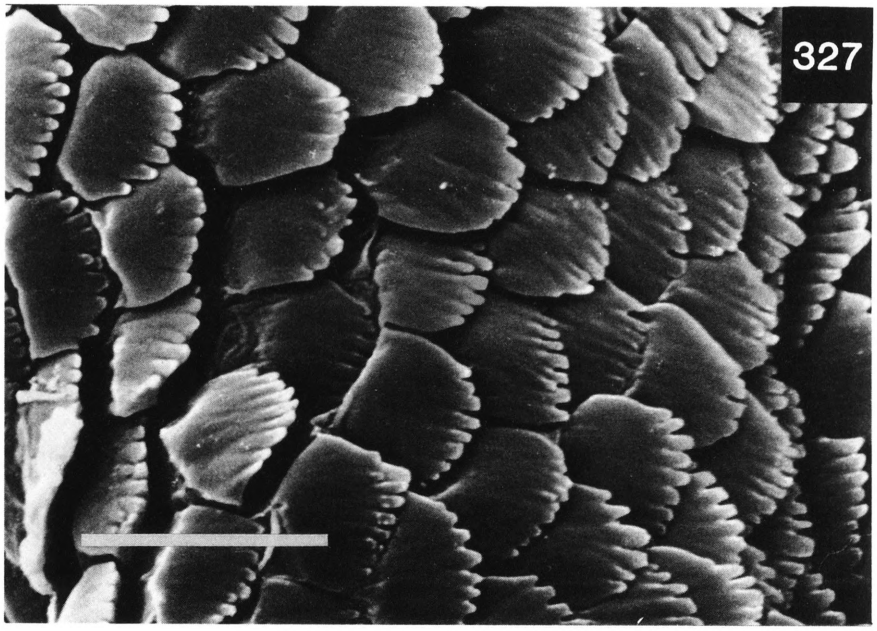
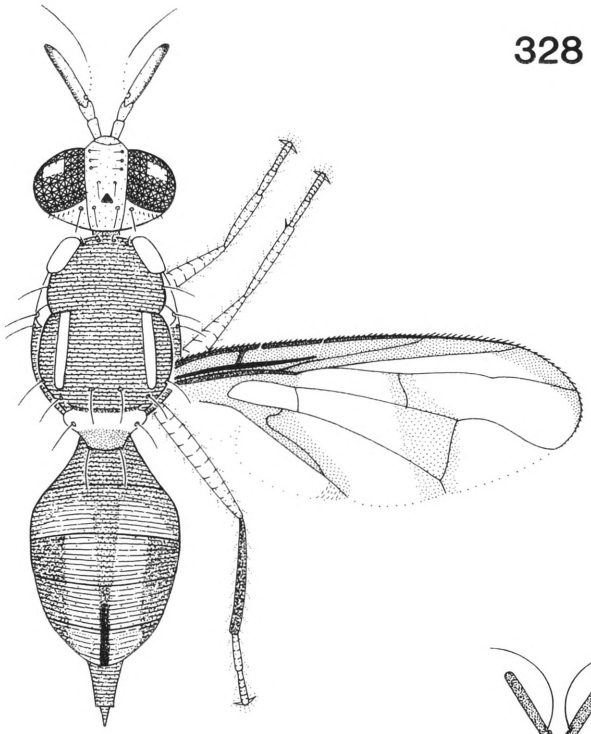


FIG. 324. *Bactrocera* (*Hemizeugodacus*) *abdomininigra* n. sp., adult male (x10). FIG. 325. *Bactrocera* (*Hemizeugodacus*) *aglaiae* (Hardy), adult male (x8).





FIGS 326–327. *Bactrocera* (*Hemizeugodacus*) *aglaiae* (Hardy): 326, apex of aculeus (scale 0.1 mm); 327, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



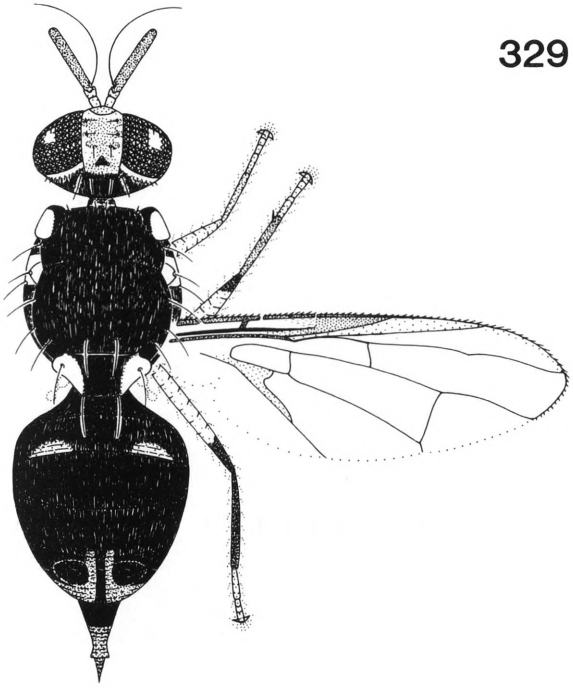
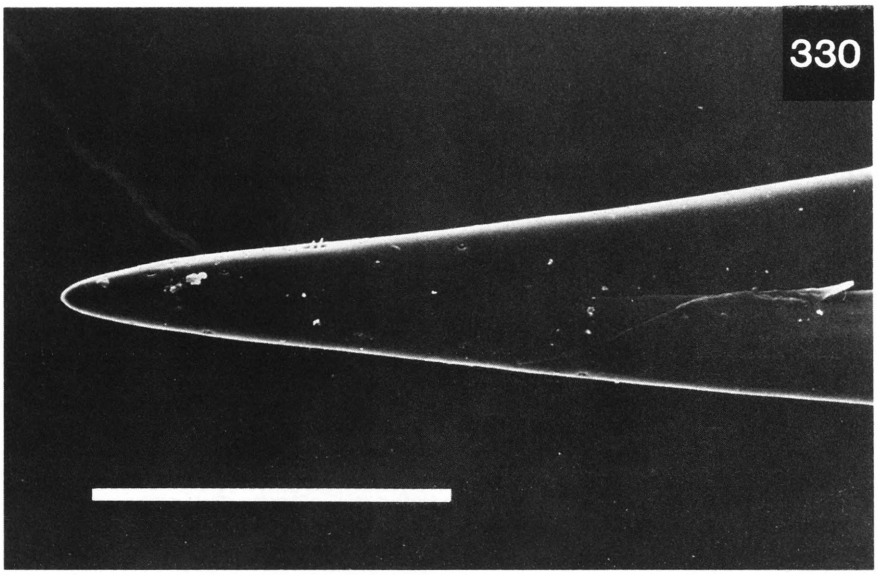
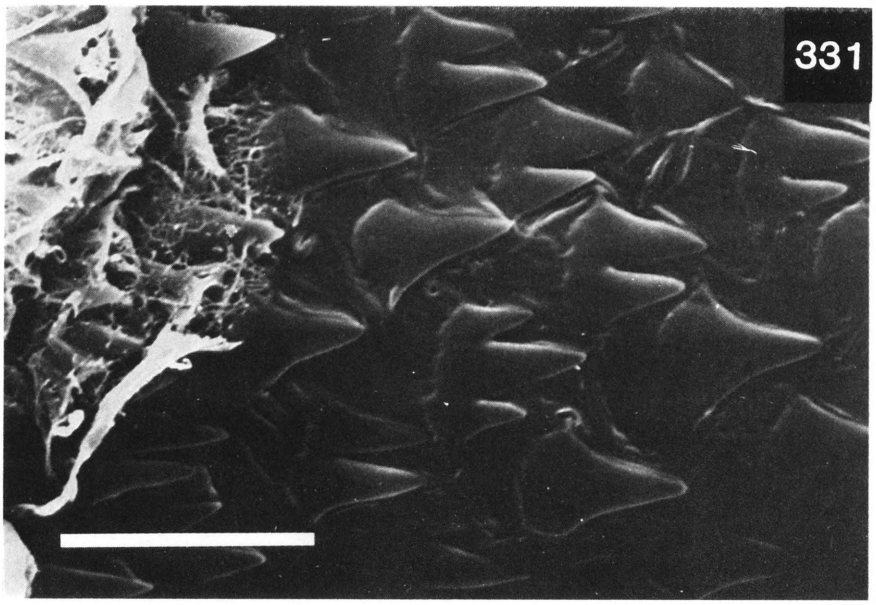


FIG. 328. *Bactrocera* (*Hemizeugodacus*) *aurea* (May), adult female (x10). FIG. 329. *Bactrocera* (*Melanodacus*) *nigra* (Tryon), adult female (x11).





FIGS 330–331. *Bactrocera* (*Melanodacus*) *nigra* (Tryon): 330, apex of aculeus (scale 0.1 mm); 331, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

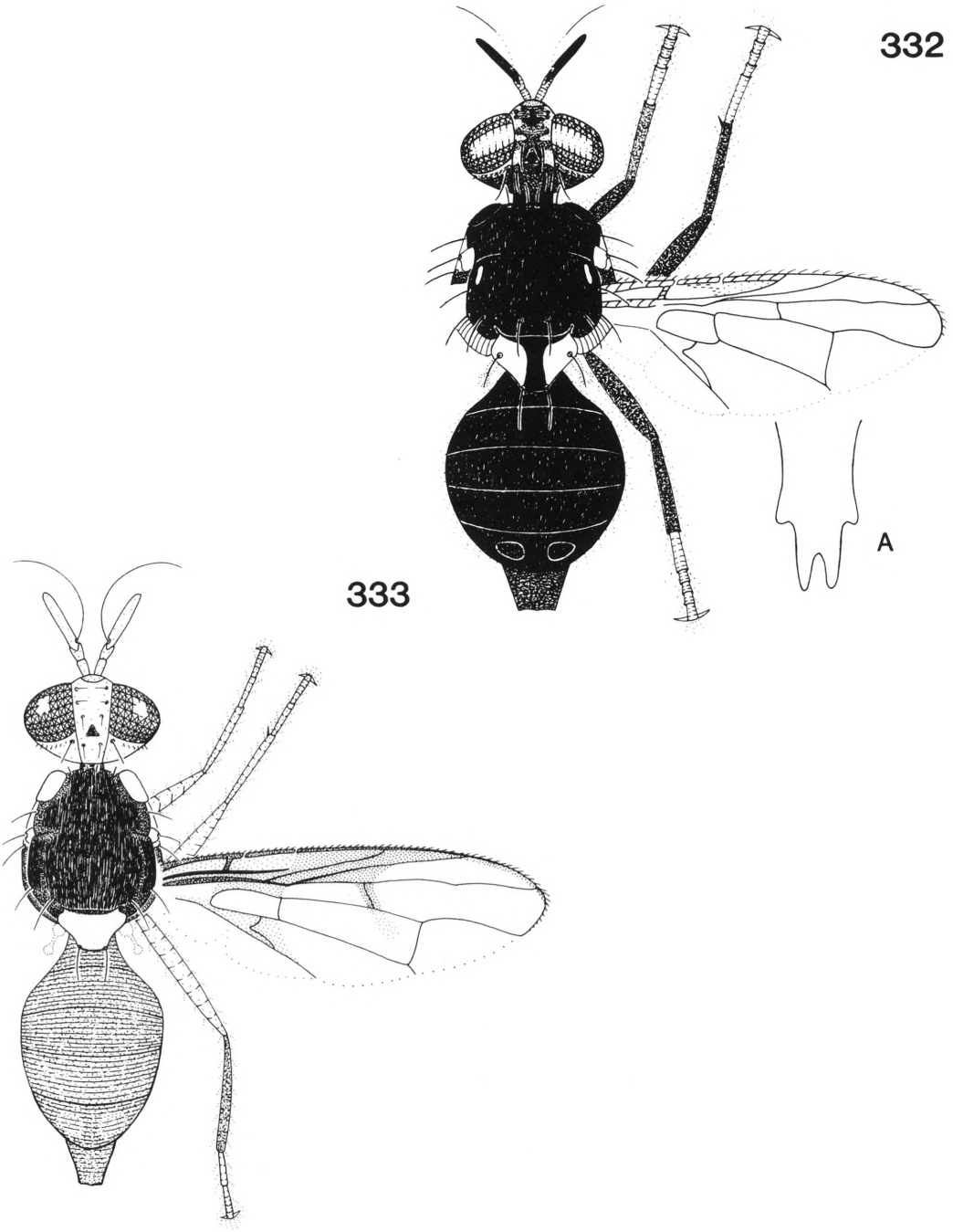
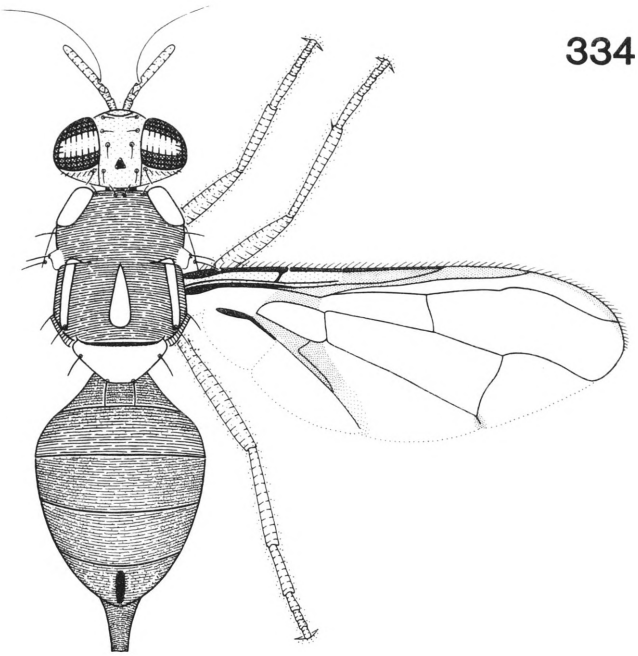
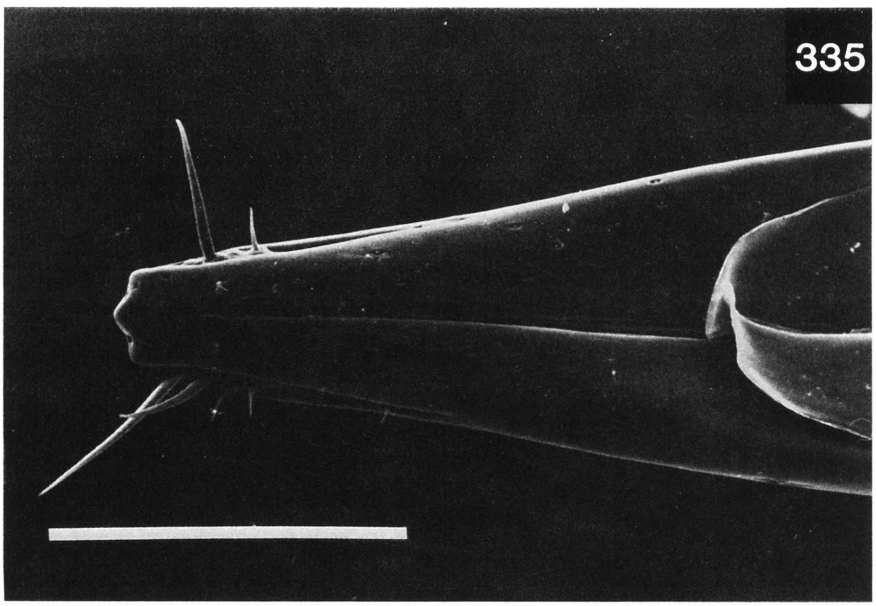
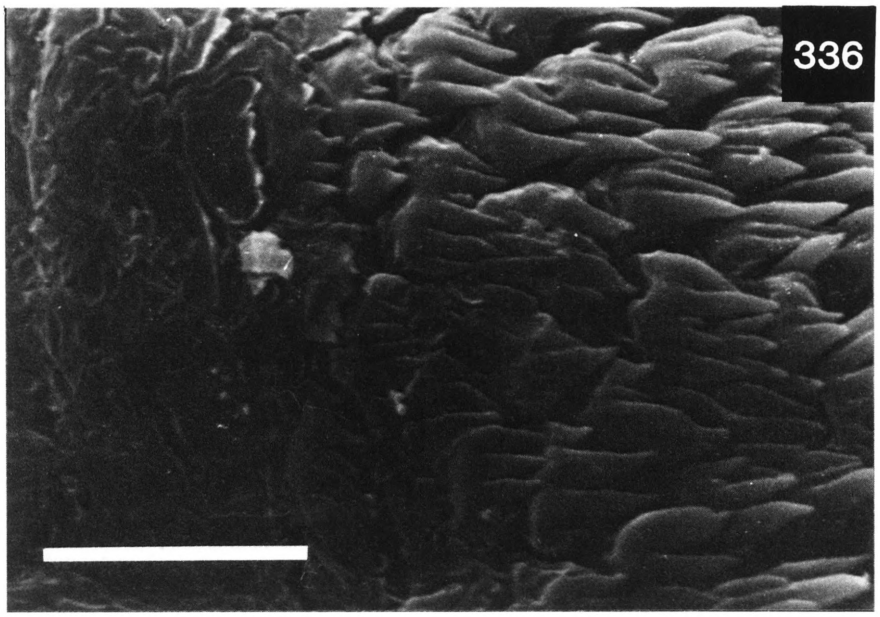


FIG. 332. *Bactrocera* (*Melanodacus*) *satanellus* (Hering), adult female (x14). A, apex of aculeus. FIG. 333. *Bactrocera* (*Queenslandacus*) *exigua* (May), adult female (x11).





FIGS 334–335. *Bactrocera* (*Austrodacus*) *cucumis* (French): 334, adult female (x11); 335, apex of aculeus (scale 0.1 mm).



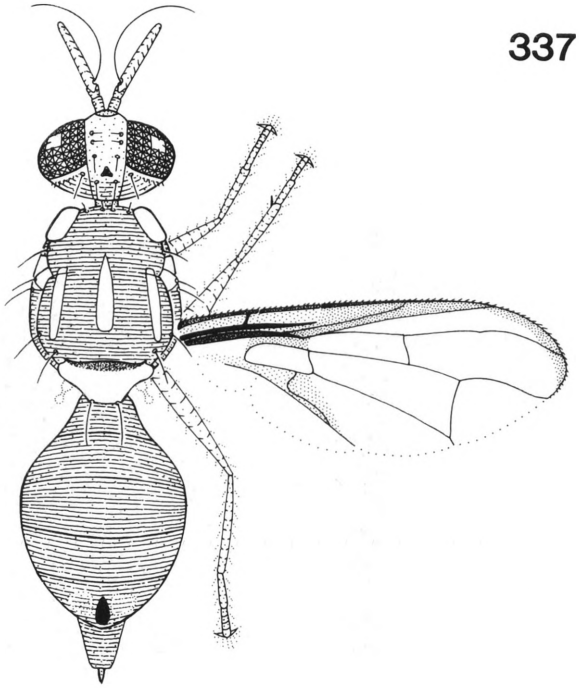
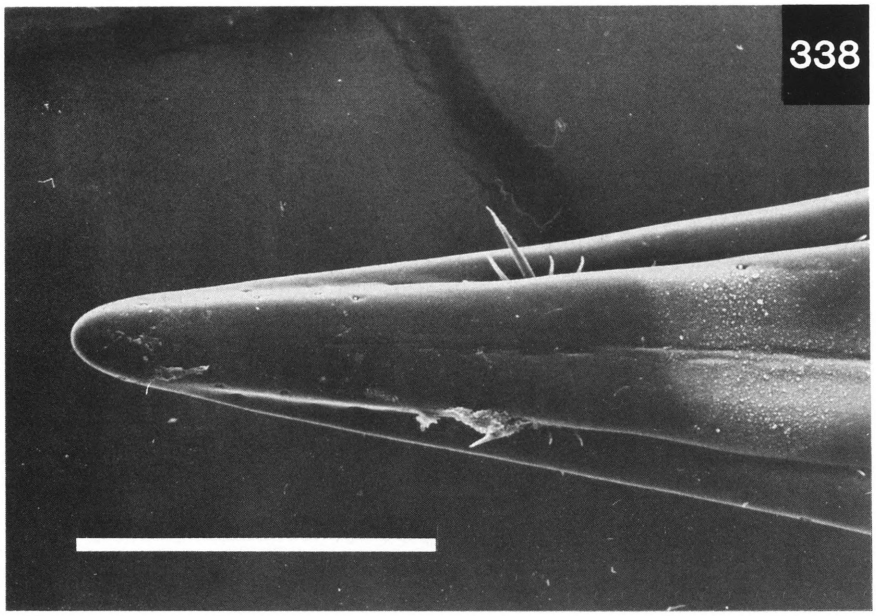
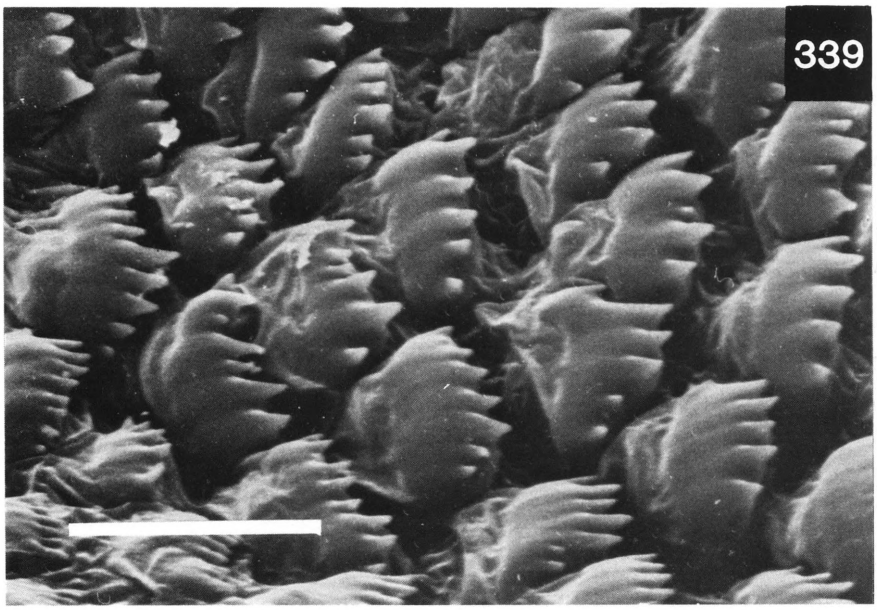


FIG. 336. *Bactrocera* (*Austrodacus*) *cucumis* (French), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 337. *Bactrocera* (*Diplodacus*) *signatifera* (Tryon), adult female (x10).





FIGS 338–339. *Bactrocera* (*Diplodacus*) *signatifera* (Tryon): 338, apex of aculeus (scale 0.1 mm); 339, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

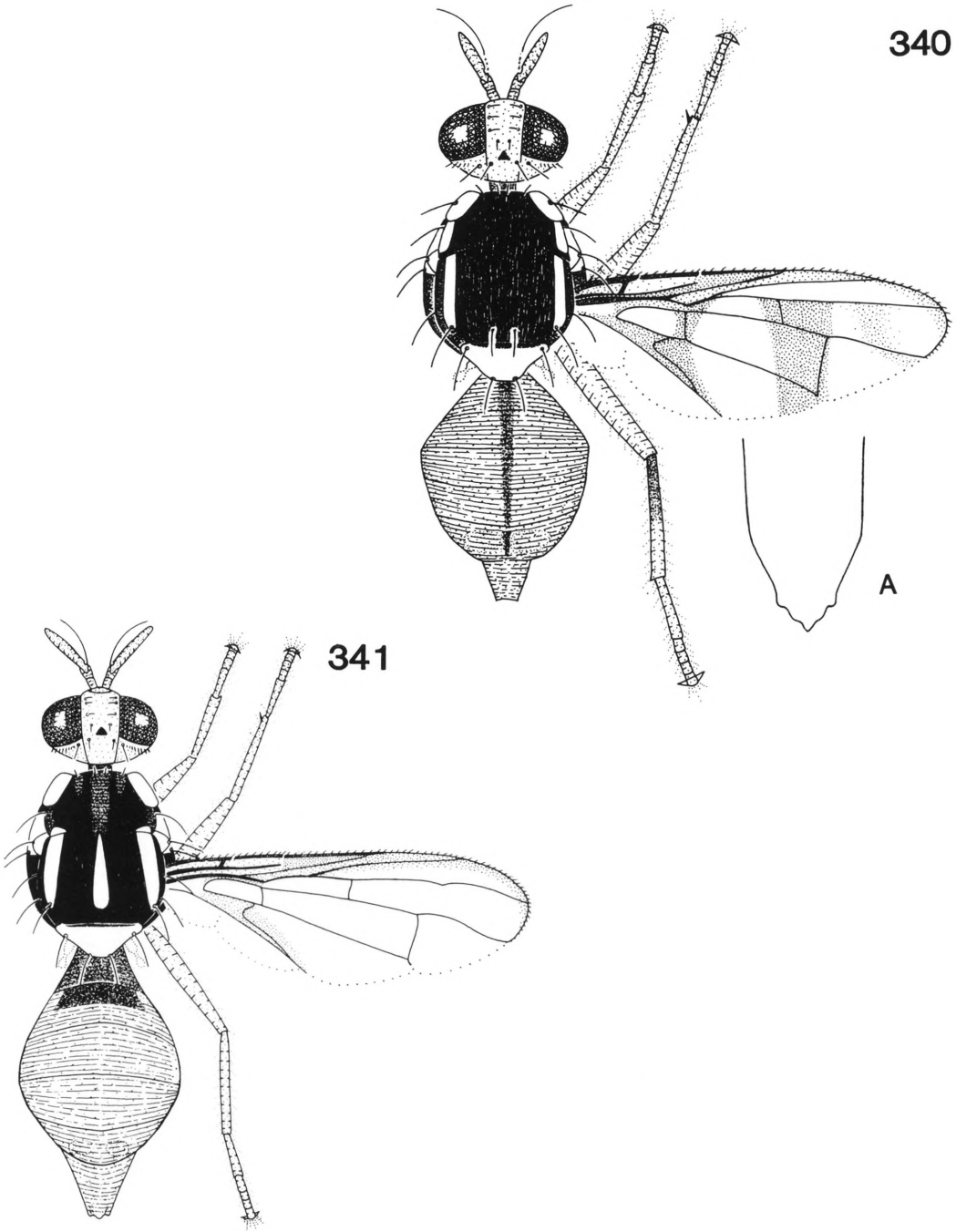
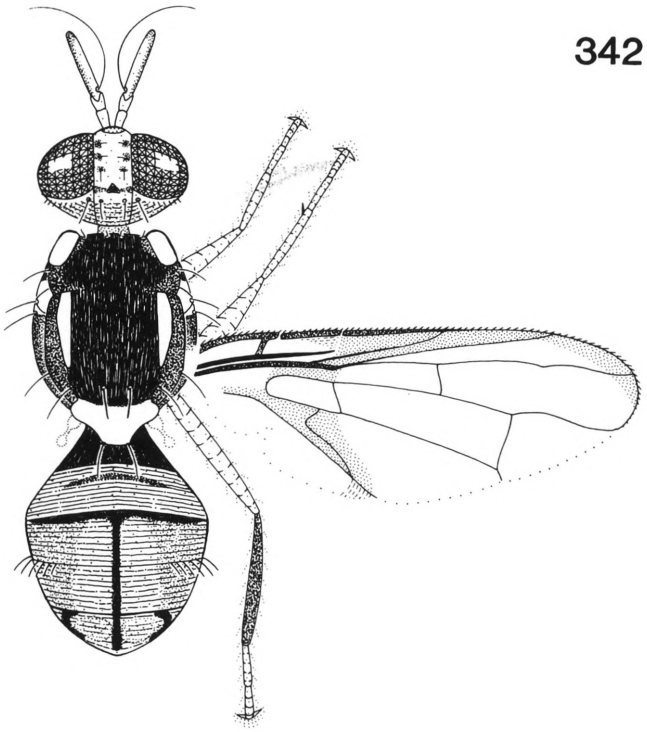
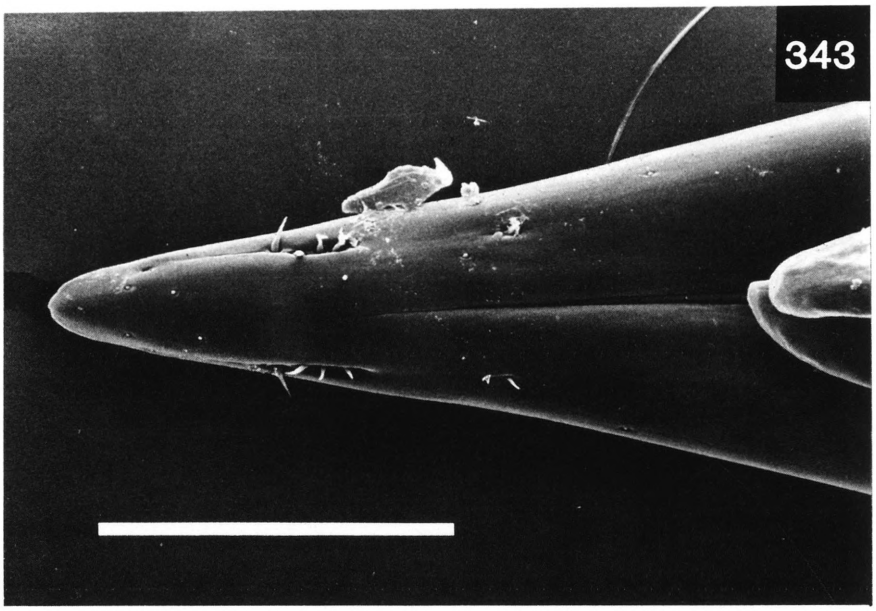
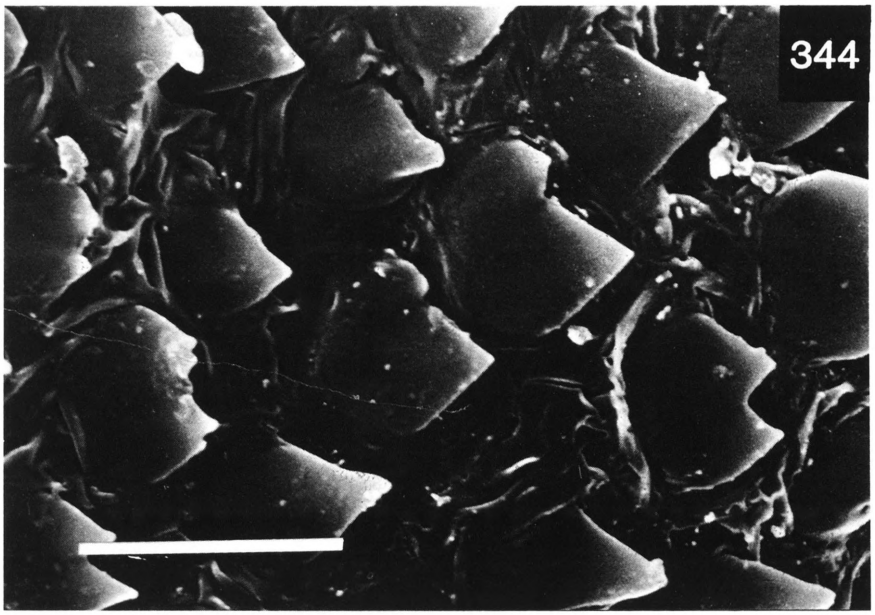


FIG. 340. *Bactrocera* (*Heminotodacus*) *dissidens* n. sp., adult female (x11). A, apex of aculeus. FIG. 341. *Bactrocera* (*Hemiparatridacus*) *abdoaurantiaca* n. sp., adult female (x8).





FIGS 342–343. *Bactrocera* (*Javadacus*) *aberrans* (Hardy): 342, adult male (x12); 343, apex of aculeus (scale 0.1 mm).



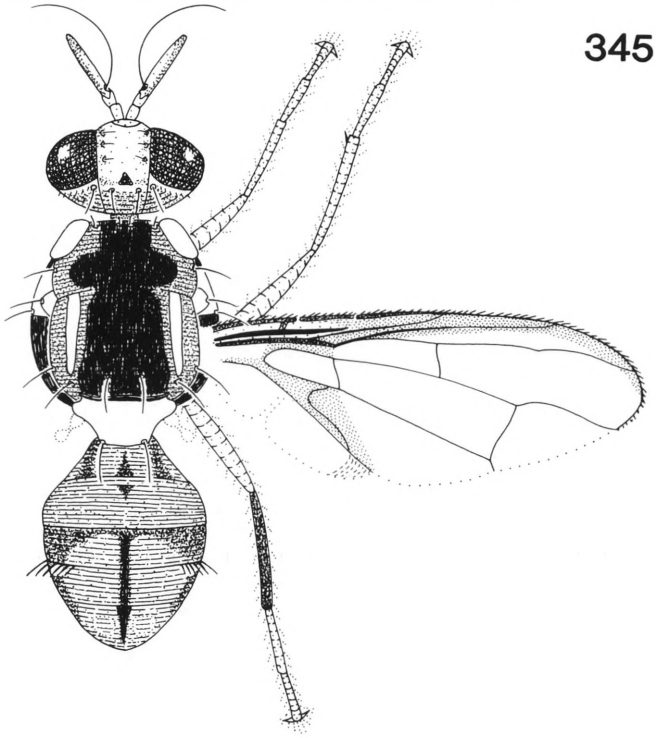


FIG. 344. *Bactrocera* (*Javadacus*) *aberrans* (Hardy), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 345. *Bactrocera* (*Javadacus*) *melanothoracica* n. sp., adult male (x11).

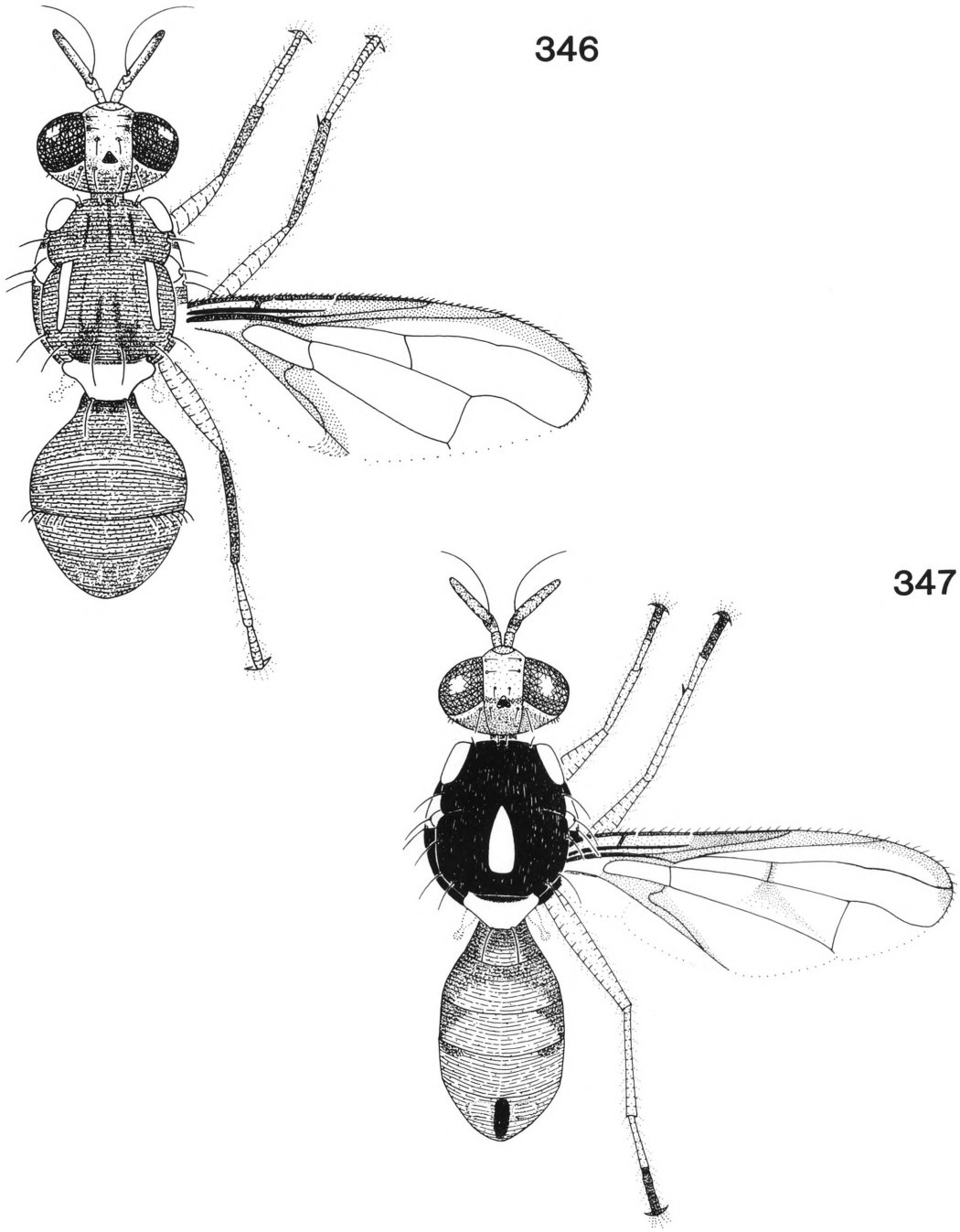


FIG. 346. *Bactrocera* (*Javadacus*) *unirufa* n. sp., adult male (x11). FIG. 347. *Bactrocera* (*Niuginidacus*) *singularis* n. sp., adult male (x11).

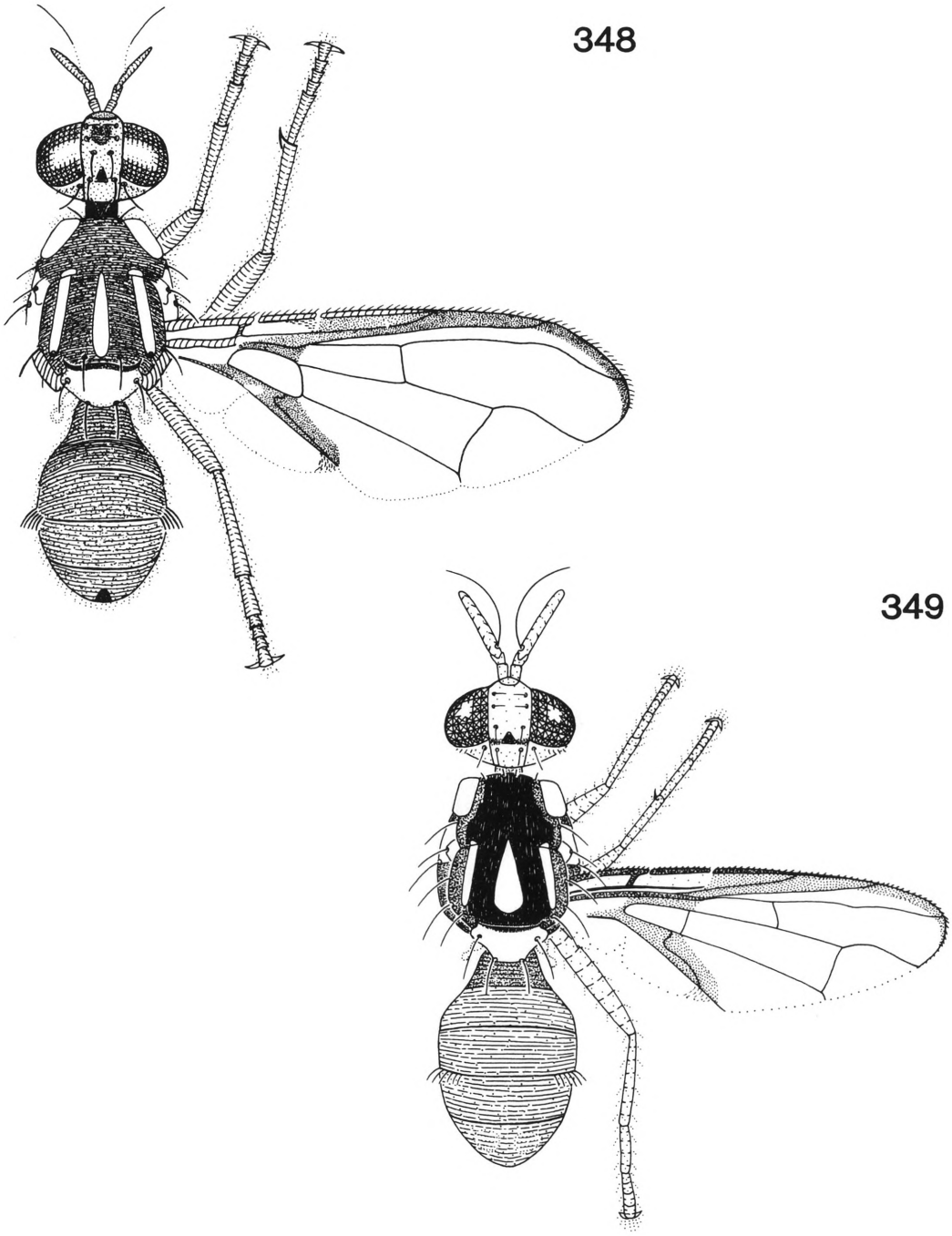
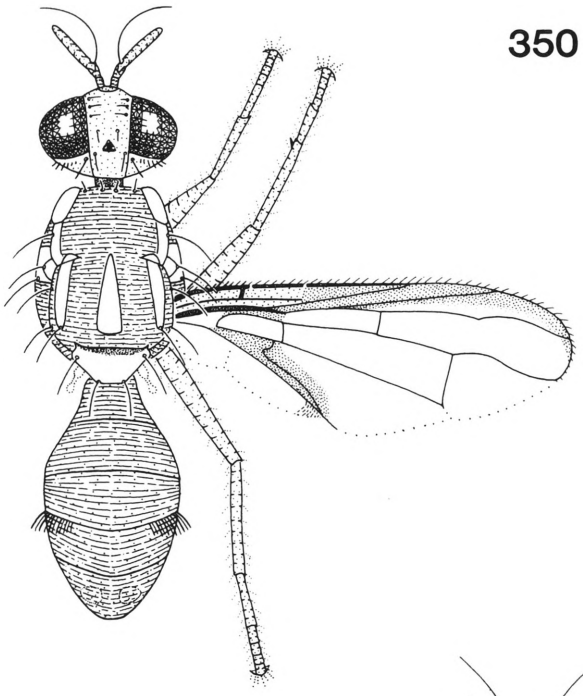


FIG. 348. *Bactrocera* (*Papuodacus*) *neopallescentis* n. nom., adult male (x12). FIG. 349. *Bactrocera* (*Paradacus*) *aurantiventer* n. sp., adult male (x10).



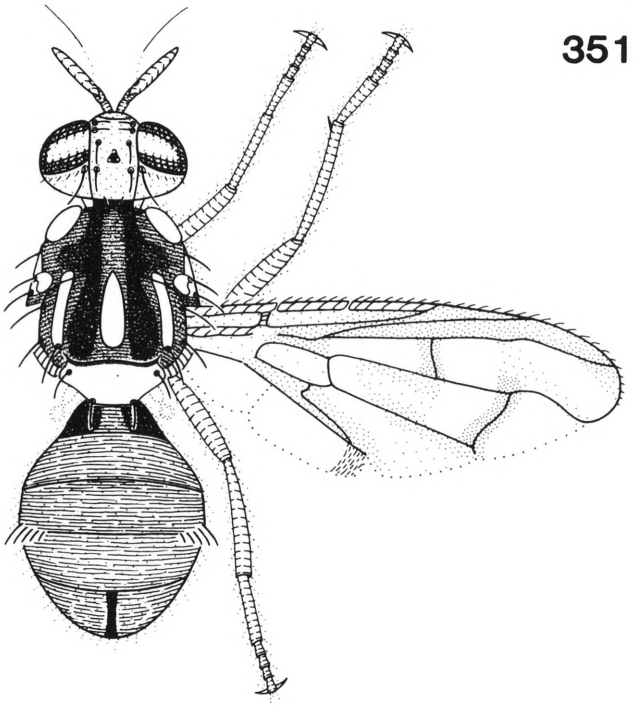
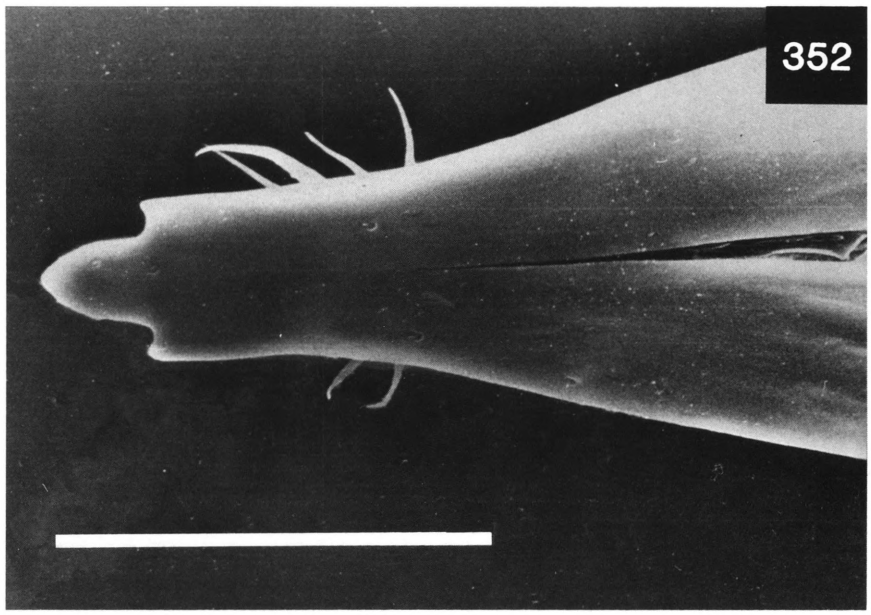
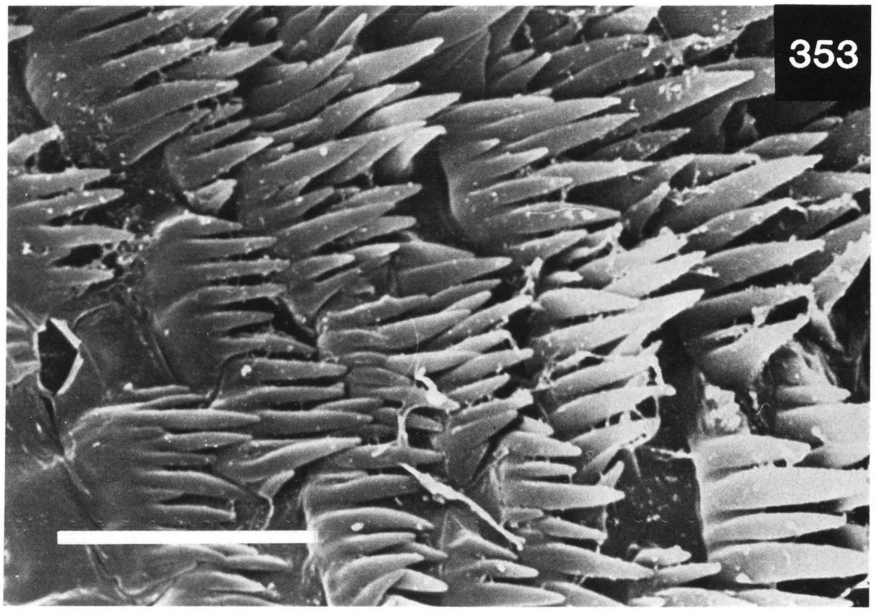
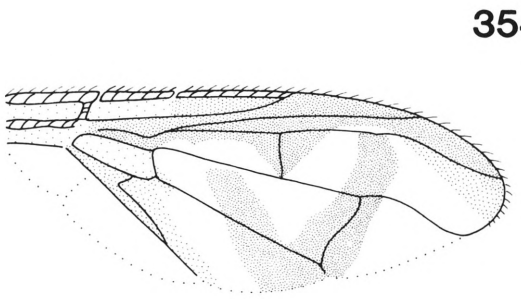


FIG. 350. *Bactrocera* (*Paradacus*) *citroides* n. sp., adult male (x9). FIG. 351. *Bactrocera* (*Paradacus*) *decipiens* (Drew), adult male (x7).





FIGS 352–353. *Bactrocera* (*Paradacus*) *decipiens* (Drew): 352, apex of aculeus (scale 0.1 mm); 353, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



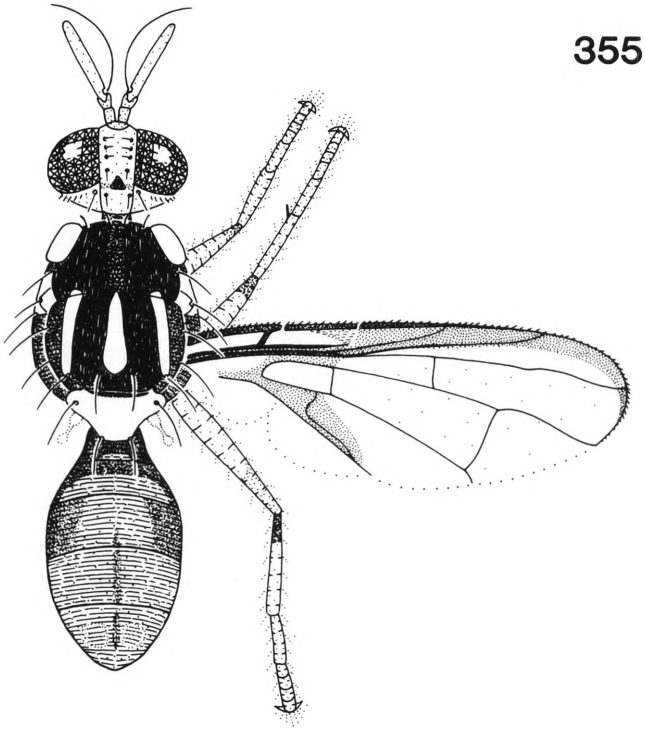
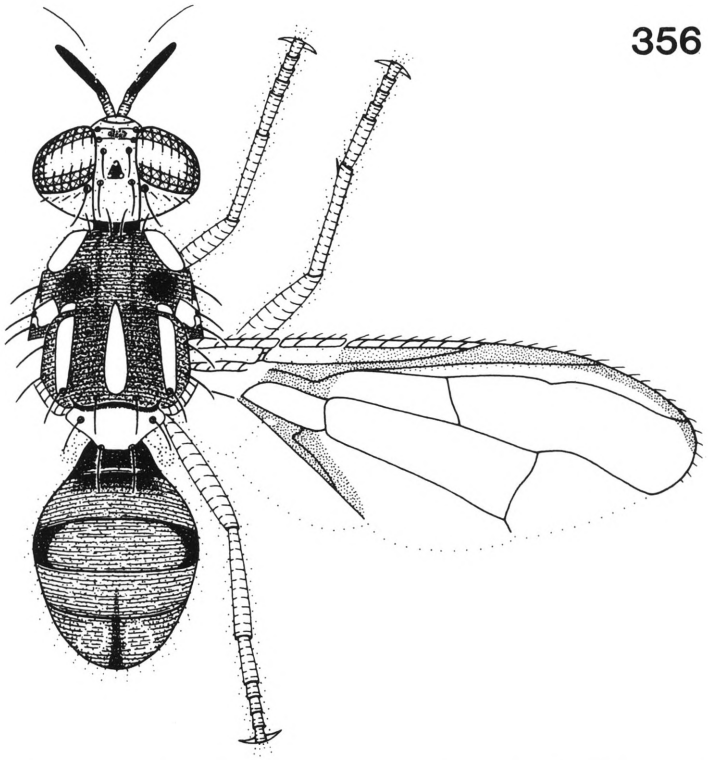
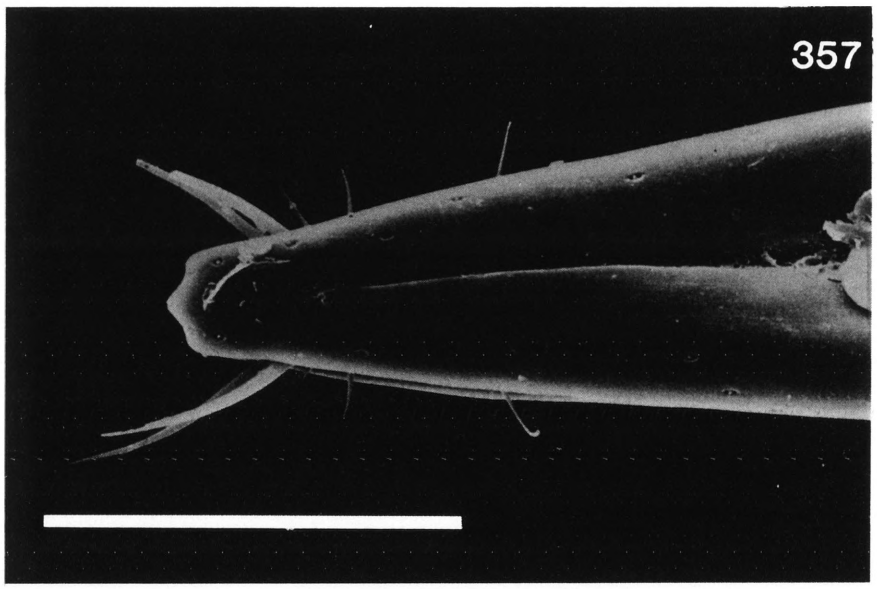
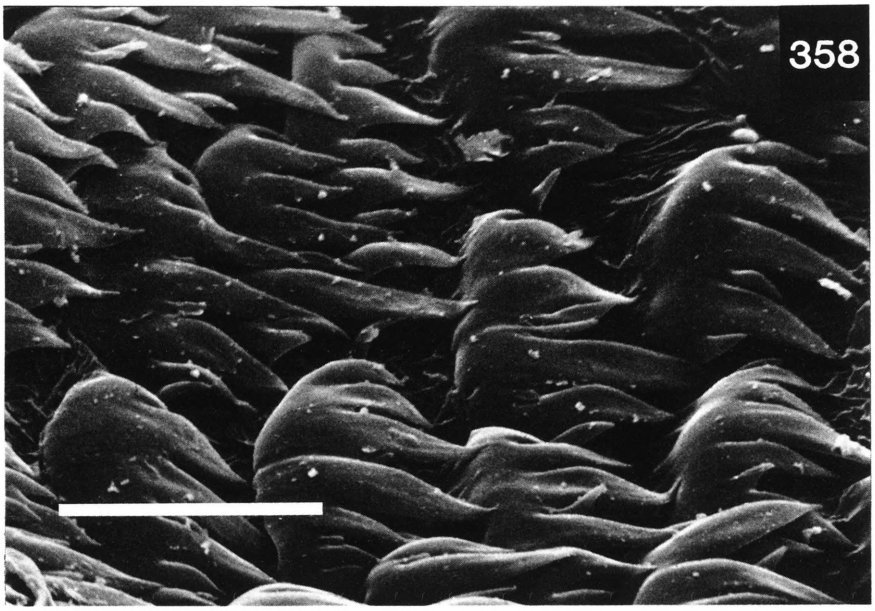


FIG. 354. *Bactrocera* (*Paradacus*) *perplexa* (Walker), wing (x8). FIG. 355. *Bactrocera* (*Paratridacus*) *alampeta* n. sp., adult male (x9).





FIGS 356–357. *Bactrocera* (*Paratridacus*) *atrisetosa* (Perkins): 356, adult male (x11); 357, apex of aculeus (scale 0.1 mm).



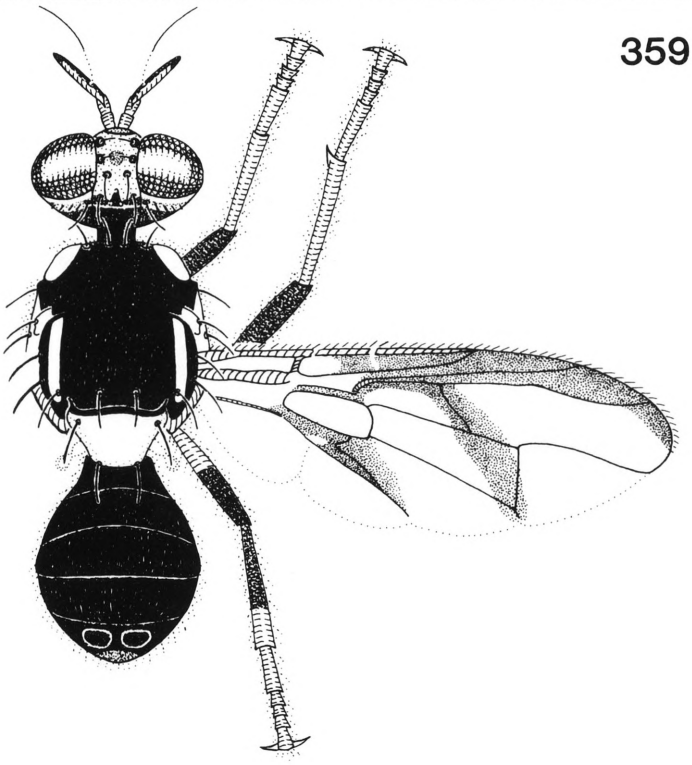
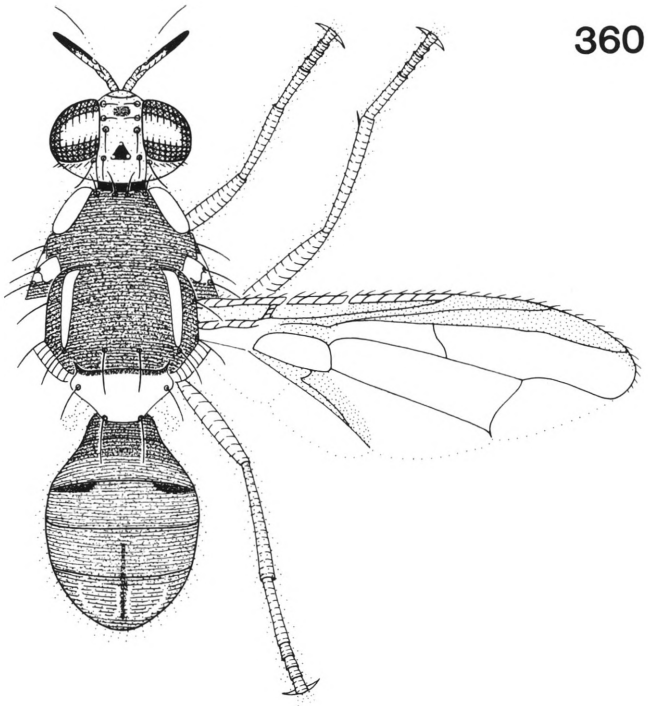
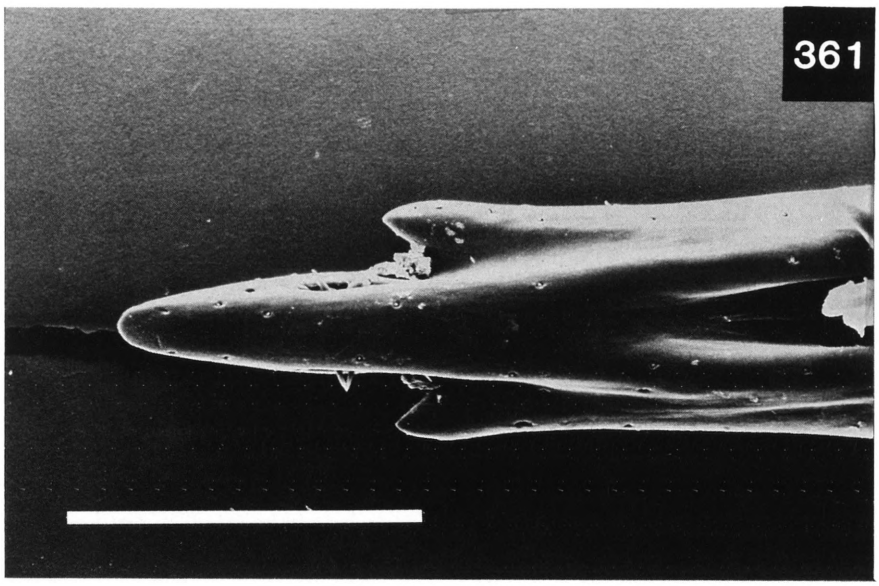


FIG. 358. *Bactrocera* (*Paratridacus*) *atrisetosa* (Perkins), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 359. *Bactrocera* (*Paratridacus*) *coracinus* (Drew), adult male (x13).





FIGS 360–361. *Bactrocera* (*Paratridacus*) *expandens* (Walker): 360, adult male (x7); 361, apex of aculeus (scale 0.1 mm).



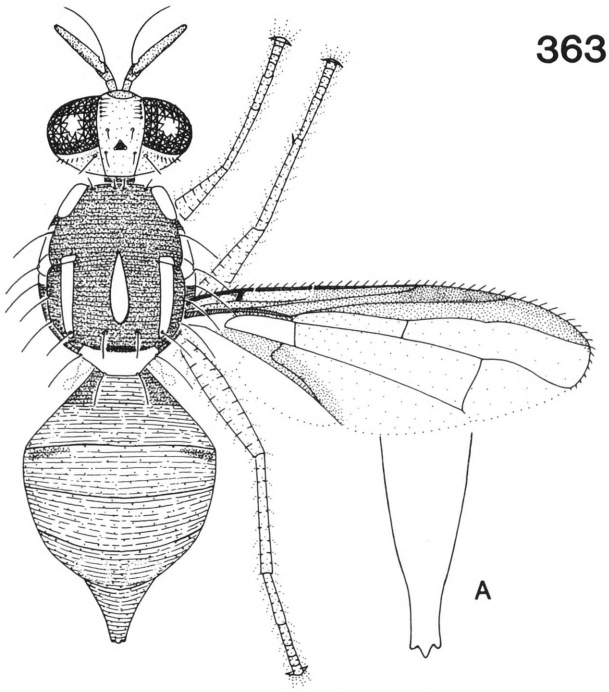


FIG. 362. *Bactrocera* (*Paratridacus*) *expandens* (Walker), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 363. *Bactrocera* (*Paratridacus*) *mesonotaitha* n. sp., adult female (x6). A, apex of aculeus.

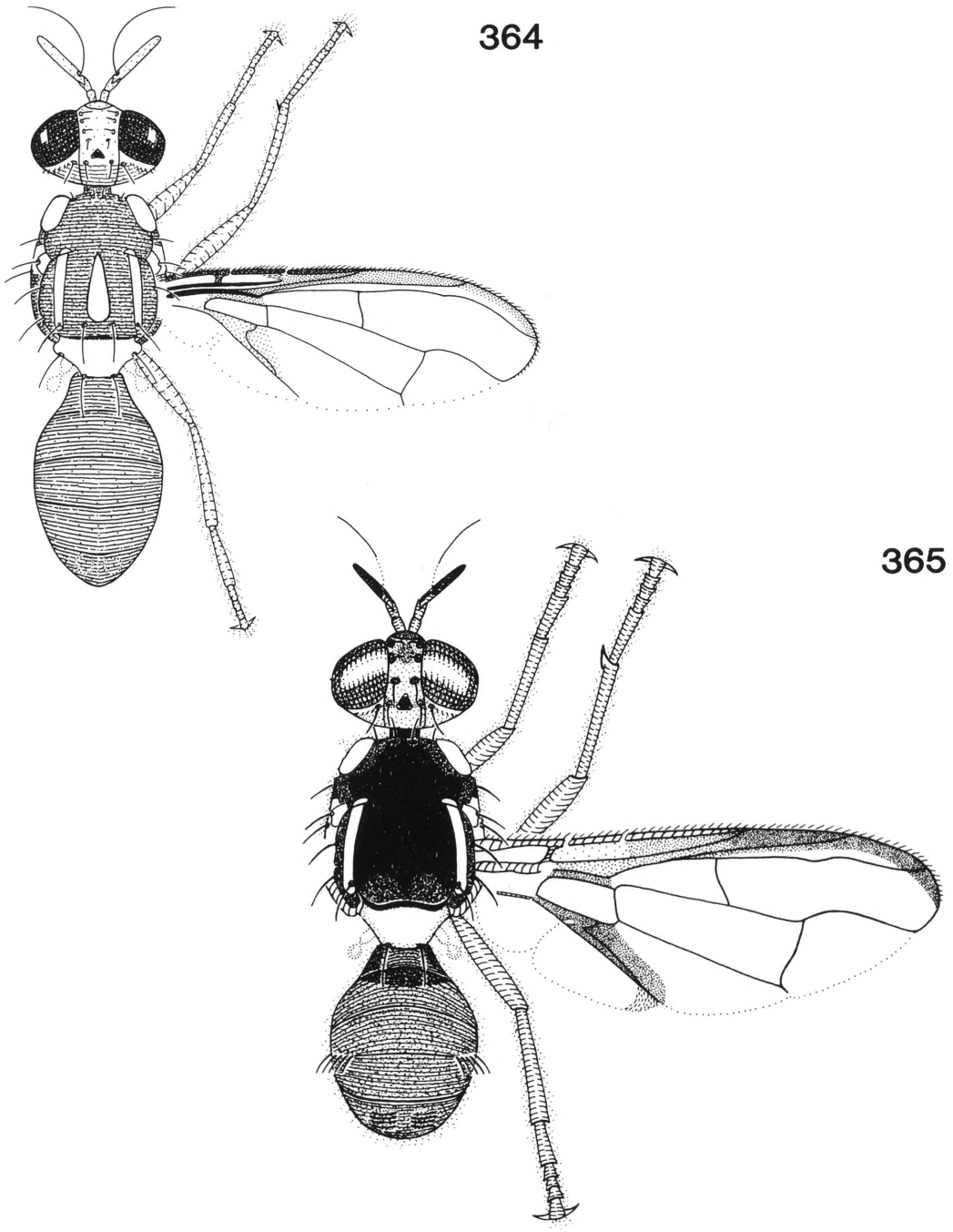


FIG. 364. *Bactrocera* (*Paratridacus*) *unichromata* n. sp., adult male (x9). FIG. 365. *Bactrocera* (*Sinodacus*) *abdopallescens* (Drew), adult male (x13).

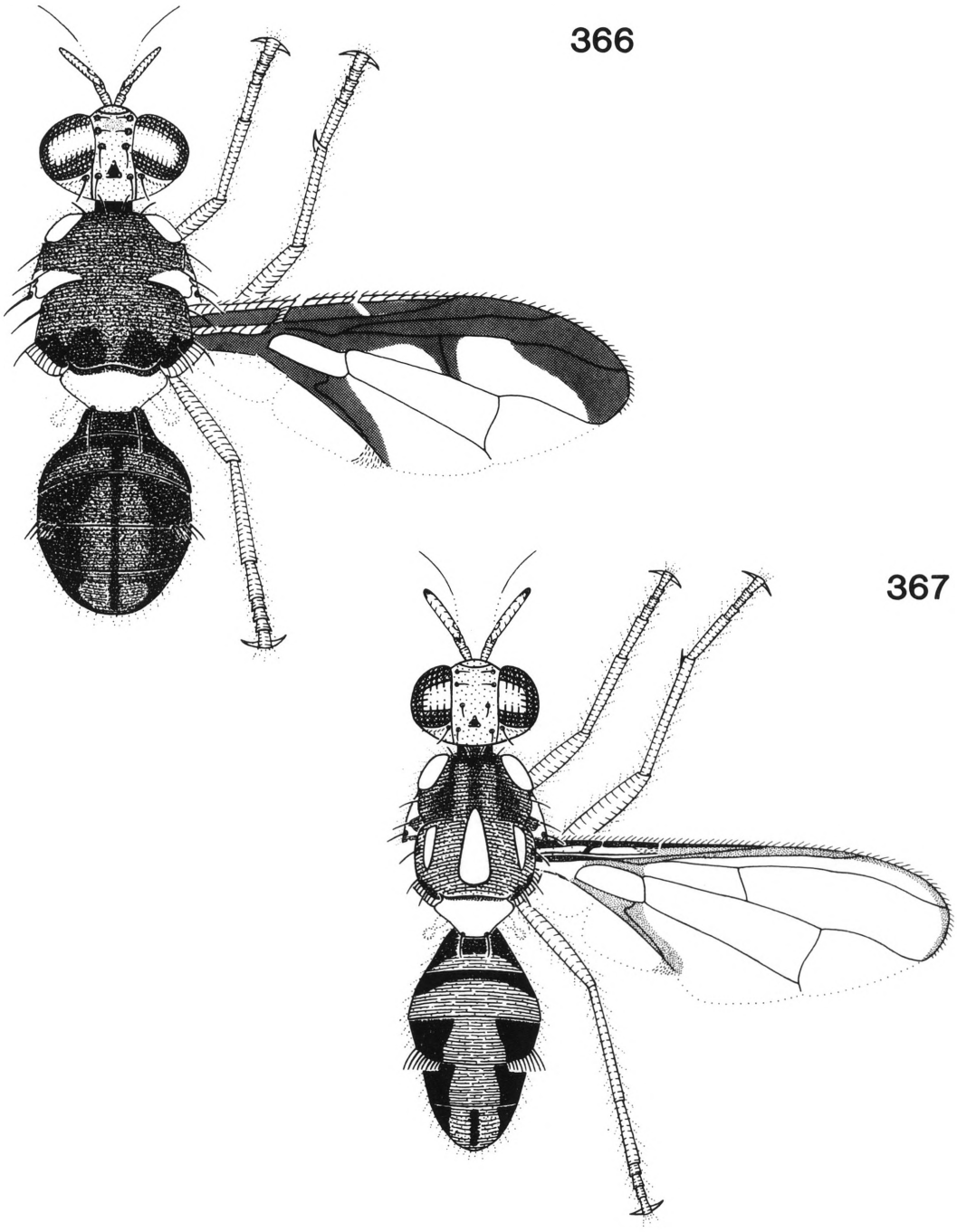


FIG. 366. *Bactrocera* (*Sinodacus*) *aneuvittata* (Drew), adult male (x11). FIG. 367. *Bactrocera* (*Sinodacus*) *angusticostata* n. sp., adult male (x12).

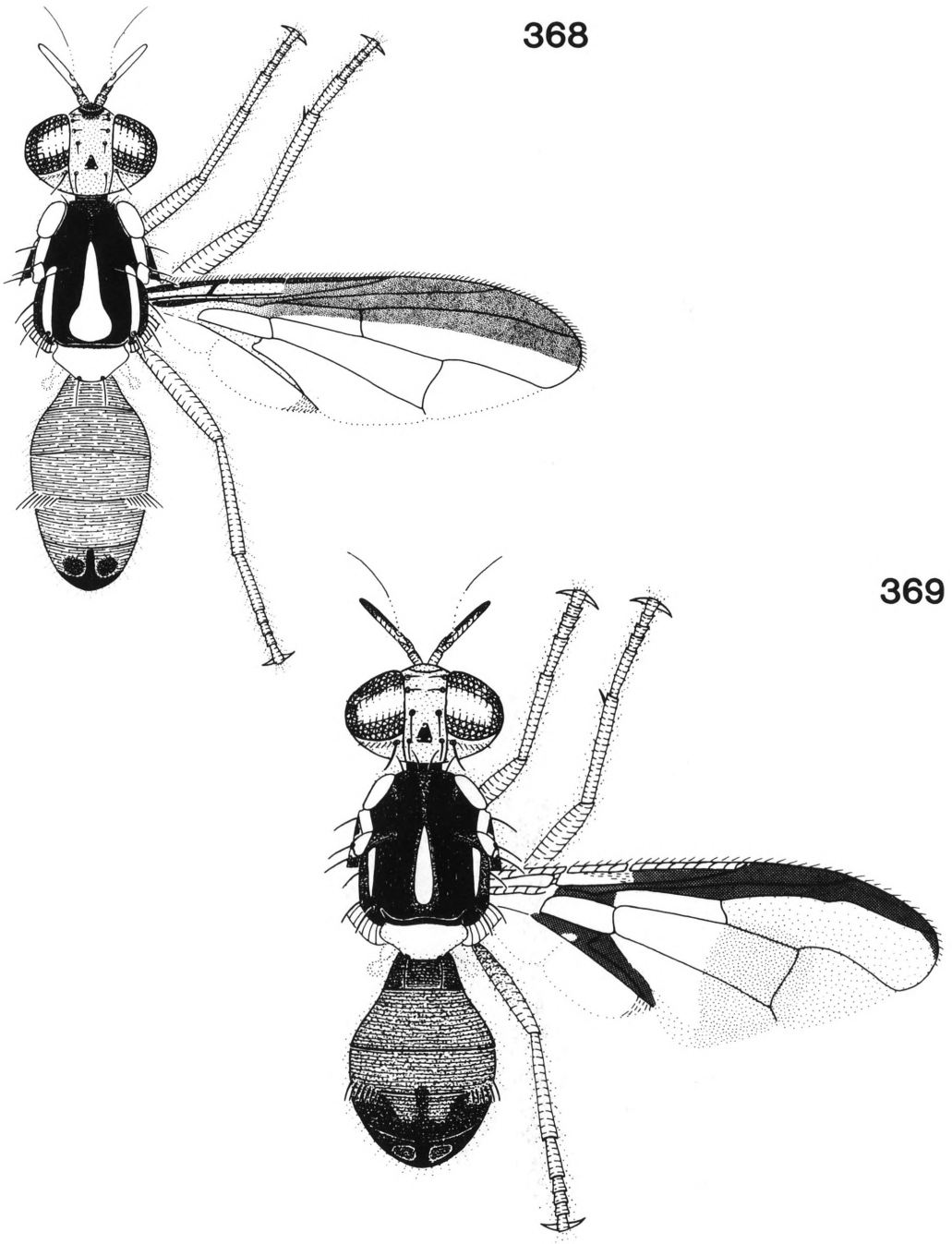


FIG. 368. *Bactrocera* (*Sinodacus*) *buvittata* n. sp., adult male (x11). FIG. 369. *Bactrocera* (*Sinodacus*) *emarginata* (Perkins), adult male (x12).

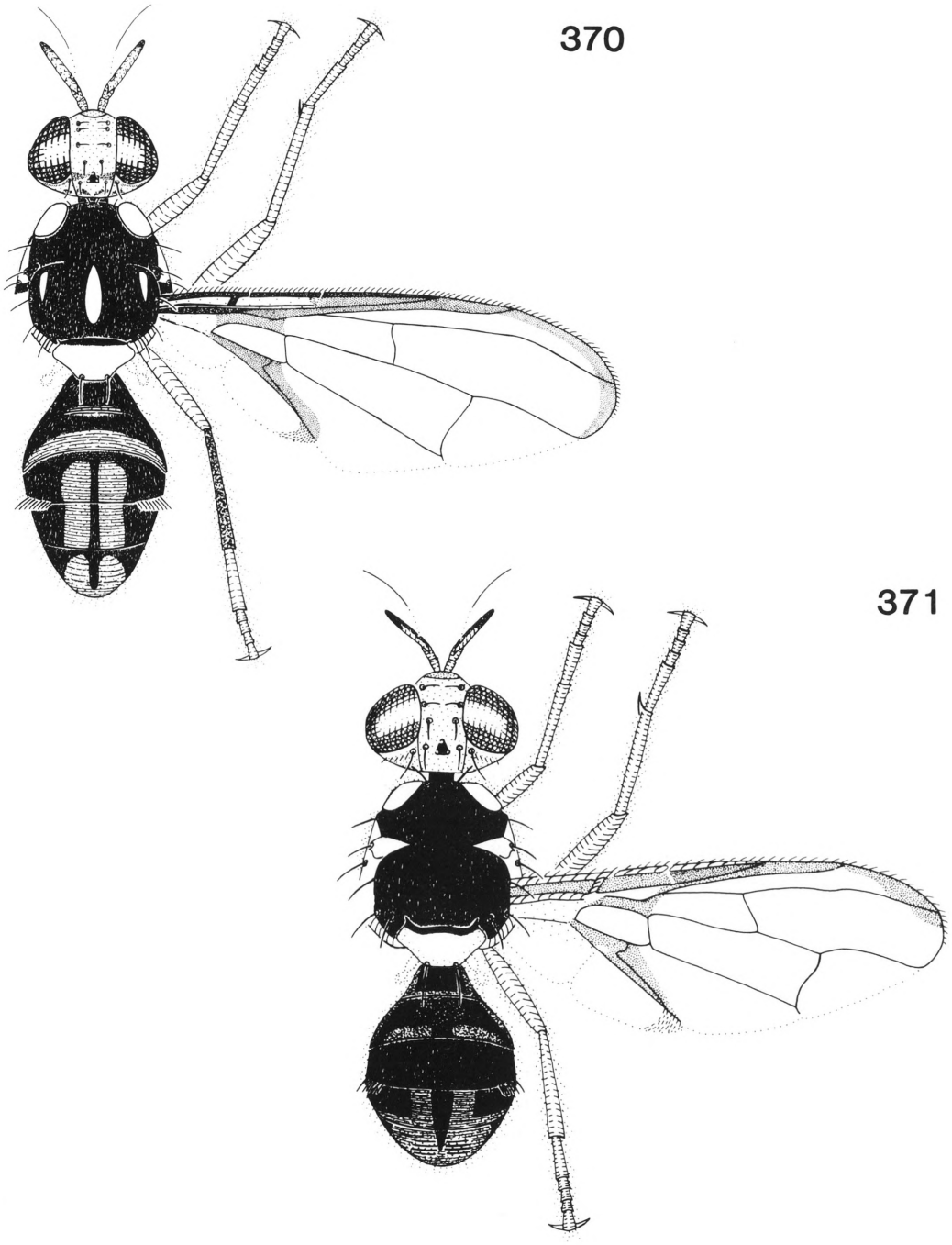
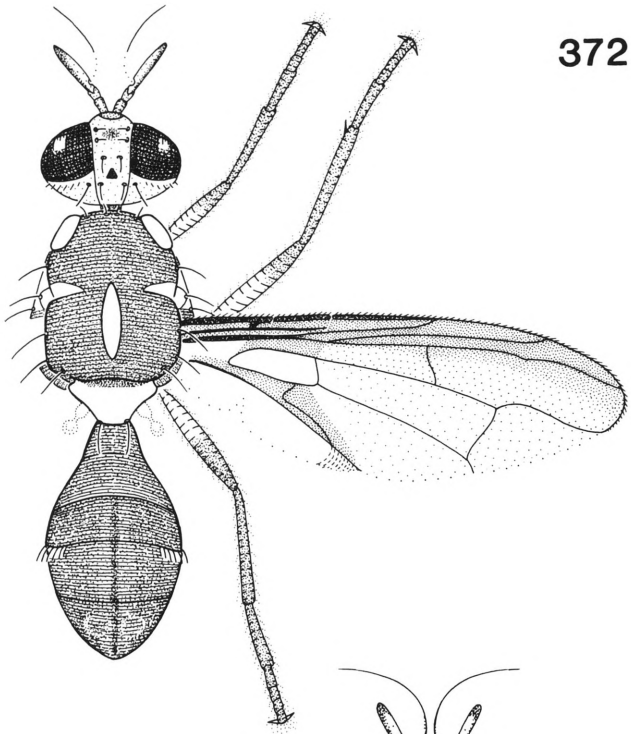


FIG. 370. *Bactrocera* (*Sinodacus*) *paulula* n. sp., adult male (x16). FIG. 371. *Bactrocera* (*Sinodacus*) *perpusilla* (Drew), adult male (x15).



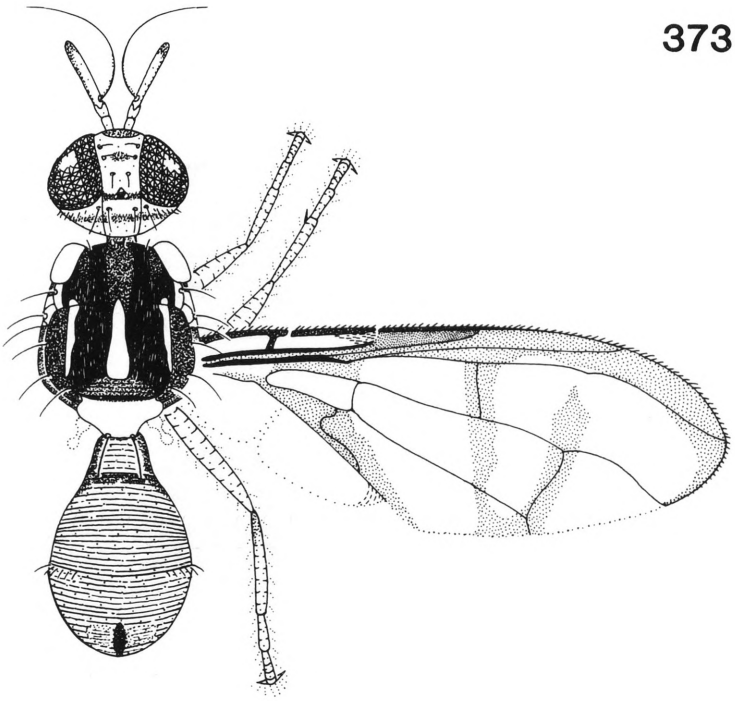
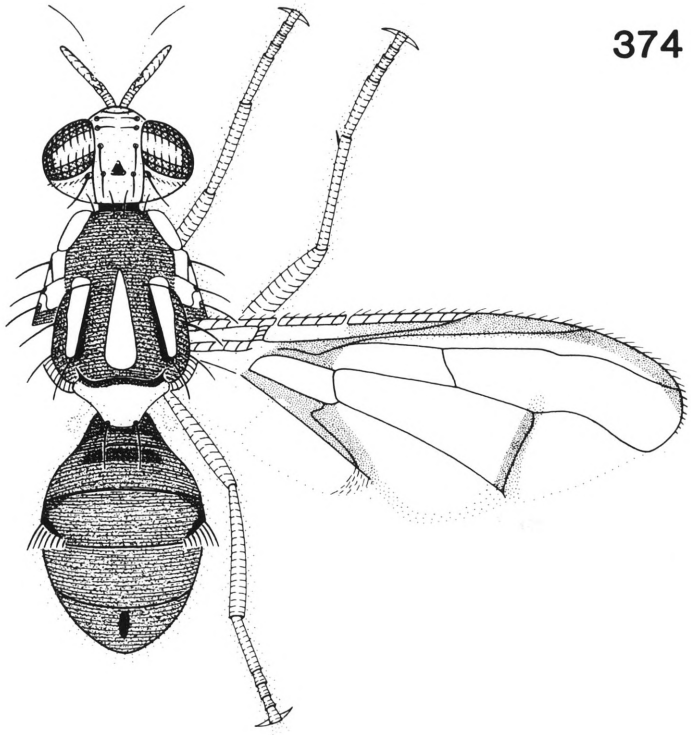
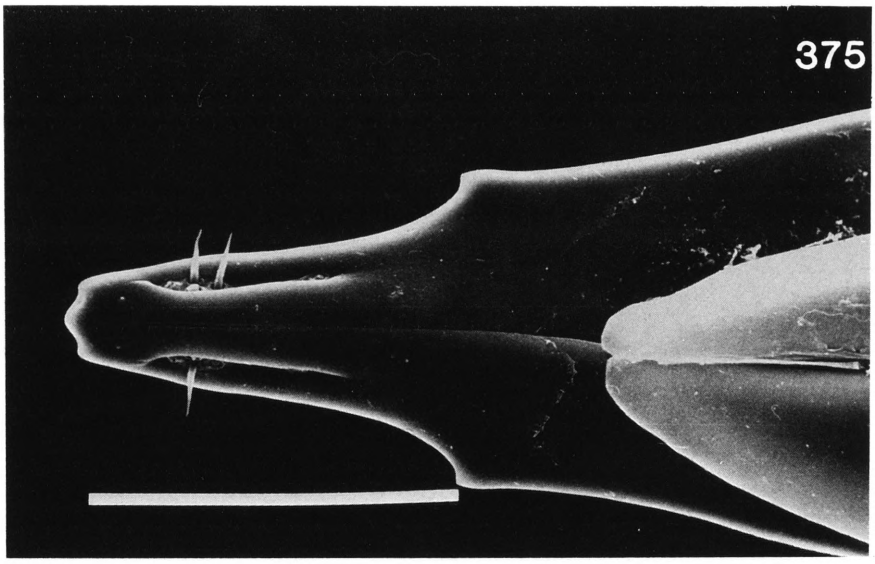
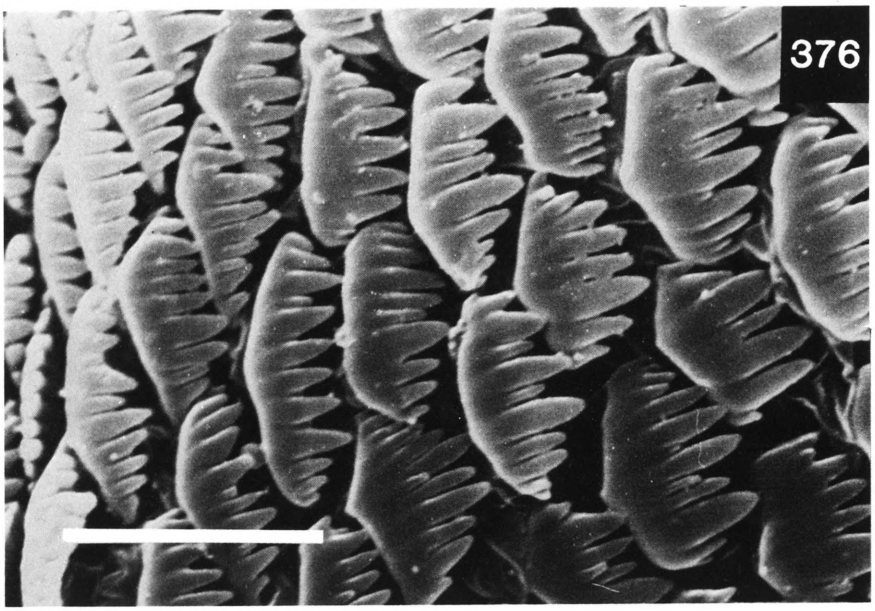


FIG. 372. *Bactrocera* (*Sinodacus*) *salamander* (Drew and Hancock), adult male (x9). FIG. 373. *Bactrocera* (*Sinodacus*) *sepikae* n. sp., adult male (x14).





FIGS 374–375. *Bactrocera* (*Sinodacus*) *strigifinis* (Walker): 374, adult male (x11); 375, apex of aculeus (scale 0.1 mm).



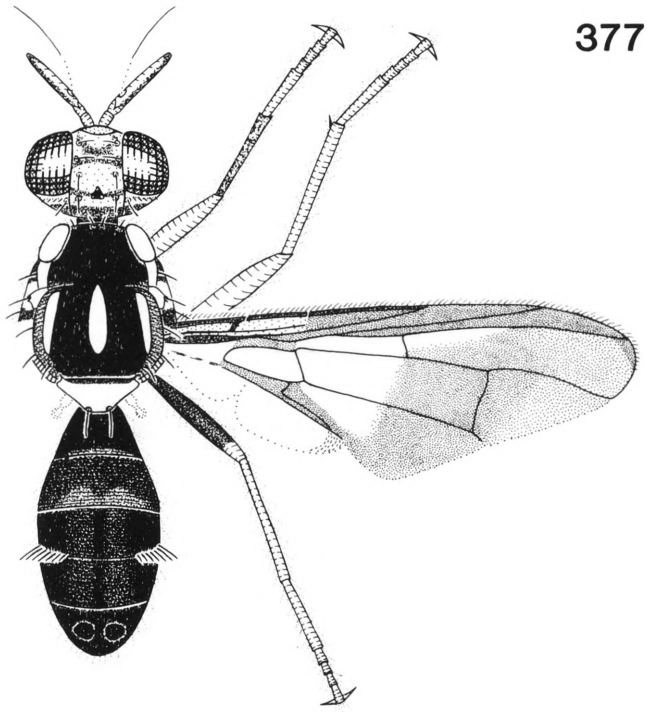


FIG. 376. *Bactrocera* (*Sinodacus*) *strigifinis* (Walker), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 377. *Bactrocera (Sinodacus) surrufula* n. sp., adult male (x12).

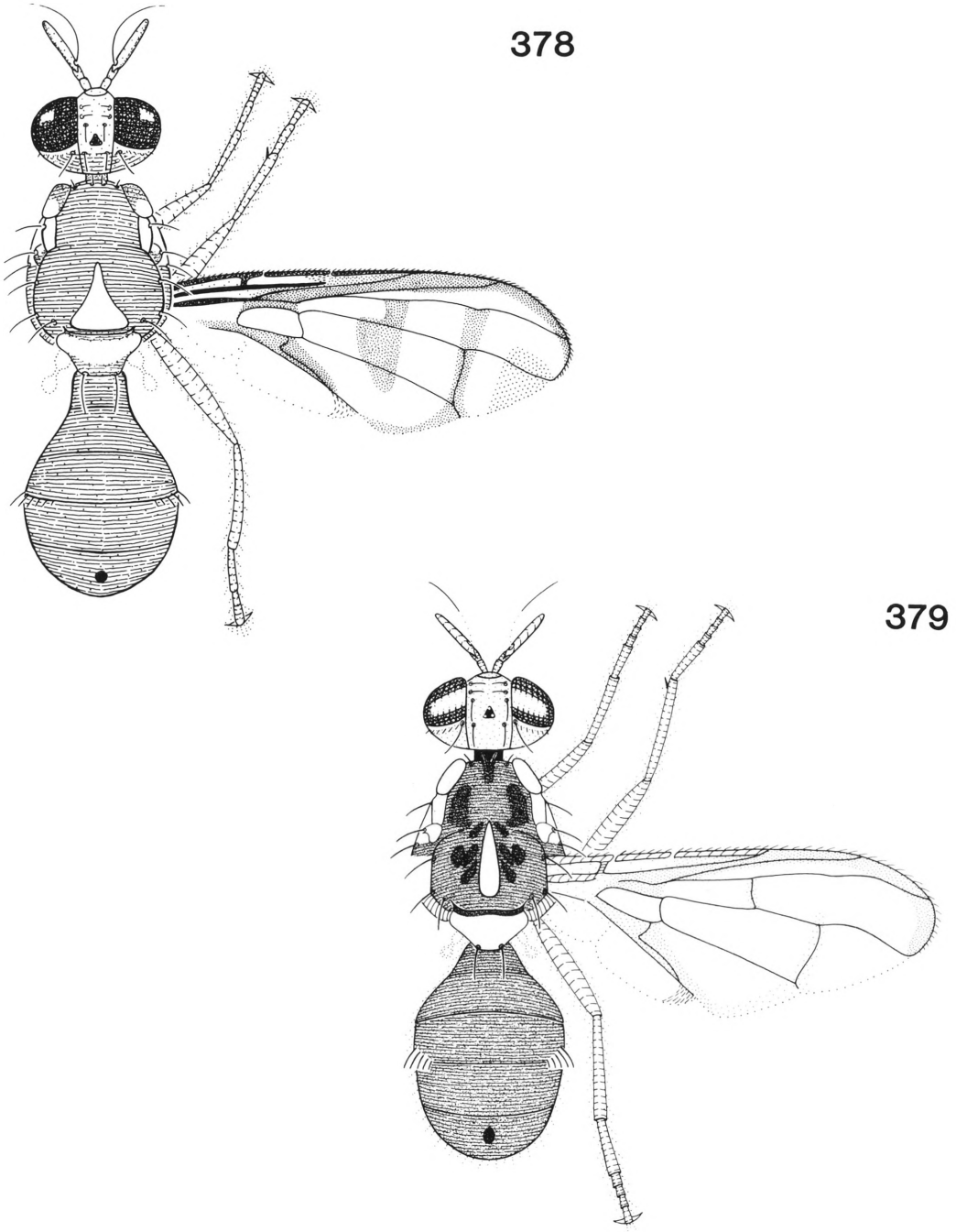
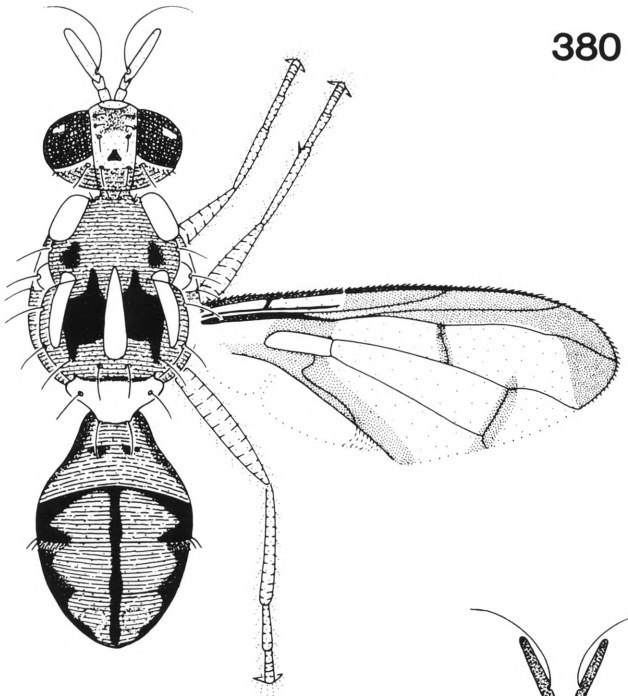


FIG. 378. *Bactrocera* (*Sinodacus*) *triangularis* (Drew), adult male (x11). FIG. 379. *Bactrocera* (*Sinodacus*) *univittata* (Drew), adult male (x10).



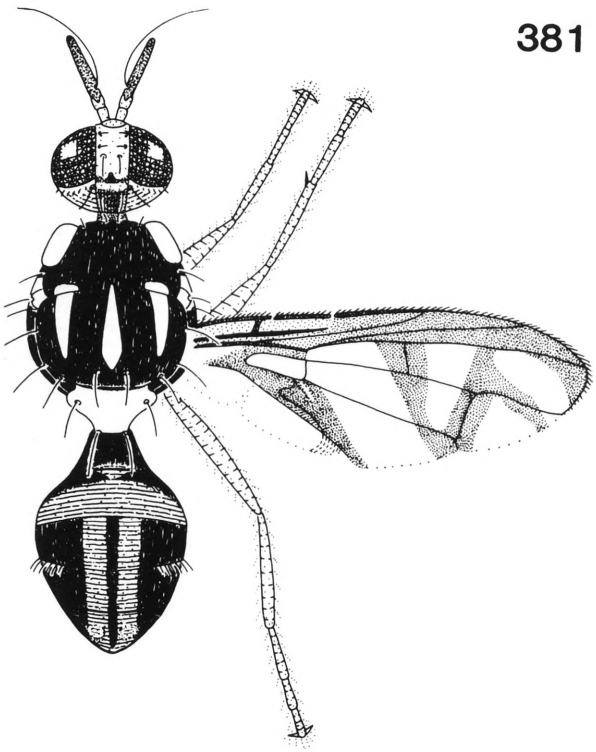


FIG. 380. *Bactrocera* (*Zeugodacus*) *abdoangusta* (Drew), adult male (x7). FIG. 381. *Bactrocera* (*Zeugodacus*) *amoena* (Drew), adult male (x11).

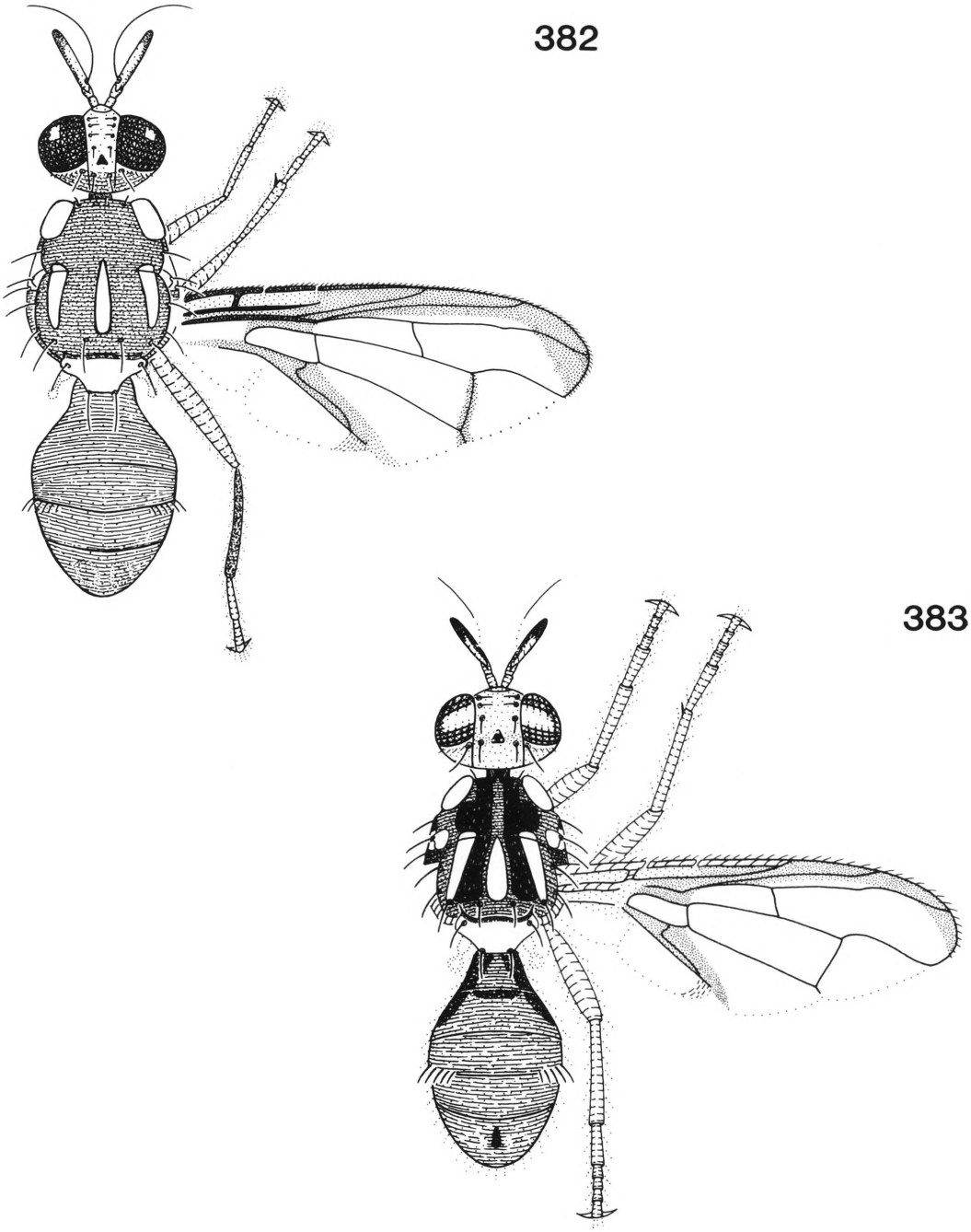
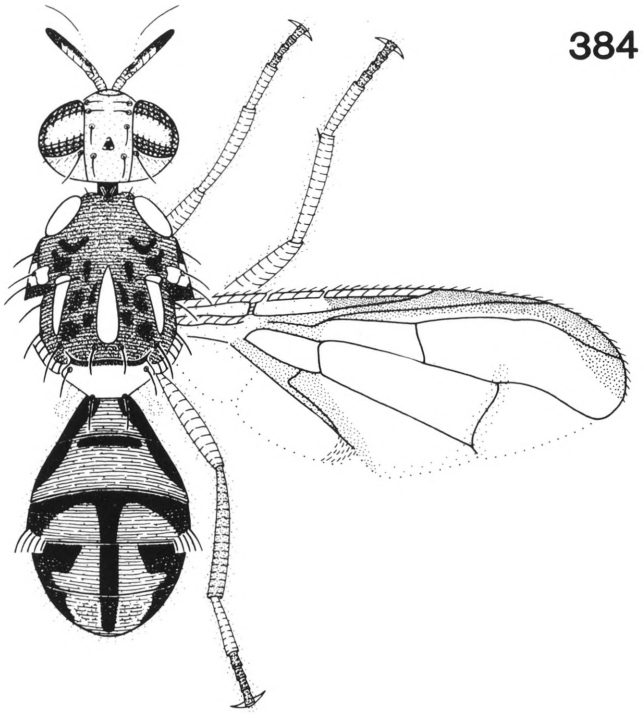
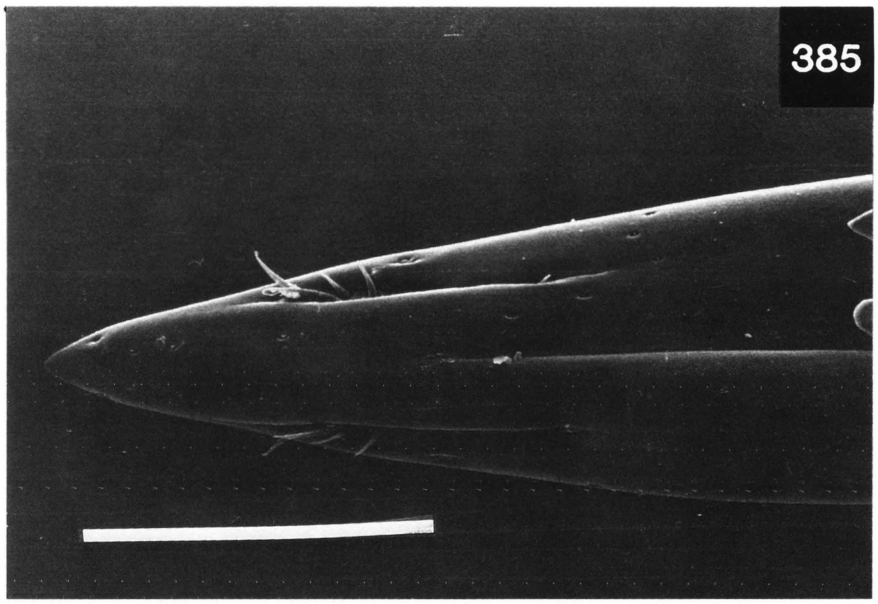
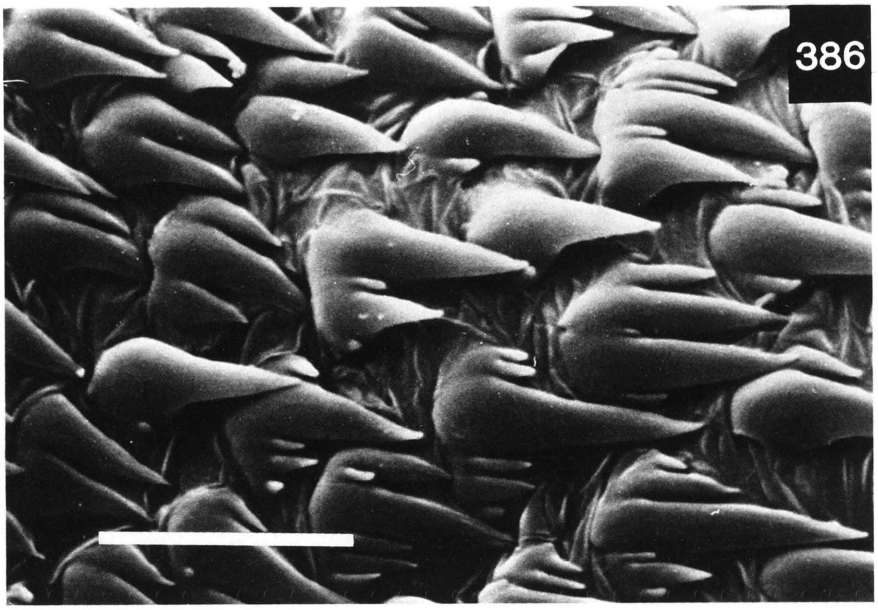


FIG. 382. *Bactrocera* (*Zeugodacus*) *anchitrichota* n. sp., adult male (x9). FIG. 383. *Bactrocera* (*Zeugodacus*) *brachus* (Drew), adult male (x11).





FIGS 384–385. *Bactrocera* (*Zeugodacus*) *chorista* (May): 384, adult male (x8); 385, apex of aculeus (scale 0.1 mm).



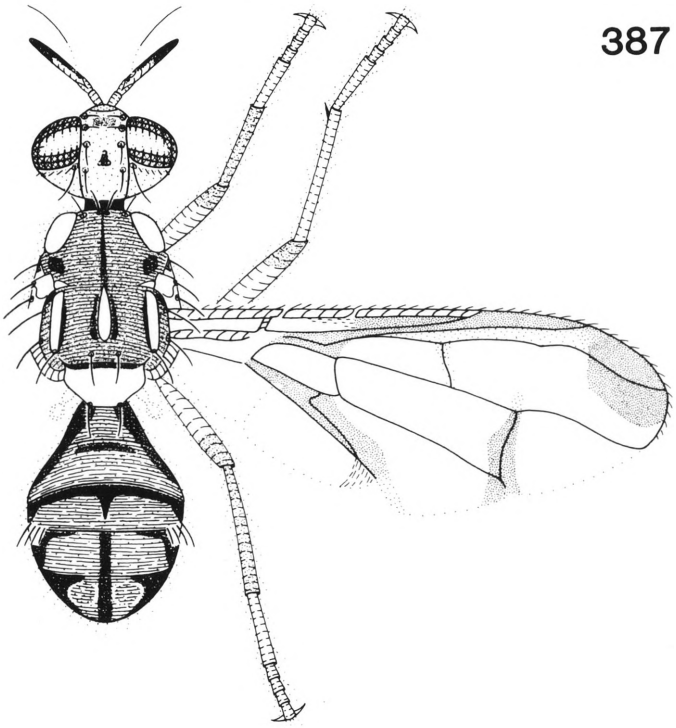
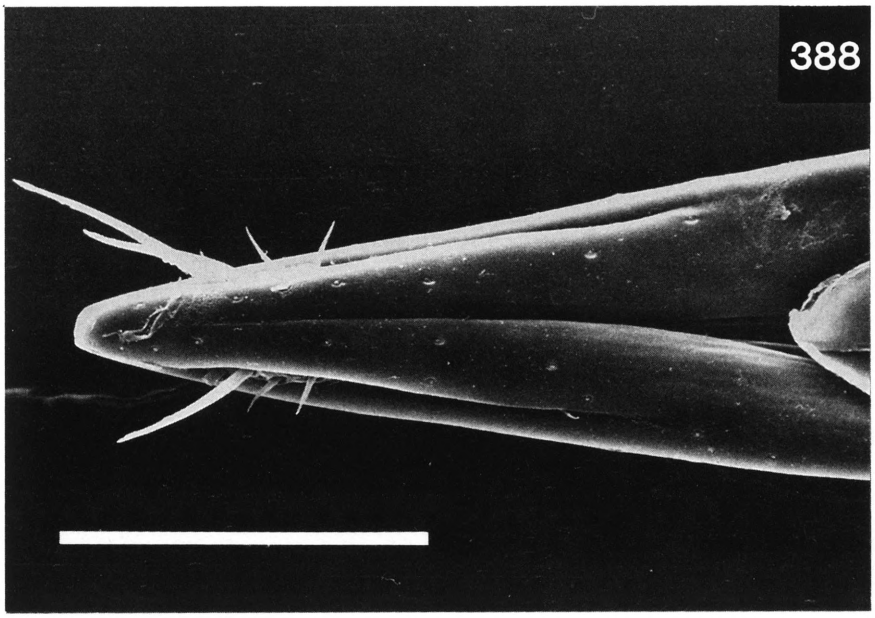
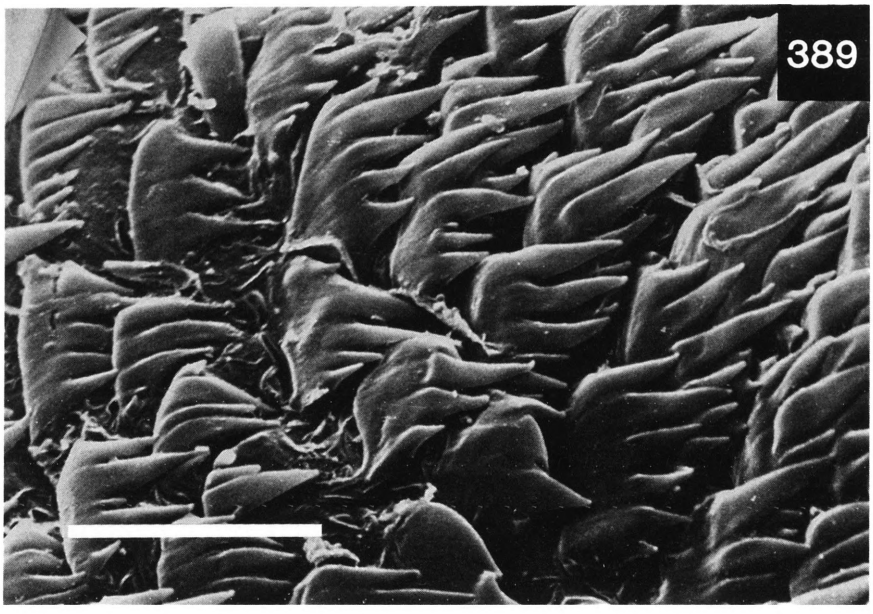


FIG. 386. *Bactrocera* (*Zeugodacus*) *chorista* (May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 387. *Bactrocera* (*Zeugodacus*) *cucurbitae* (Coquillett), adult male (x10).





FIGS 388–389. *Bactrocera* (*Zeugodacus*) *cucurbitae* (Coquillett): 388, apex of aculeus (scale 0.1 mm); 389, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).

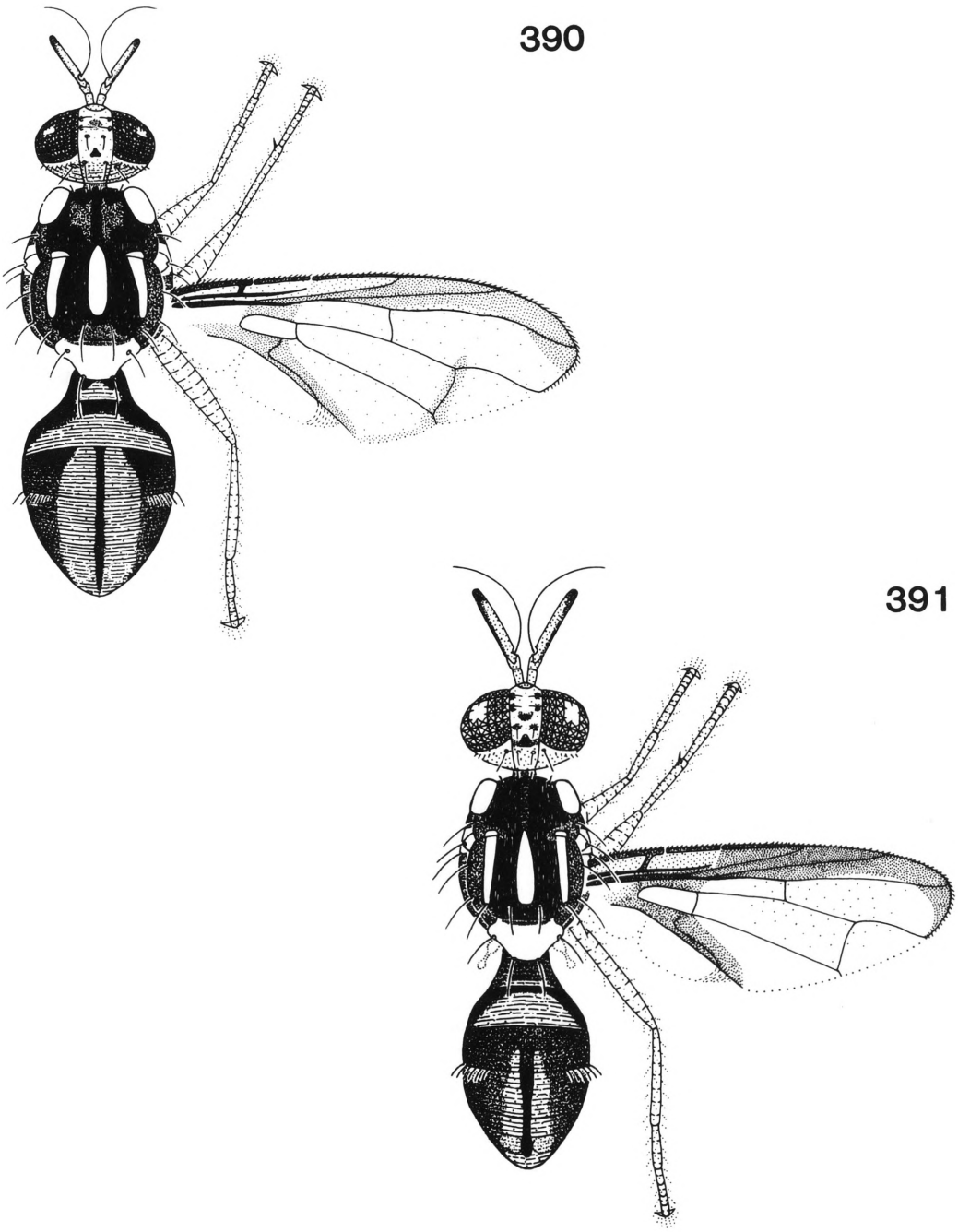
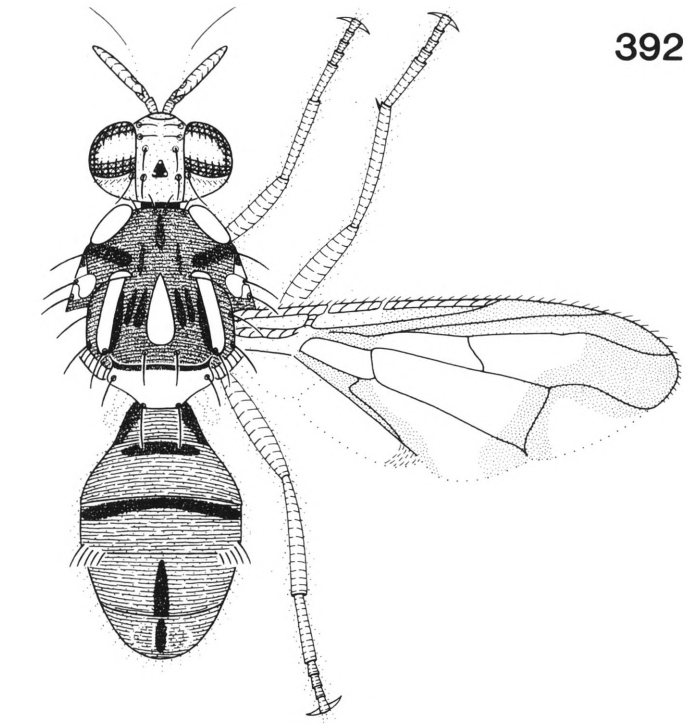


FIG. 390. *Bactrocera* (*Zeugodacus*) *curta* (Drew), adult male (x8). FIG. 391. *Bactrocera* (*Zeugodacus*) *daula* n. sp., adult male (x10).



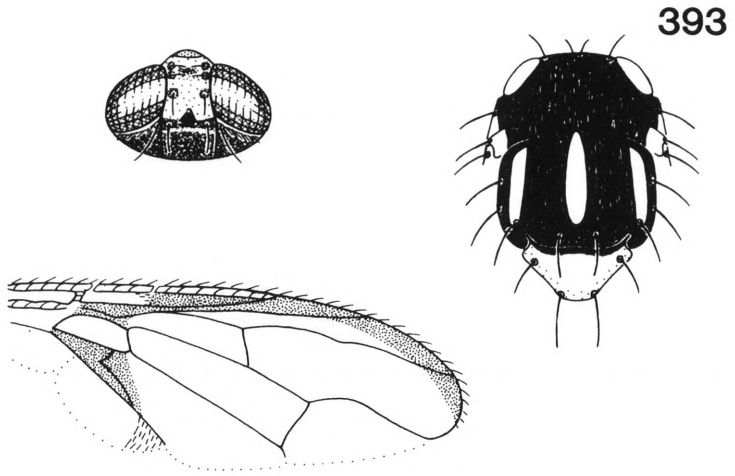
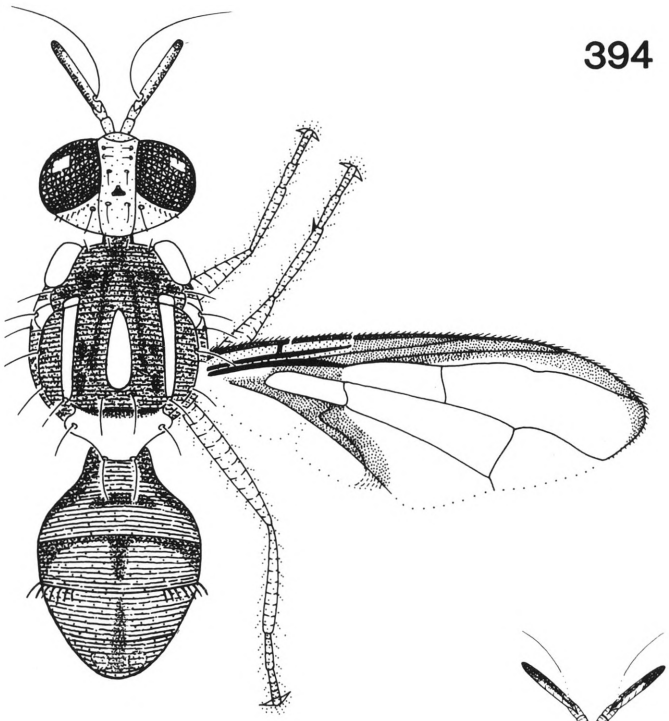


FIG. 392. *Bactrocera* (*Zeugodacus*) *emittens* (Walker), adult male (x8). FIG. 393. *Bactrocera* (*Zeugodacus*) *exornata* (Hering), adult male (x8).



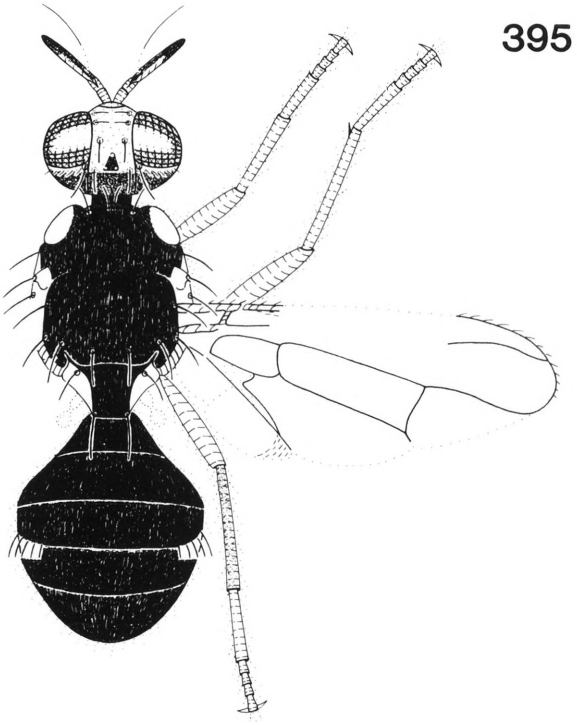
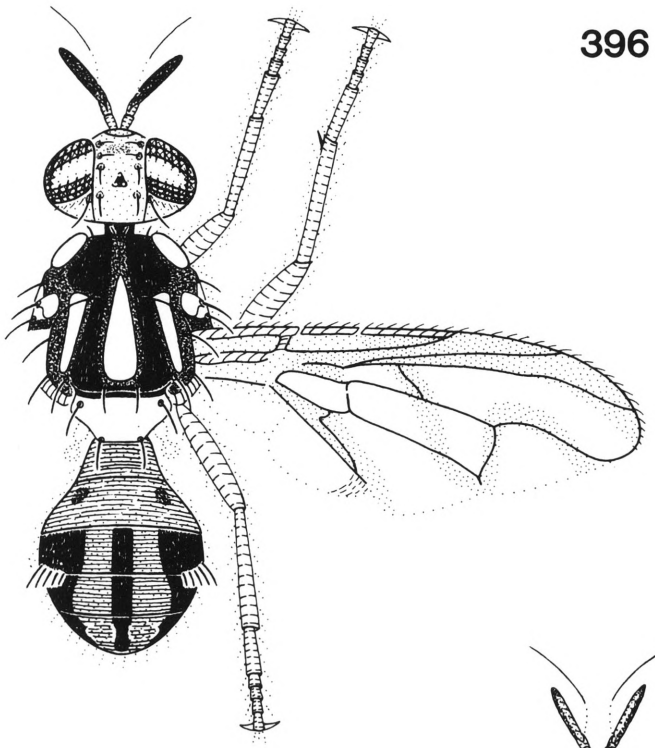


FIG. 394. *Bactrocera* (*Zeugodacus*) *fallacis* (Drew), adult male (x12). FIG. 395. *Bactrocera* (*Zeugodacus*) *fulvifacies* (Perkins), adult male (x10).



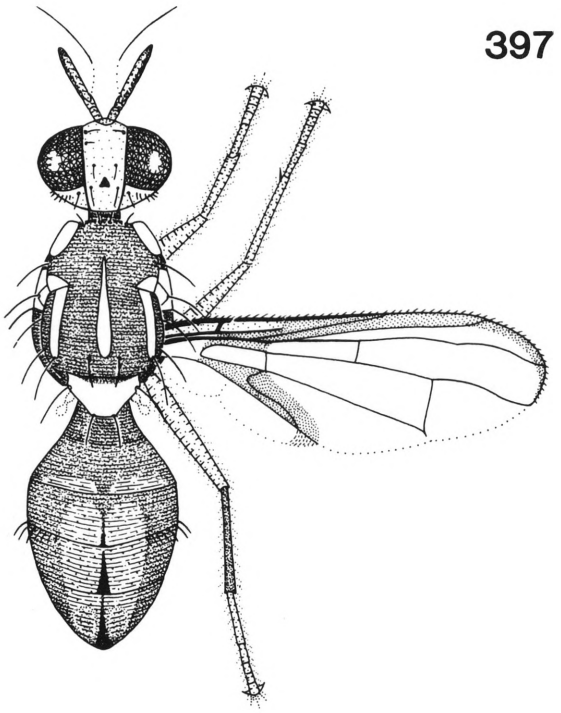
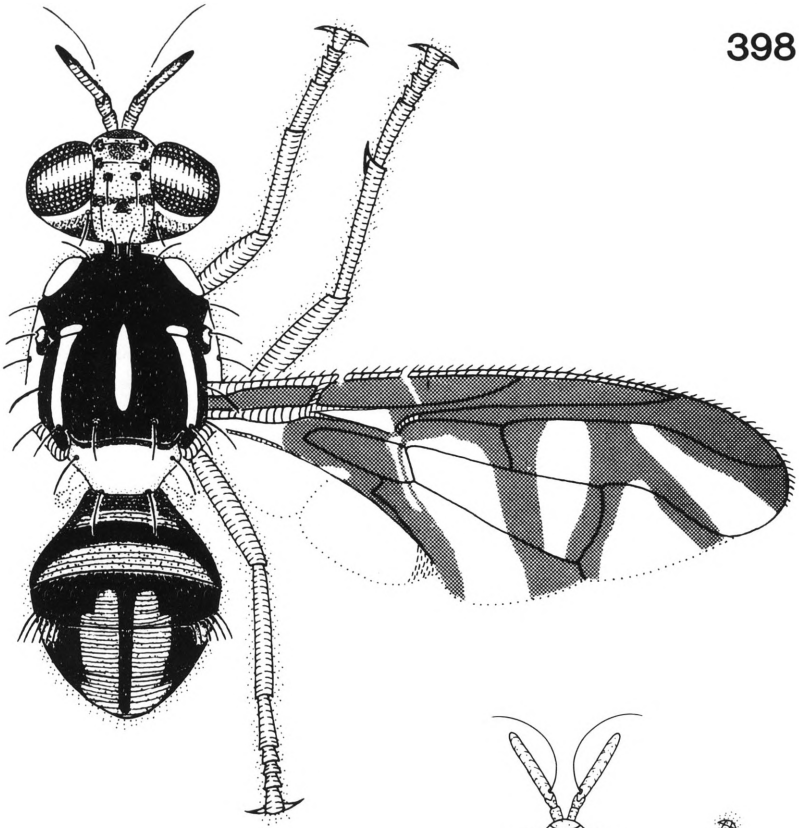


FIG. 396. *Bactrocera* (*Zeugodacus*) *gracilis* (Drew), adult male (x12). FIG. 397. *Bactrocera* (*Zeugodacus*) *macrovittata* n. sp., adult male (x8).



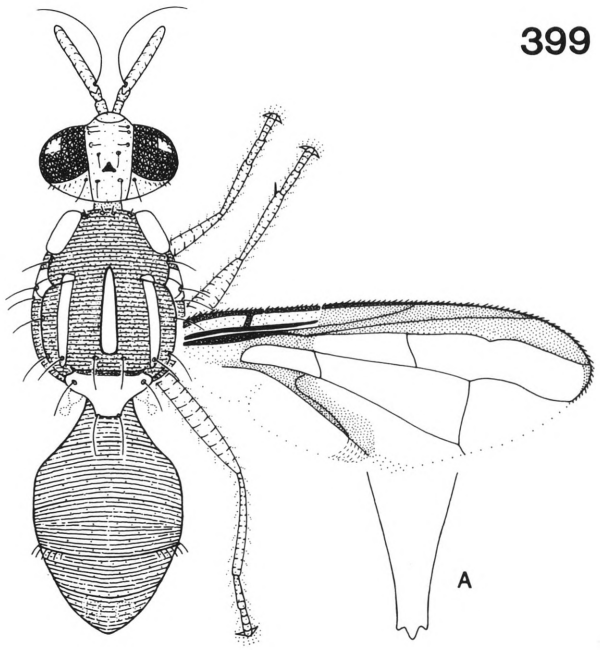


FIG. 398. *Bactrocera* (*Zeugodacus*) reflexa (Drew), adult male (x13). FIG. 399. *Bactrocera* (*Zeugodacus*) *sandaracina* n. sp., adult male (x7). A, apex of aculeus.

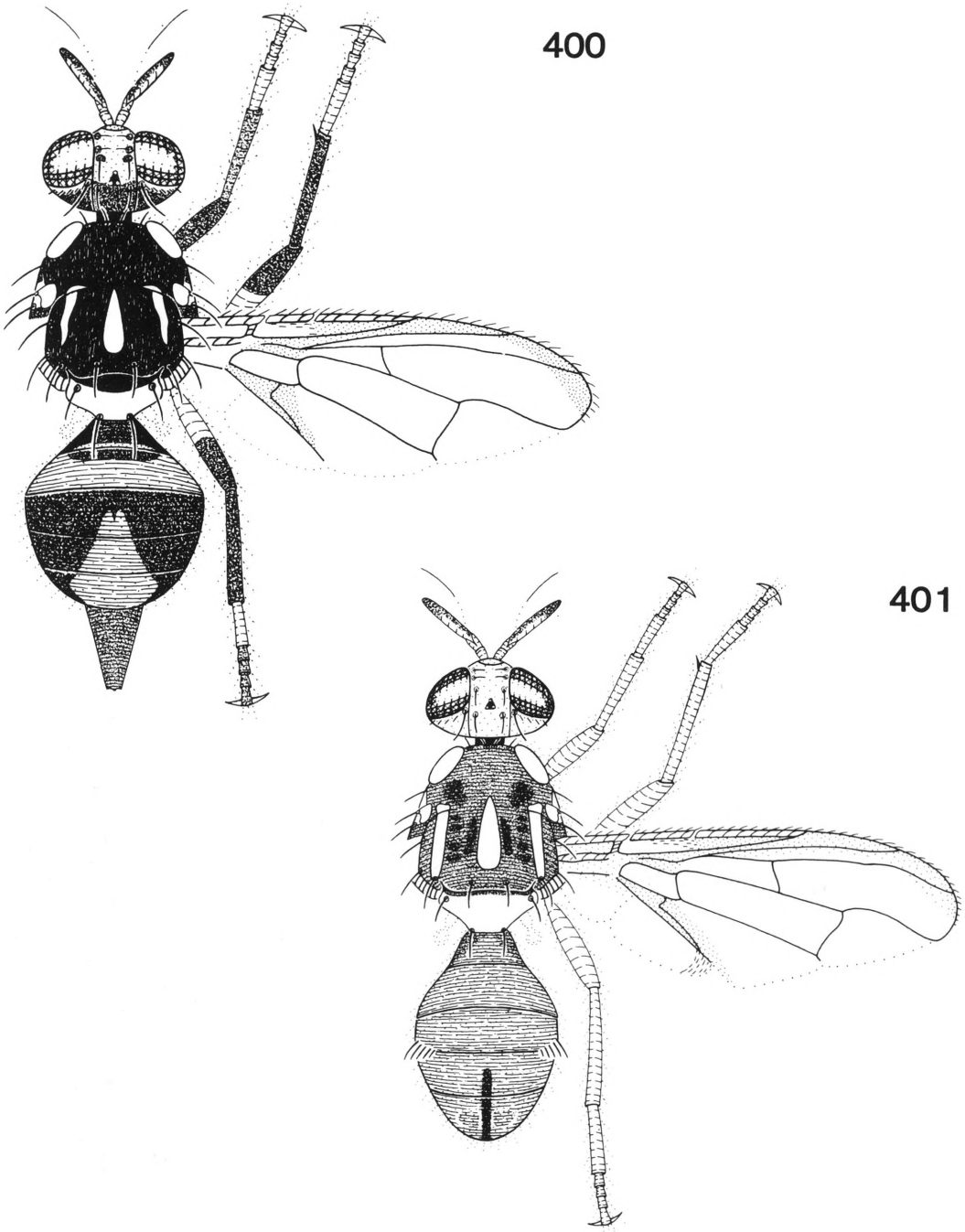
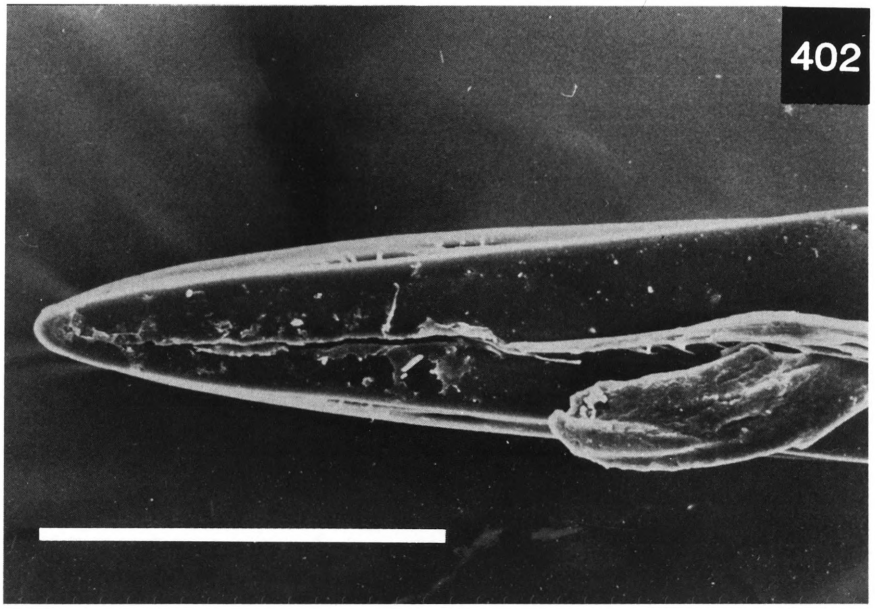
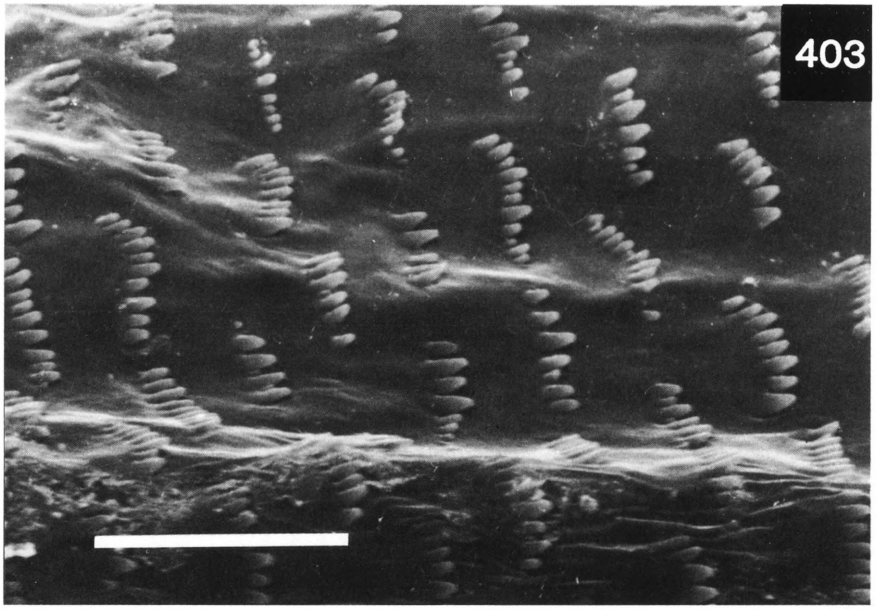
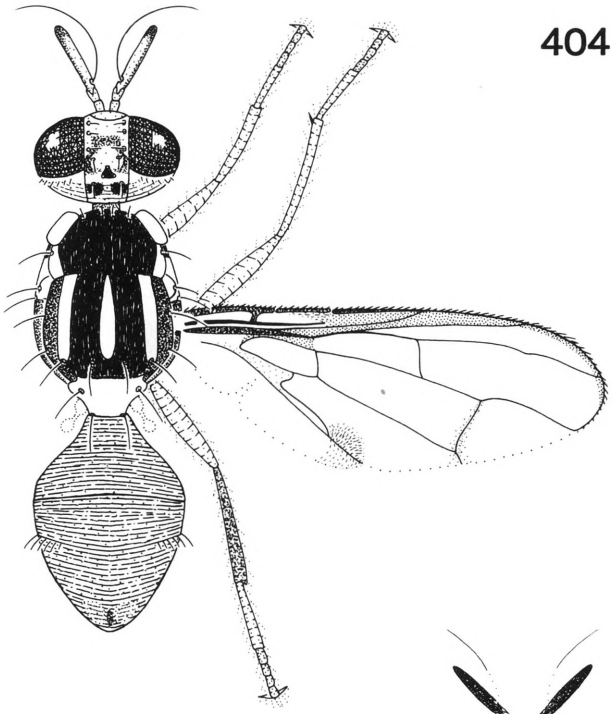


FIG. 400. *Bactrocera* (*Zeugodacus*) *timorensis* (Perkins), adult female (x13). FIG. 401. *Bactrocera* (*Zeugodacus*) *trichota* (May), adult male (x8).





FIGS 402–403. *Bactrocera* (*Zeugodacus*) *trichota* (May): 402, apex of aculeus (scale 0.1 mm); 403, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



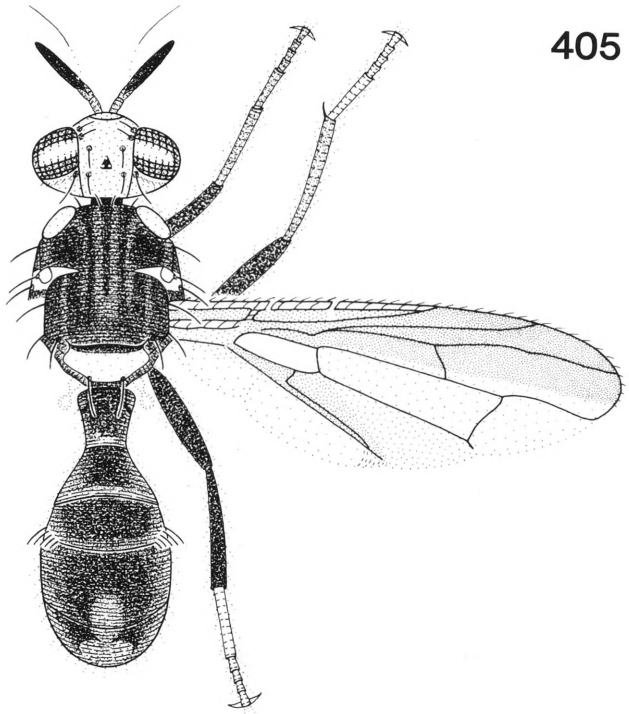
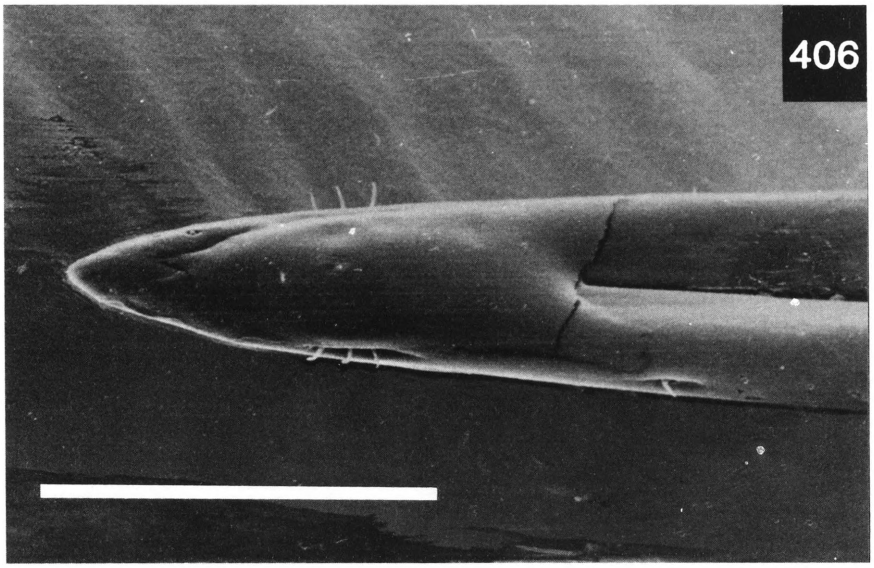
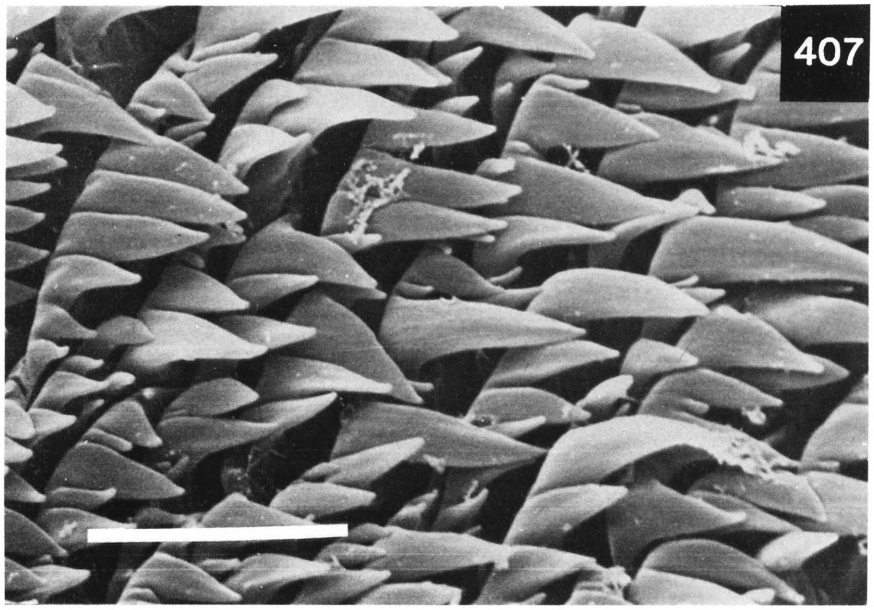
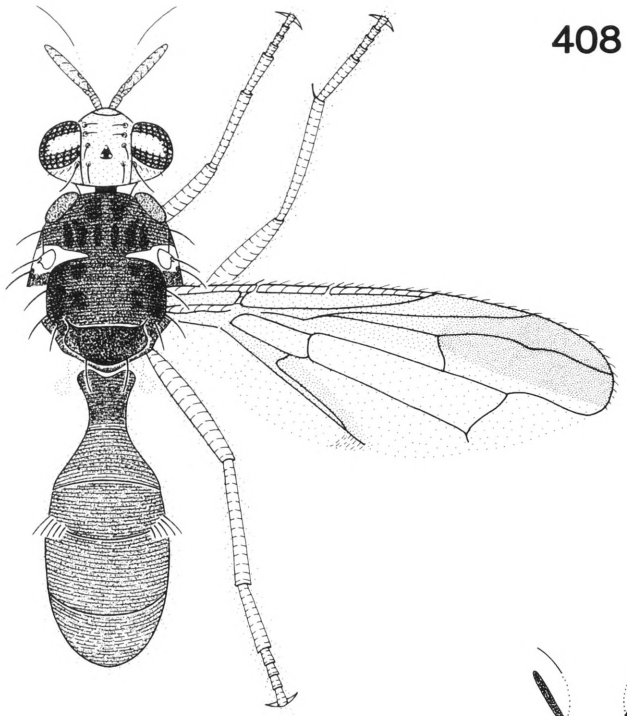


FIG. 404. *Bactrocera* (*Zeugodacus*) *unilateralis* n. sp., adult male (x8). FIG. 405. *Dacus* (*Callantra*) *axanus* (Hering), adult male (x7).





FIGS 406–407. *Dacus* (*Callantra*) *axanus* (Hering): 406, apex of aculeus (scale 0.1 mm); 407, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



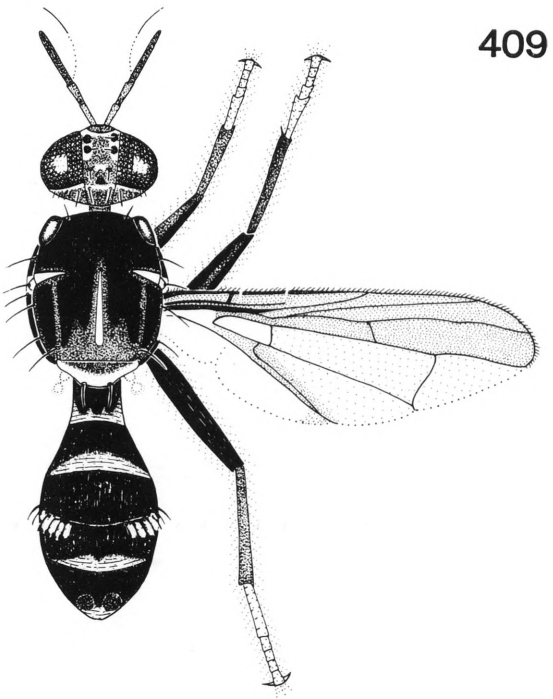
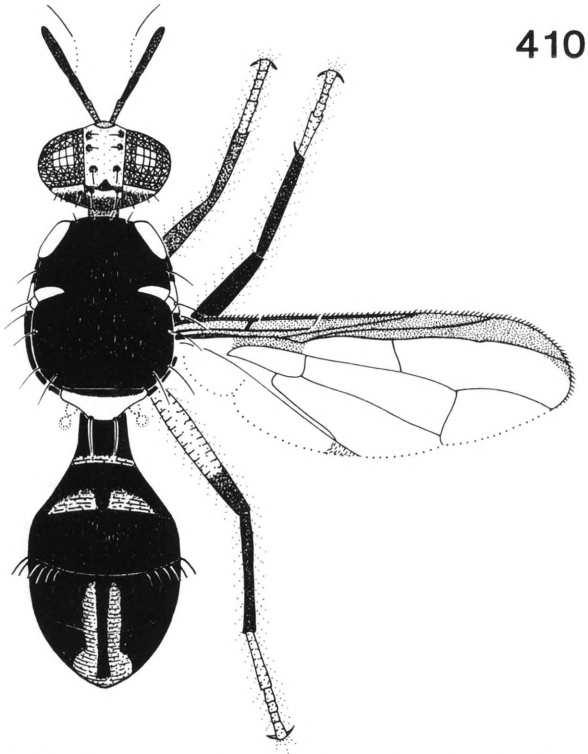
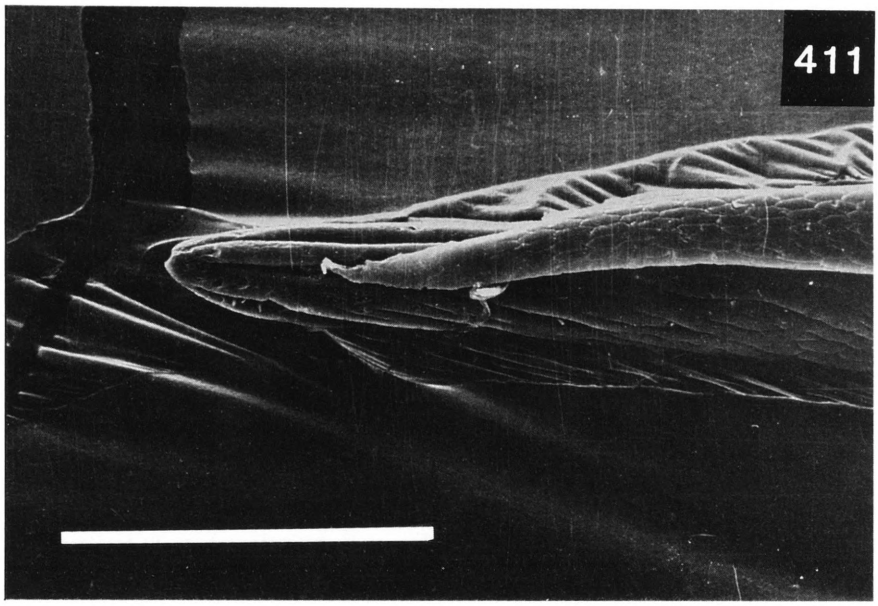
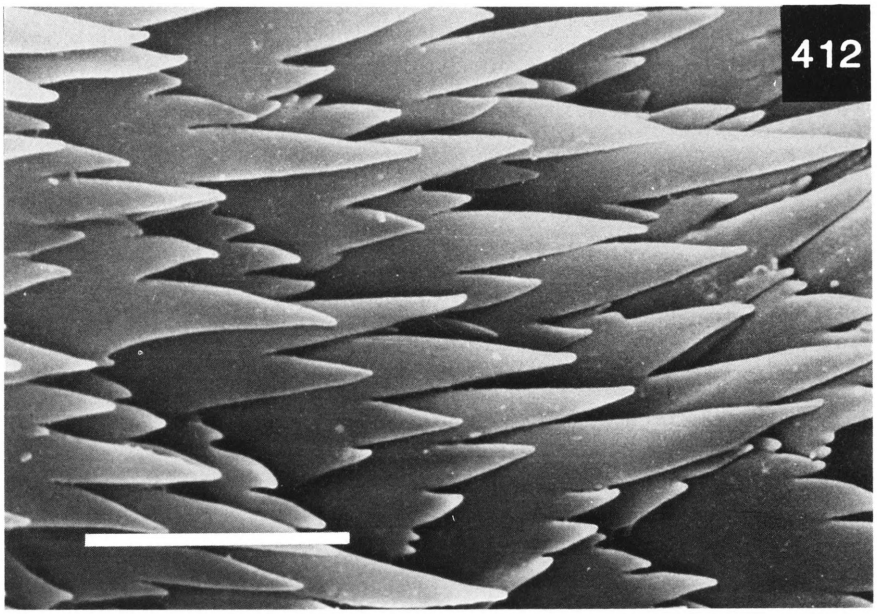


FIG. 408. *Dacus* (*Callantra*) *capillaris* (Drew), adult male (x7). FIG. 409. *Dacus* (*Callantra*) *discors* n. sp., adult male (x7).





FIGS 410–411. *Dacus* (*Callantra*) *impar* n. sp.: 410, adult male (x11); 411, apex of aculeus (scale 0.1 mm).



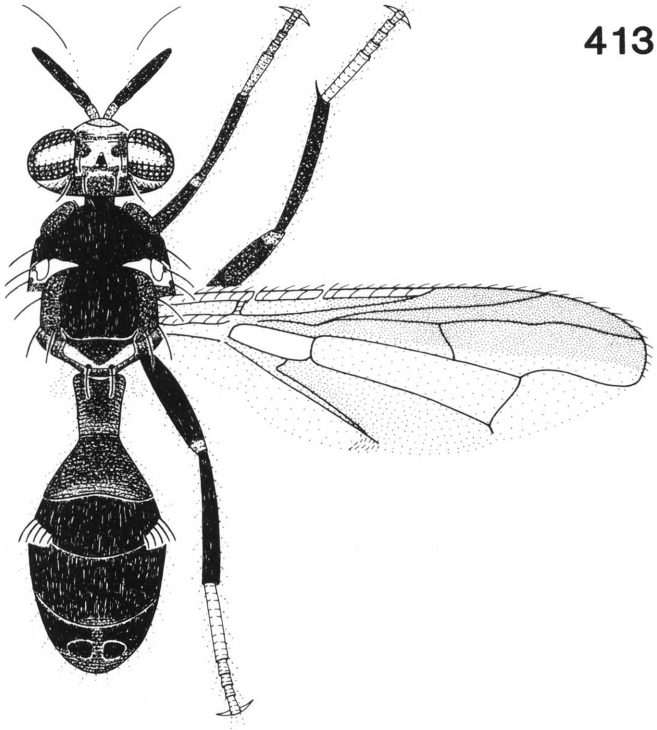


FIG. 412. *Dacus* (*Callantra*) *impar* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm).
FIG. 413. *Dacus (Callantra) mayi* (Drew), adult male (x7).

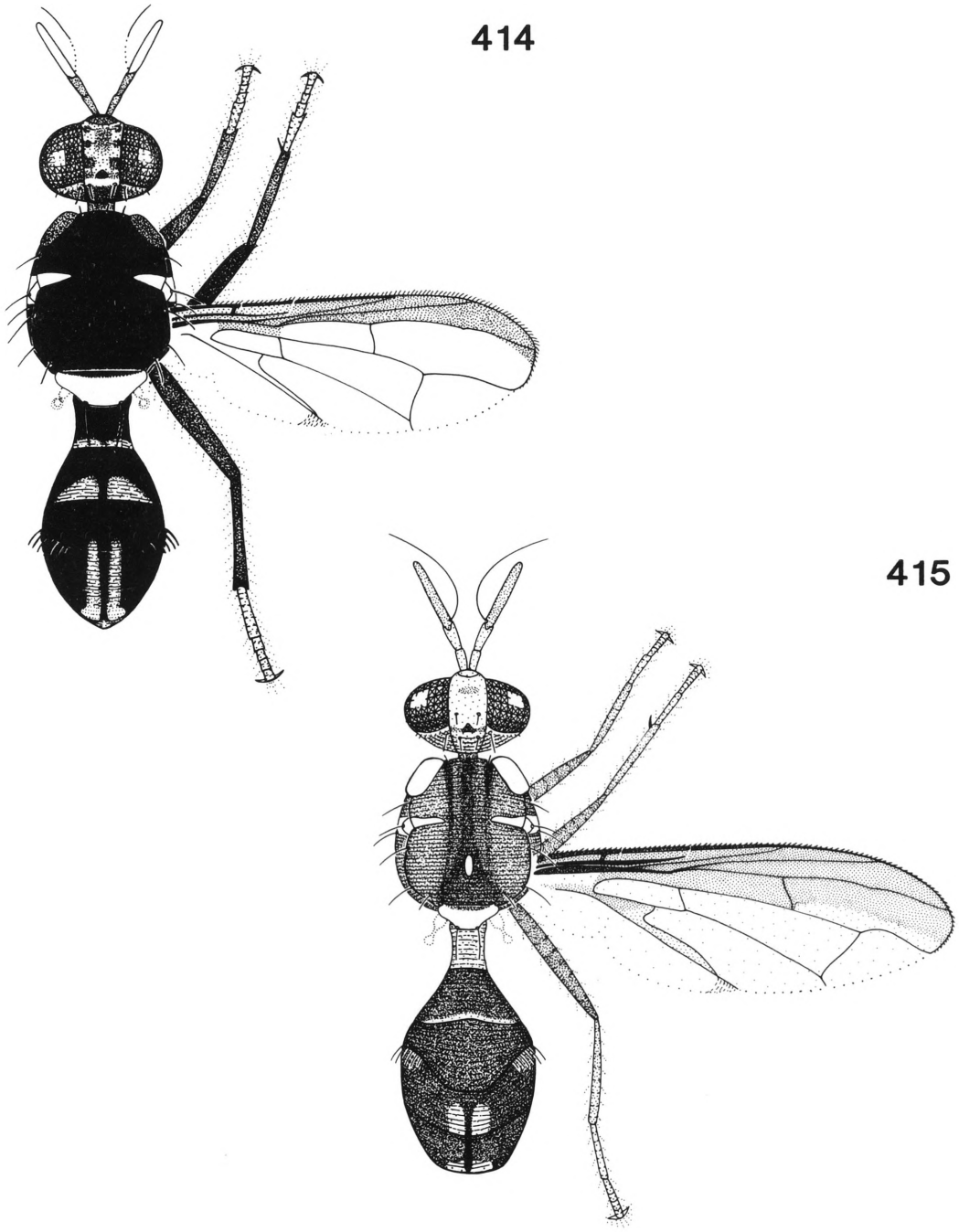
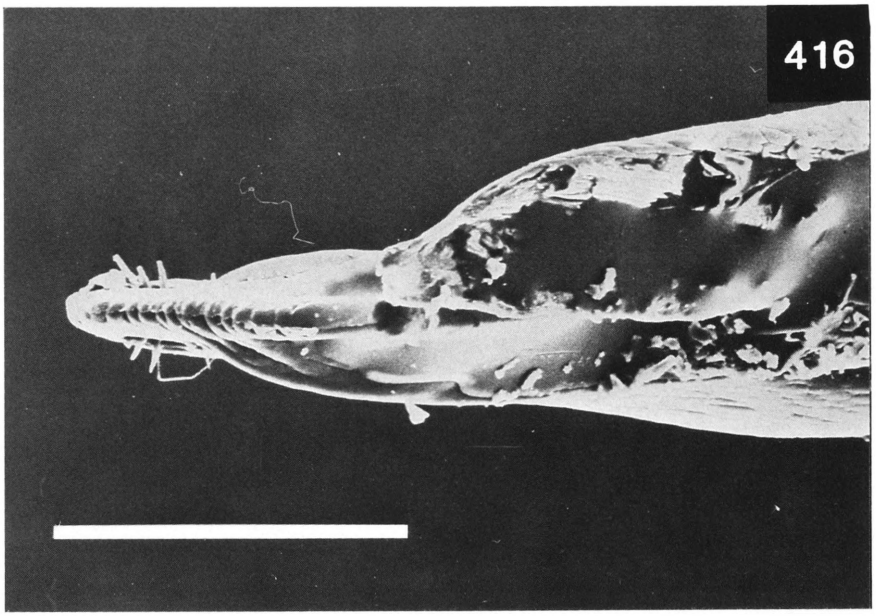
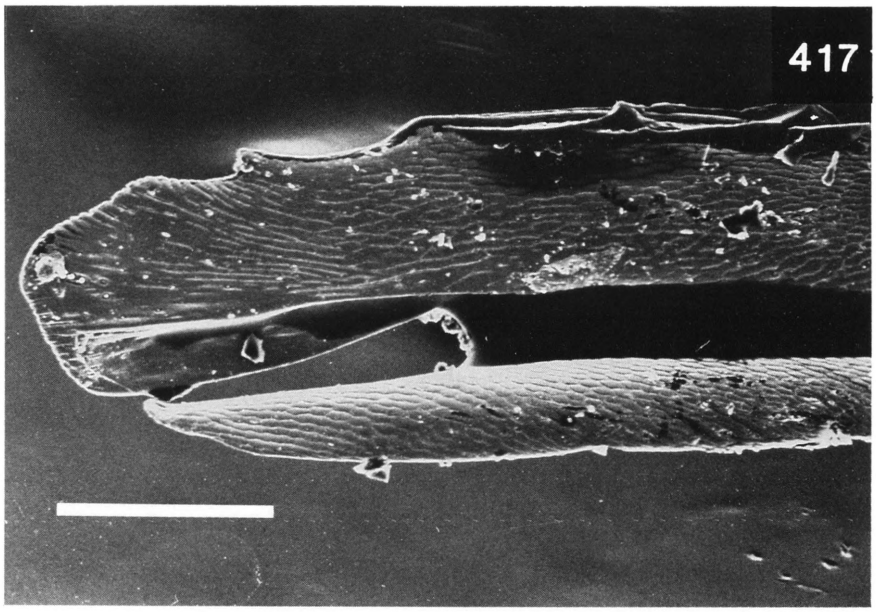
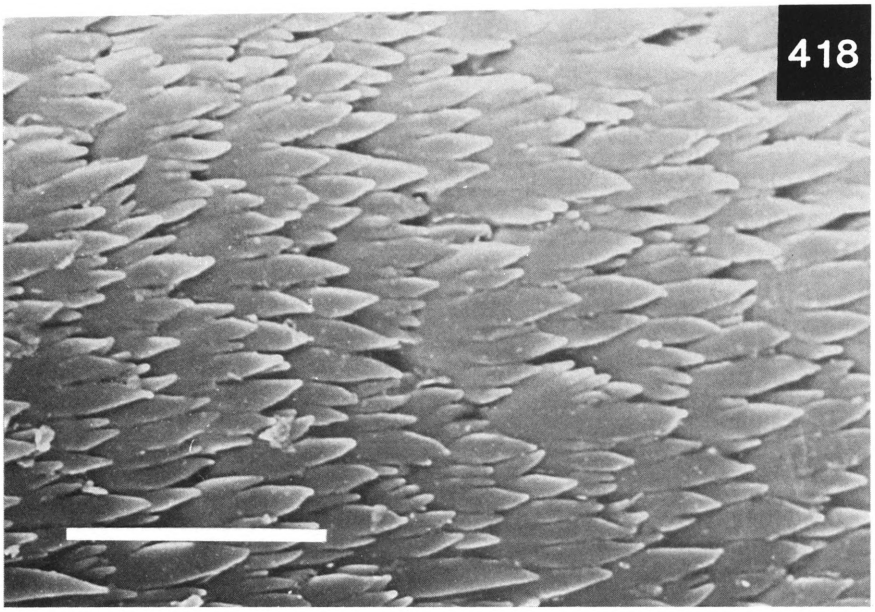


FIG. 414. *Dacus* (*Callantra*) *melanohumeralis* n. sp., adult male (x9). FIG. 415. *Dacus* (*Callantra*) *petioliforma* (May), adult male (x7).





FIGS 416–417. *Dacus* (*Callantra*) *petioliforma* (May): 416, apex of aculeus dorsal view (scale 0.1 mm); 417, apex of aculeus lateral view (scale 0.1 mm).



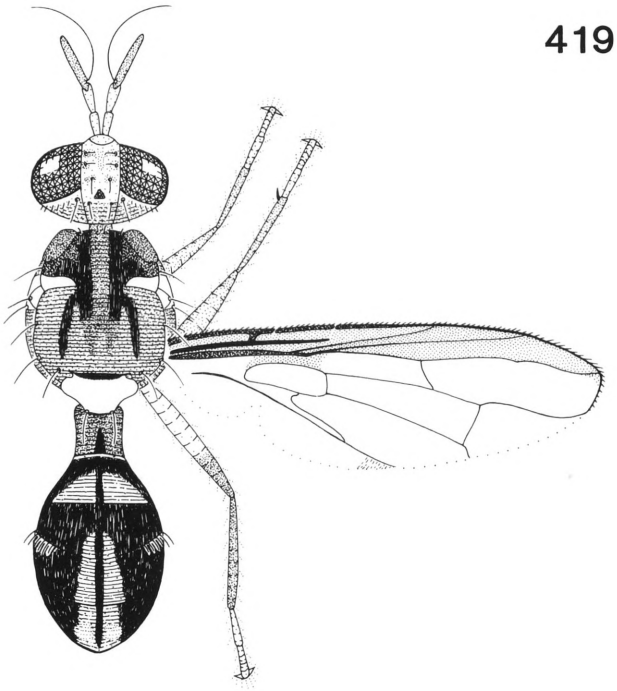
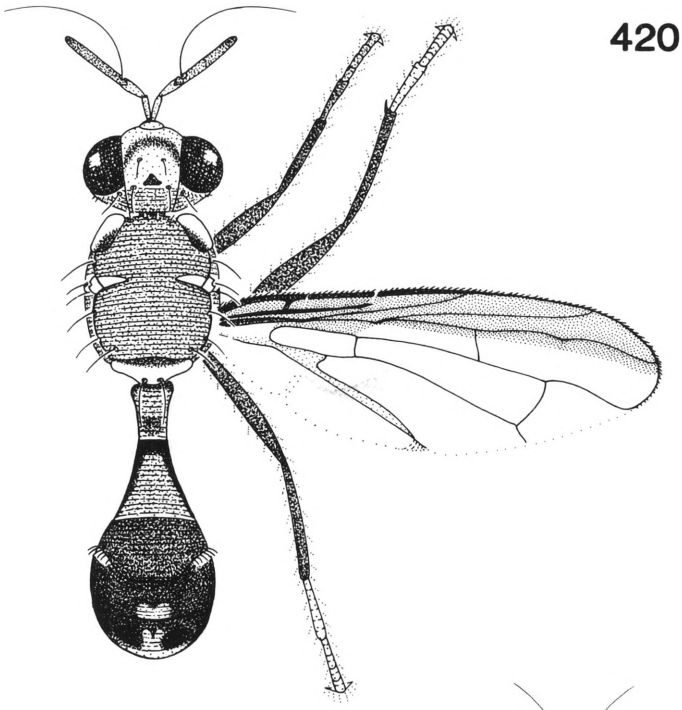


FIG. 418. Dacus (*Callantra*) *petioliforma* (May), spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 419. *Dacus* (*Callantra*) *pusillus* (May), adult male (x11).



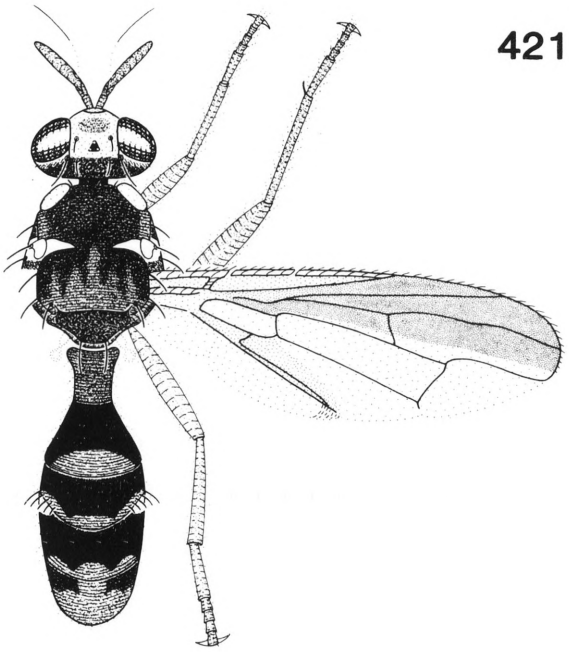
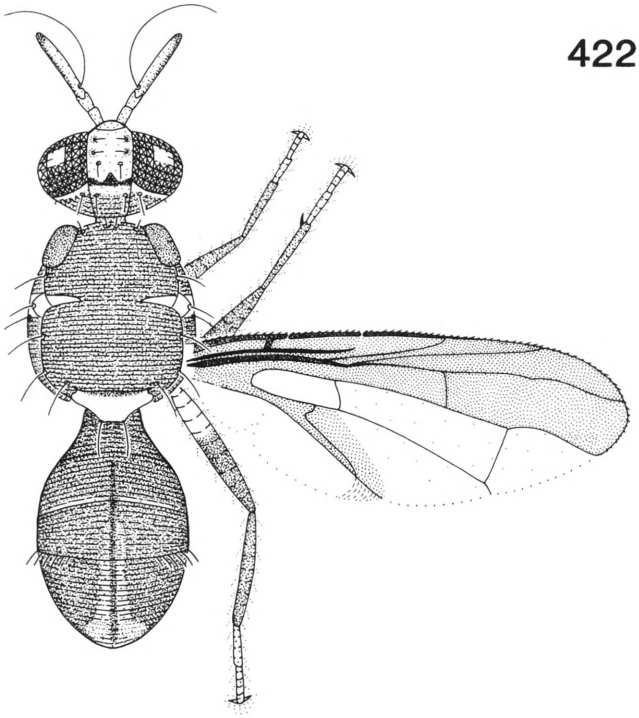
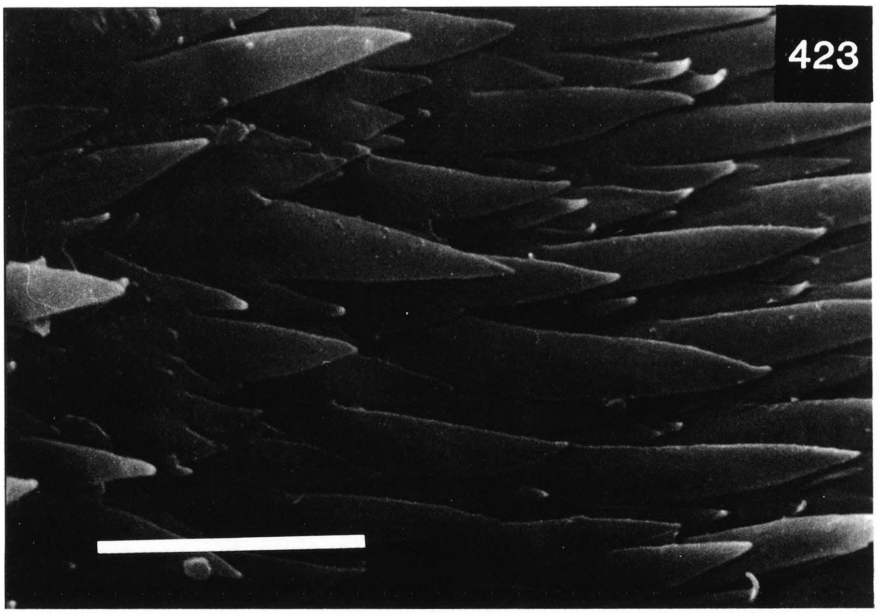
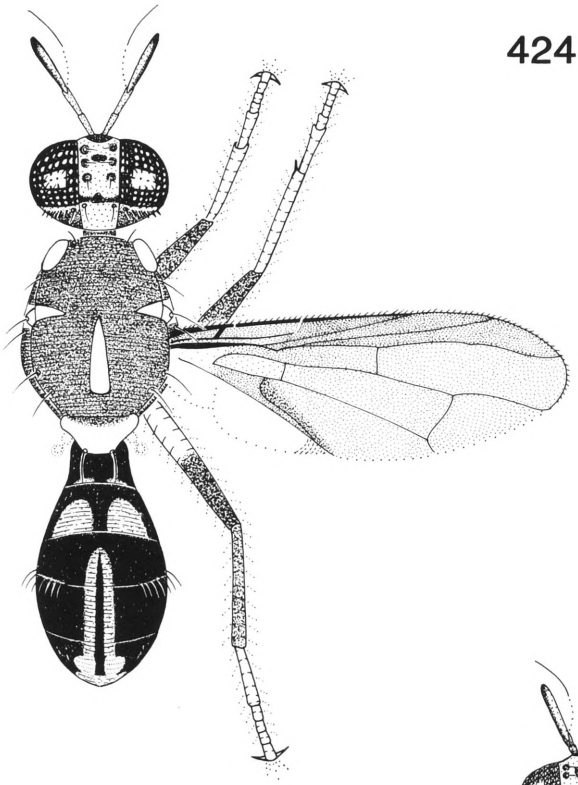


FIG. 420. *Dacus* (*Callantra*) *smieroides* (Walker), adult male (x7). FIG. 421. *Dacus* (*Callantra*) *solomonensis* Malloch, adult male (x6).





FIGS 422–423. *Dacus* (*Dacus*) *absonifacies* (May): 422, adult male (x10); 423, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).



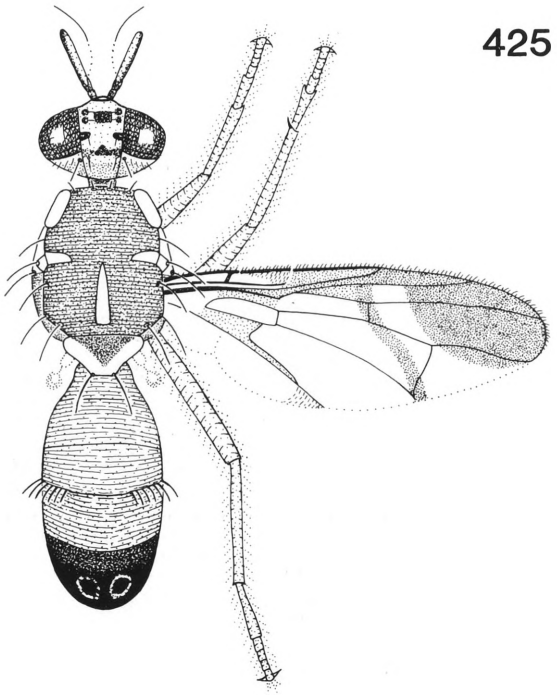


FIG. 424. *Dacus* (*Dacus*) *alarifumidus* n. sp., adult male (x9). FIG. 425. *Dacus* (*Dacus*) *alulapictus* n. sp., adult male (x7).

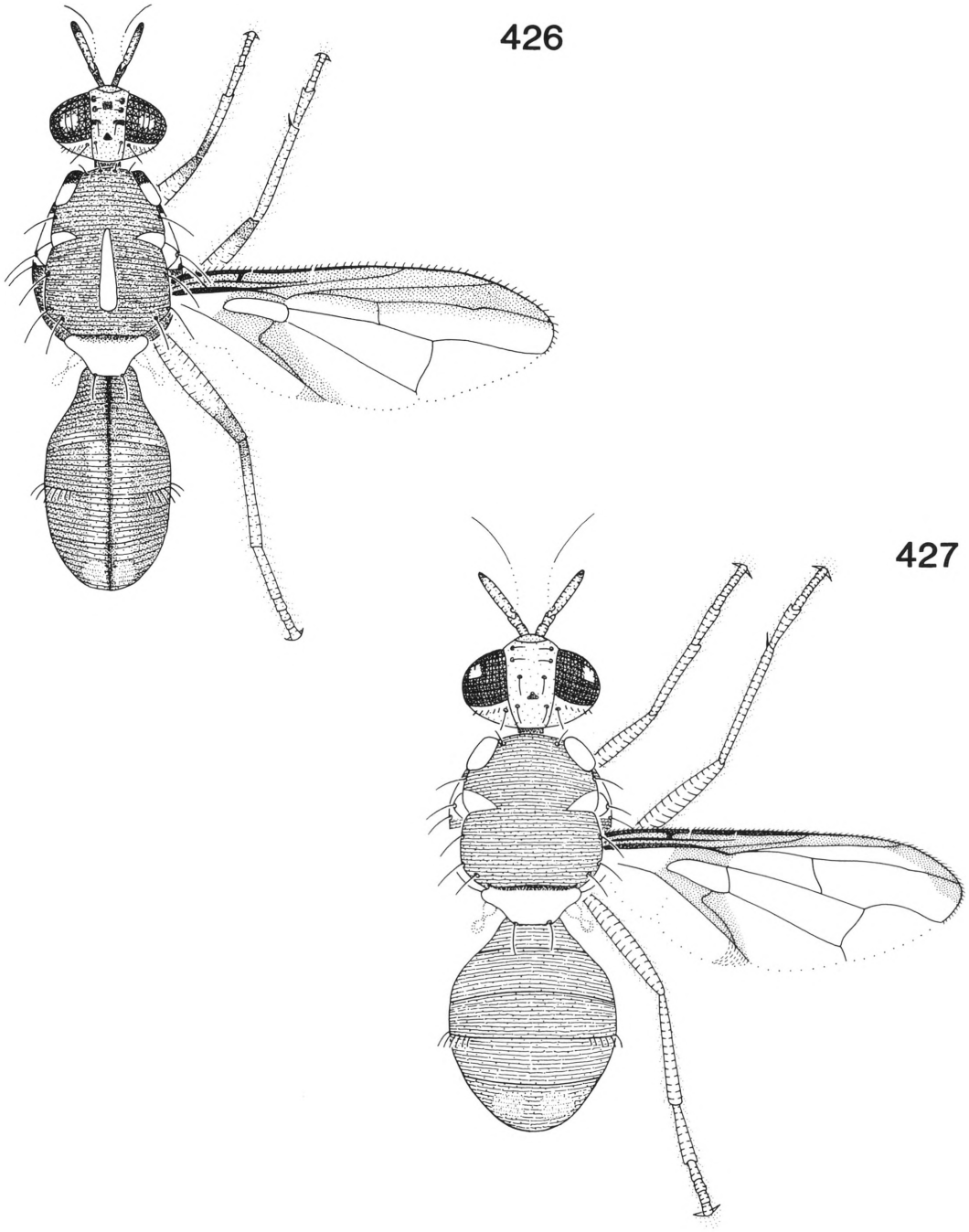
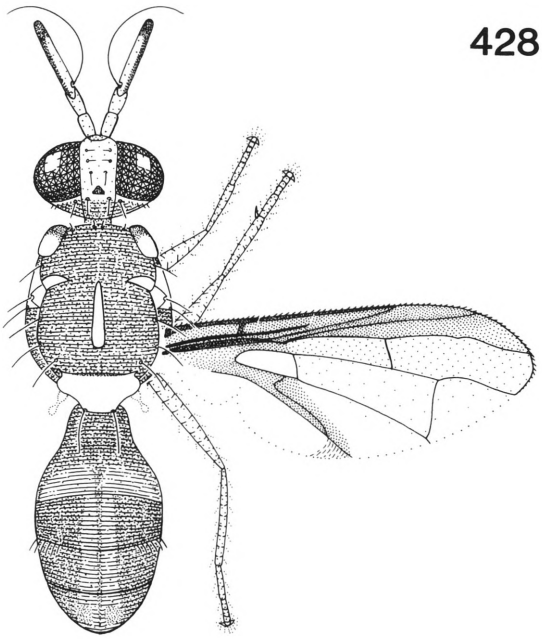


FIG. 426. *Dacus* (*Dacus*) *badius* n. sp., adult male (x8). FIG. 427. *Dacus* (*Dacus*) *bellulus* Drew and Hancock, adult male (x12).



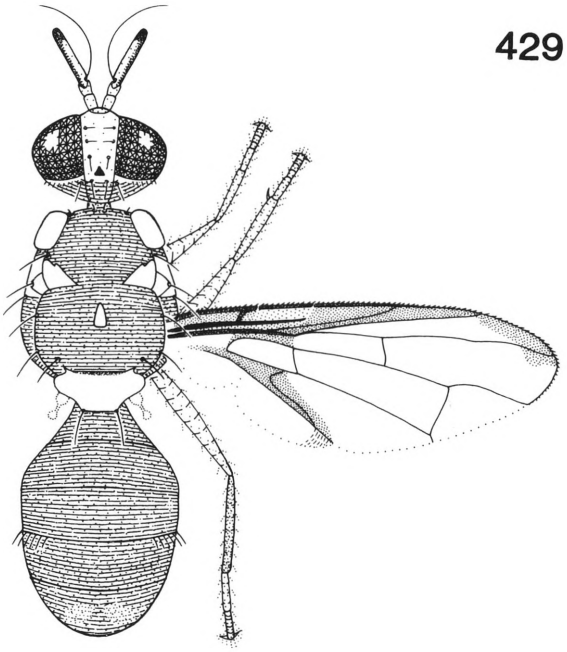
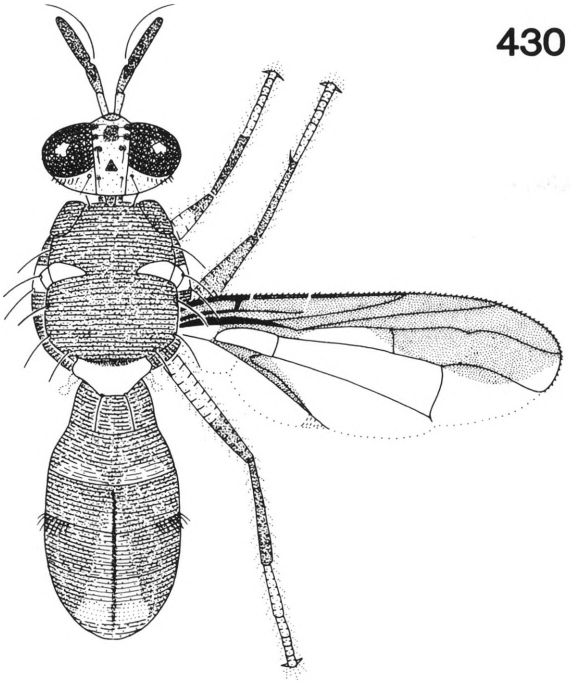
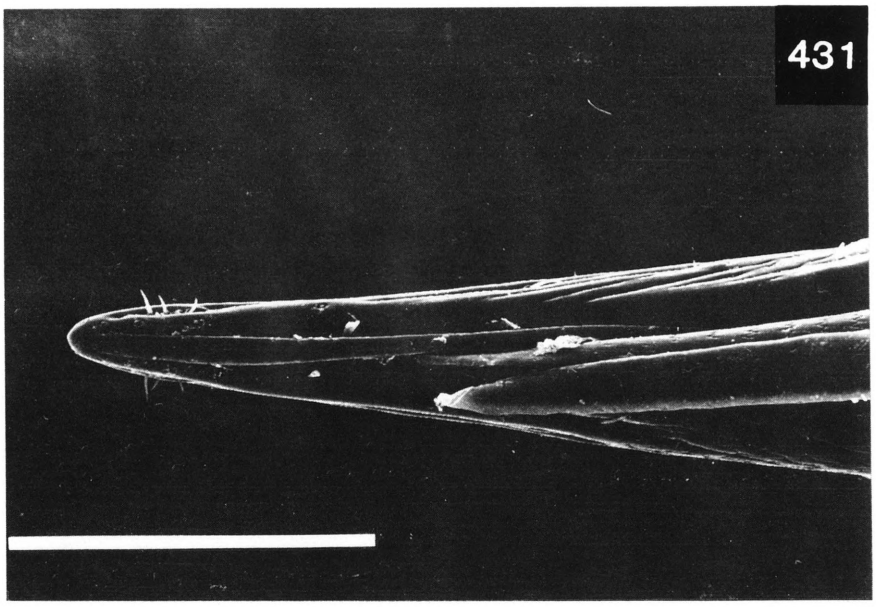
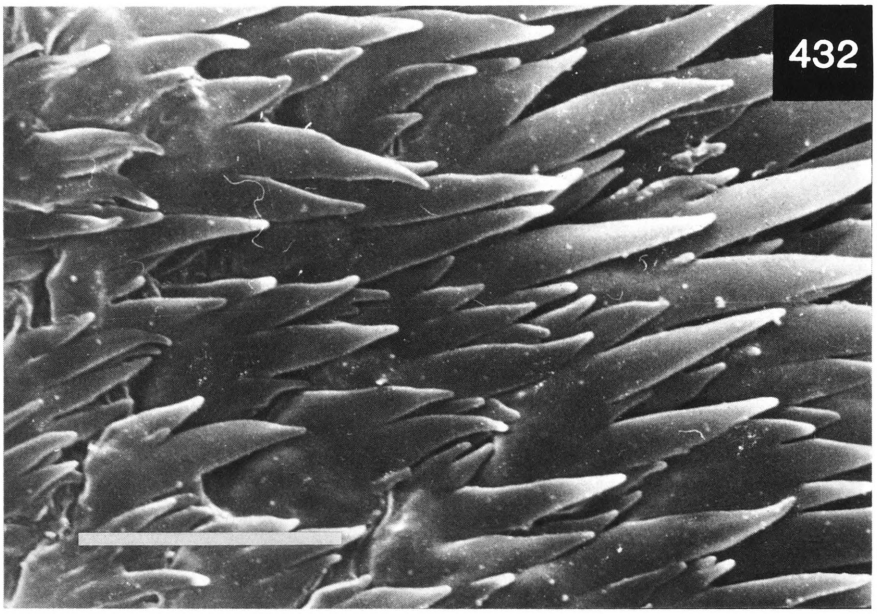


FIG. 428. *Dacus* (*Dacus*) *concolor* n. sp., adult male (x8). FIG. 429. *Dacus* (*Dacus*) *newmani* (Perkins), adult male (x11).





FIGS 430–431. *Dacus* (*Dacus*) *secamoneae* n. sp.: 430, adult male (x7); 431, apex of aculeus (scale 0.1 mm).



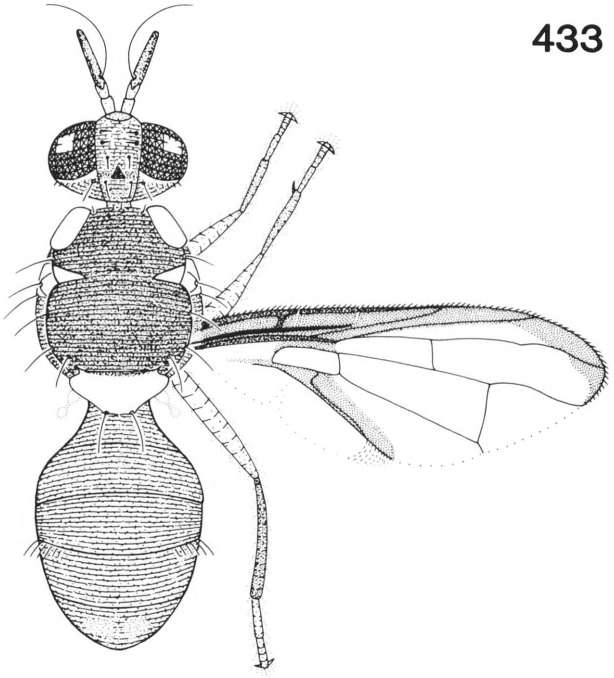
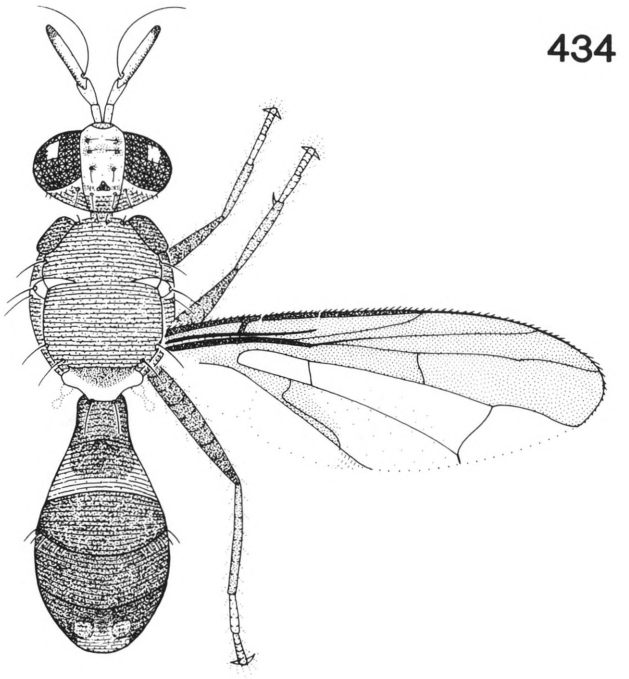
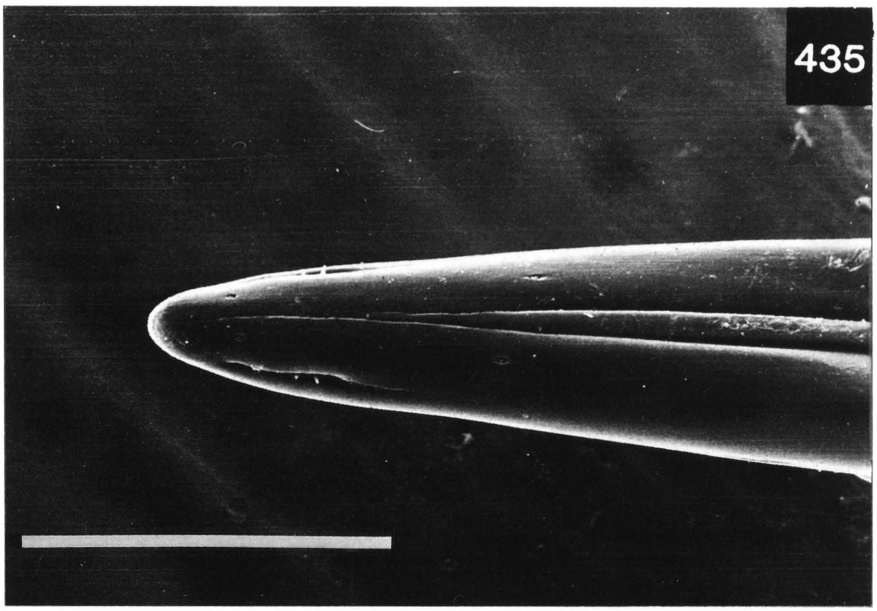
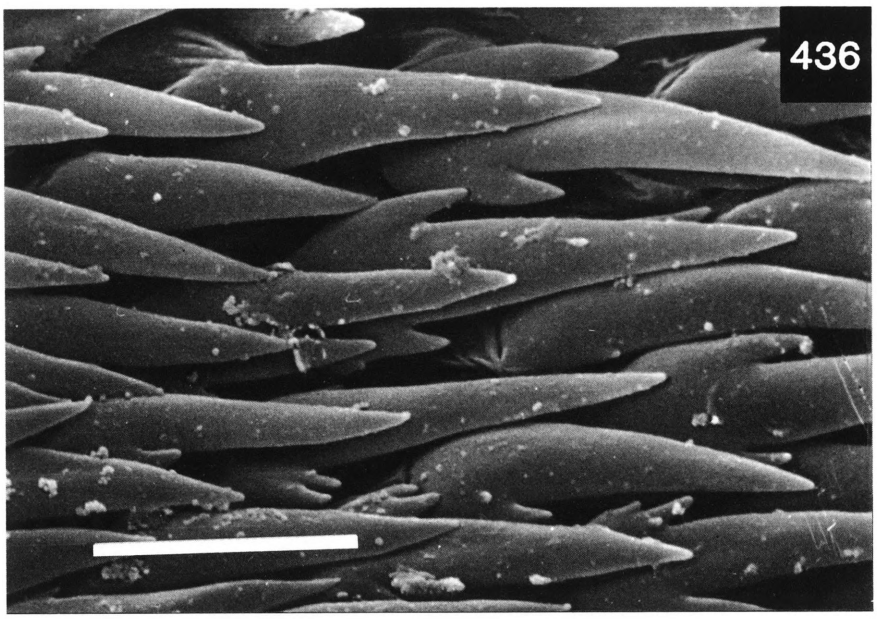


FIG 432. *Dacus* (*Dacus*) *secamoneae* n. sp., spicules on distal end of middle segment of ovipositor (scale 0.01 mm).
FIG. 433. *Dacus* (*Dacus*) *signatifrons* (May), adult male (x10).





FIGS 434–435. *Dacus* (*Didacus*) *aequalis* Coquillett: 434, adult male (x7); 435, apex of aculeus (scale 0.1 mm).



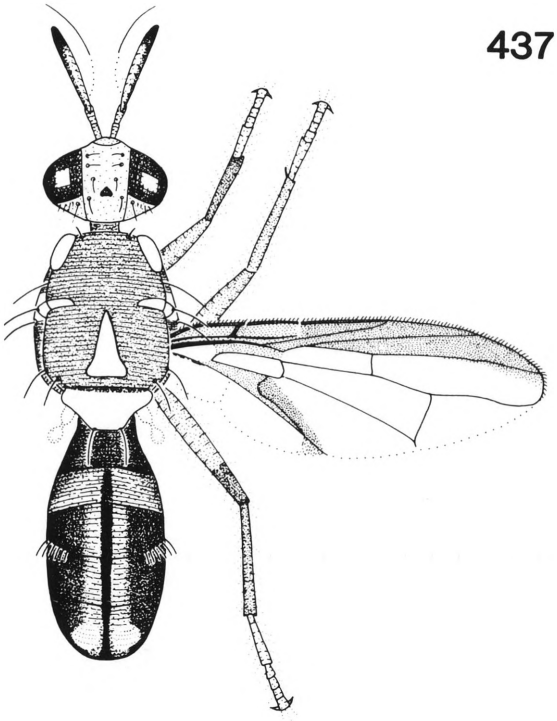
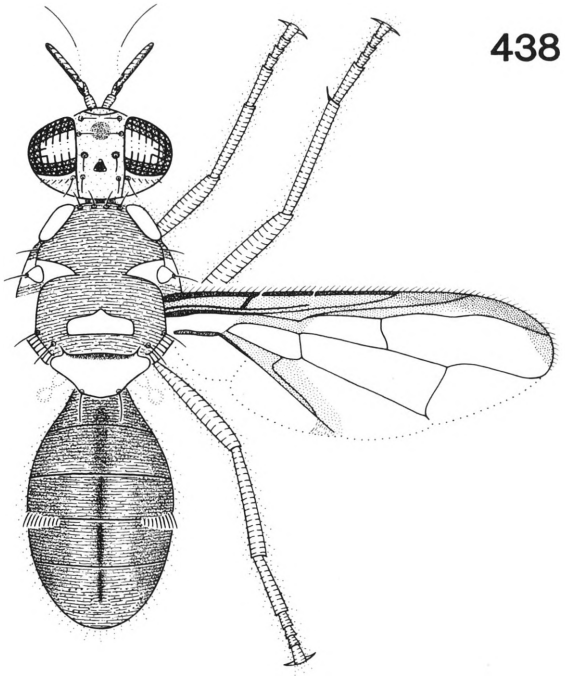
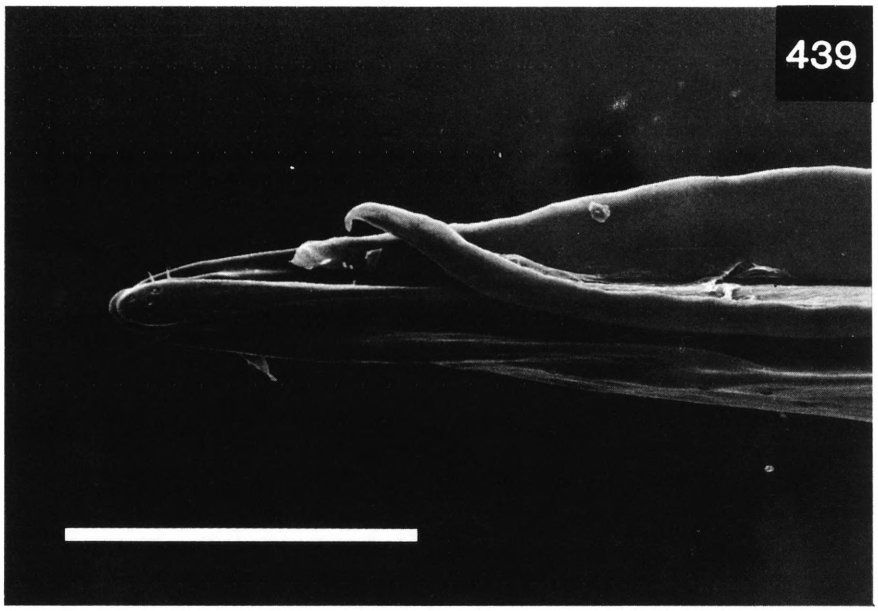
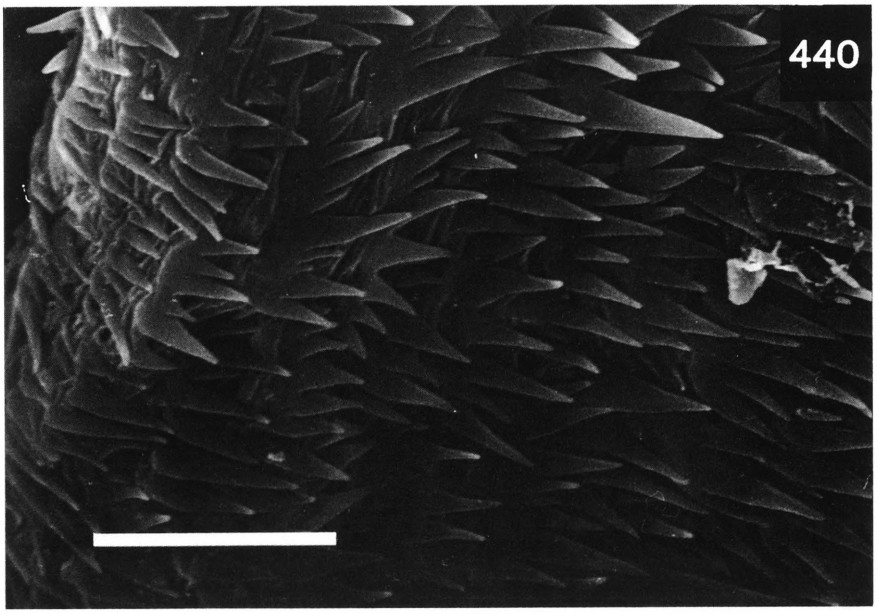


FIG. 436. *Dacus* (*Didacus*) *aequalis* Coquillett, spicules on distal end of middle segment of ovipositor (scale 0.01 mm). FIG. 437. *Dacus* (*Didacus*) *dissimilis* n. sp., adult male (x7).





FIGS 438–439. *Dacus* (*Didacus*) *hardyi* Drew: 438, adult male (x10); 439, apex of aculeus (scale 0.1 mm).



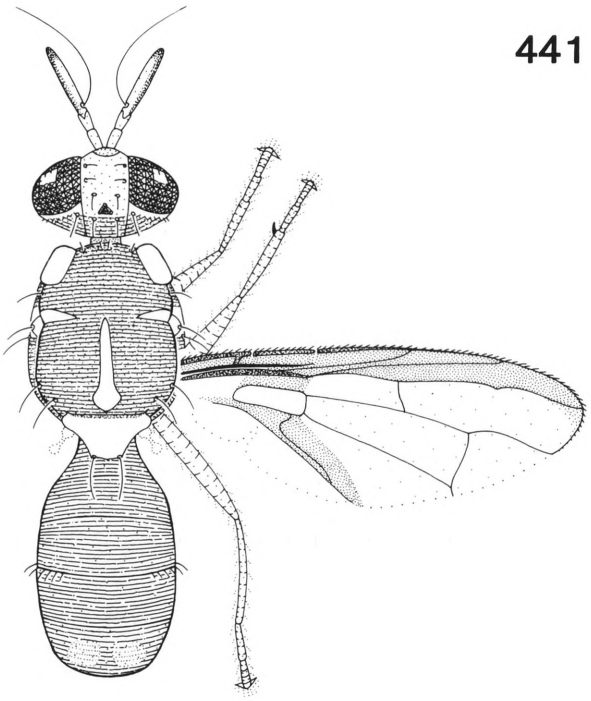


FIG. 440. *Dacus* (*Didacus*) *hardyi* Drew, spicules on distal end of middle segment of ovipositor (scale 0.01 mm).
FIG. 441. *Dacus* (*Didacus*) *maprikensis* n. sp., adult male (x8).

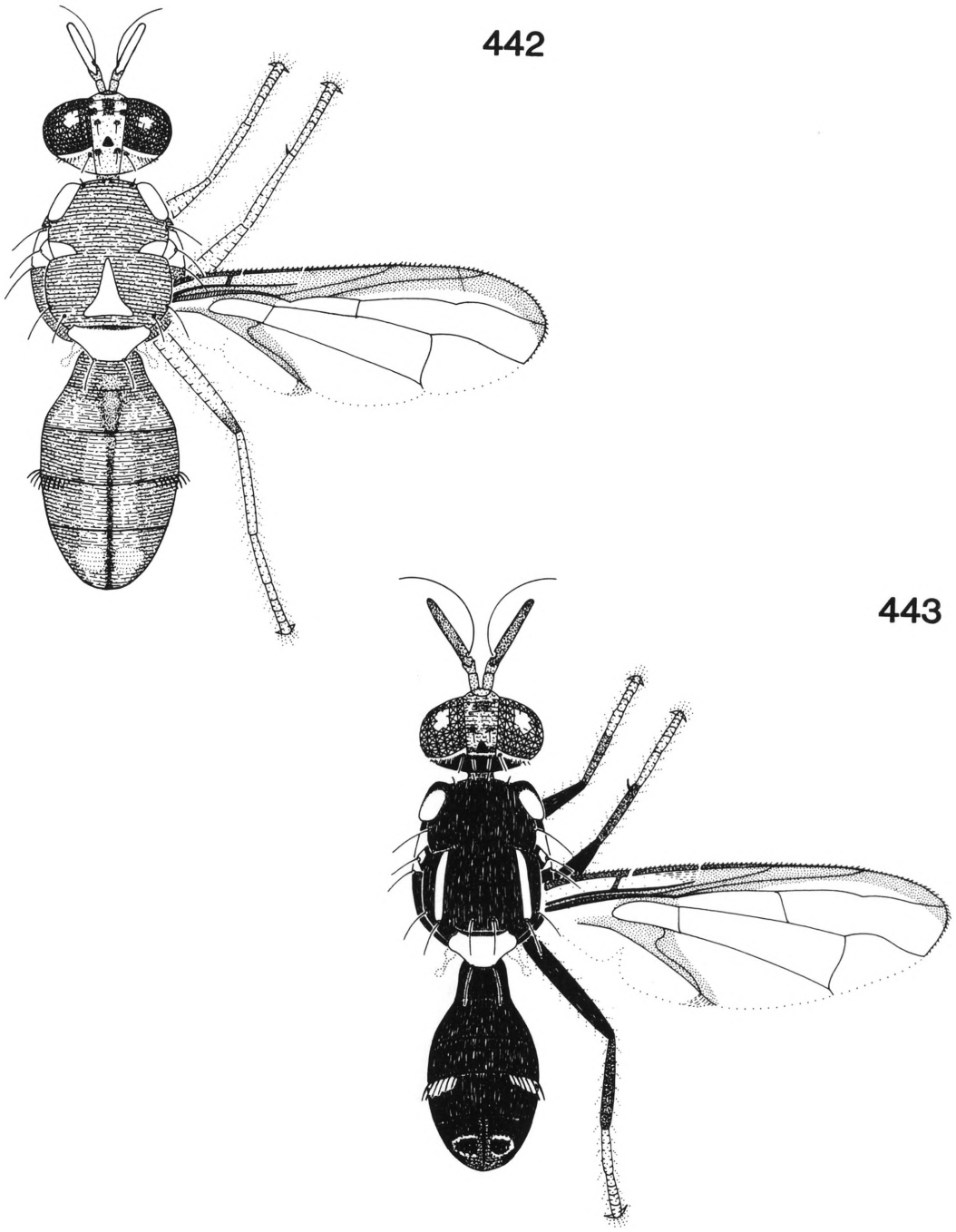


FIG. 442. *Dacus* (*Didacus*) *palmerensis* n. sp., adult male (x11). FIG. 443. *Dacus* (*Semicallantra*) *aquilus* n. sp., adult male (x9).

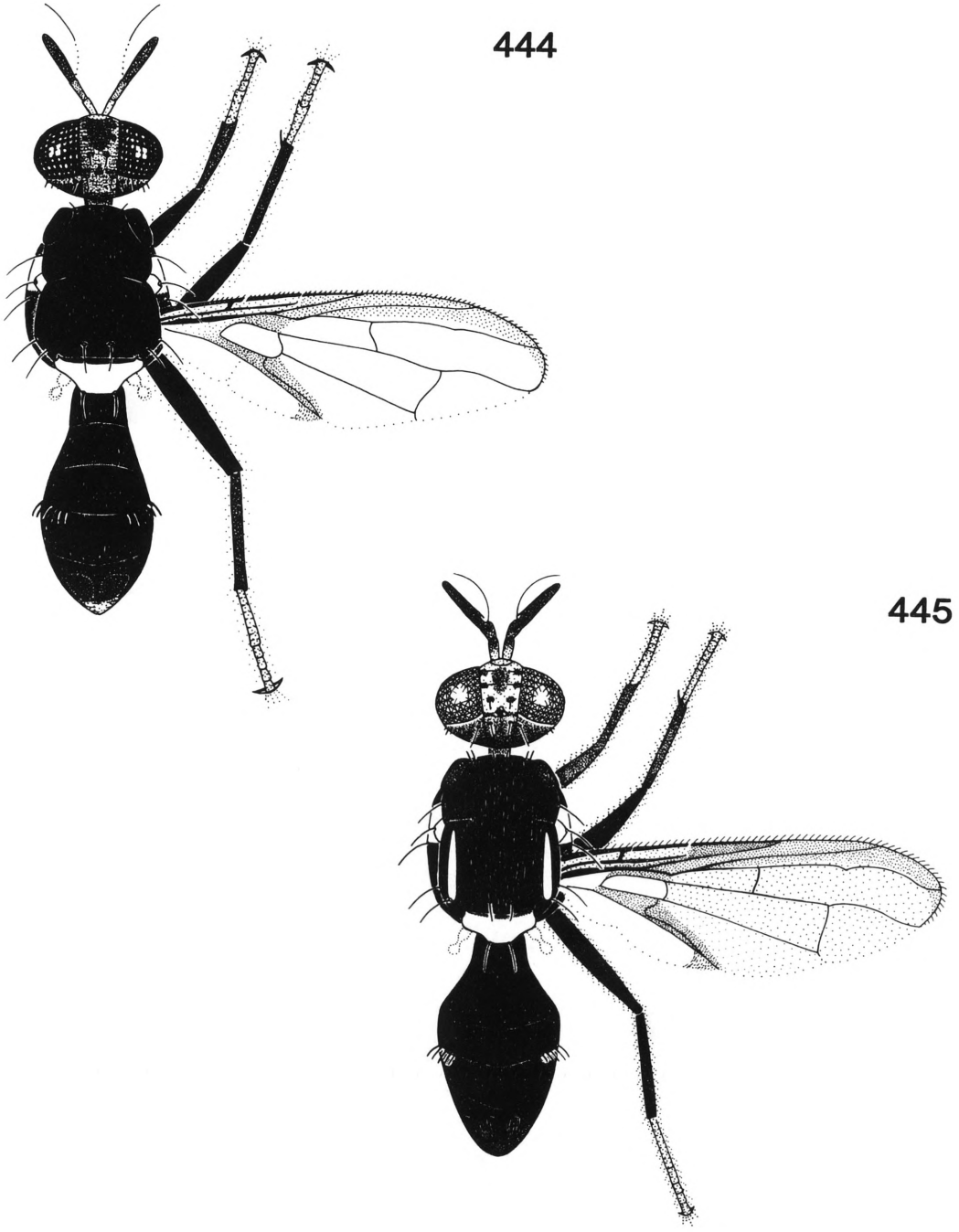


FIG. 444. *Dacus* (*Semicallantra*) *memnonius* n. sp., adult male (x8). FIG. 445. *Dacus* (*Semicallantra*) *nigriculus* n. sp., adult male (x9).

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