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BIOLOGY OF MACADAMIA FLOWER CATERPILLAR (HOMOEOSOMA VAGELLA ZELL.)

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SUMMARY

The life history, habits and seasonal incidence of *Homoeosoma vagella,* a pest of macadamia nuts in Queensland, are described. The insect attacks the flowers of the macadamias and is known only from proteaceous hosts. As populations are low during winter, early flowerings of *M. integrifolia* types usually escape serious damage. The destruction of flowers in September-October often results in severe reduction of yields. A number of natural enemies are believed to be important in regulating numbers of *H. vagella.* Control measures are discussed.

I. INTRODUCTION

The macadamia flower caterpillar (*Homoeosoma vagella* Zell.) is a very common and widespread species in Australia (Tillyard 1926), and a well-known pest of the native macadamia nut trees (Ironside and Davis 1969). Recent expansion in macadamia nut growing in Queensland has led to increased interest in insecticide treatment of these trees as a means of increasing yields, particularly by preventing the flower destruction caused by the flower caterpillar. Before the extensive use of chemical control is developed, information on the biology of this insect is desirable so that insecticidal applications can be made to the best advantage. As very little information on the biology of the flower caterpillar is available, studies on its life history and habits have been made in the Nambour and Beerwah districts.

II. HOST PLANTS AND DISTRIBUTION

The recorded host plants of *H. vagella* in the genus *Macadamia* are *M. integrifolia* Maiden and Betche, *M. tetraphylla* L. A. S. Johnson and also the hybrid types. Other hosts are *Grevillea banksii* R. Br., *G. robusta* A. Cunn., *Xylomelum pyriforme* Knight and *Buckinghamia celsissima* F. Muell. All are Proteaceae.

The flowering habits of the macadamias are significant in the importance of attacks by the flower caterpillar on nut production. Flowering time of *M. integrifolia* varies considerably: most trees have a major flowering in August to September; some may flower again in March to April; some have flowers all the year round; and some have an extended flowering period from May to September and set a significant portion of their crop during the winter. *M. tetraphylla* trees, however, usually have a more defined flowering period between August and October, with some lesser flowerings in November-December.

H. vagella attacks only the flowers, although tender terminal foliage and young nuts in the vicinity of flowers can be damaged by larvae moving from the flowers during heavy infestations.

H. vagella occurs widely throughout coastal Queensland but it appears to be a less severe pest in some localities where temperatures are probably lower when macadamias are flowering. At Maleny, numbers were not sufficient during the flowering seasons 1963 to 1969 to seriously reduce yields in *M. tetraphylla* plantings. The pest occurs in the South Burnett region but good nut sets are obtained without the use of insecticidal control. In this region heavy *H. vagella* infestations have been recorded from *Grevillea robusta,* which flowers after the main macadamia flowering.

III. LIFE HISTORY

Moths of the flower caterpillar have not yet been induced to oviposit viable eggs under laboratory conditions. Eggs of known age were obtained by covering flowers on trees, then exposing these for one night when populations of ovipositing moths were present. Data on the incubation period were supplemented by records from large numbers of field-collected eggs. Larval periods were determined by rearing the insects on flower racemes held in glass tubes in the laboratory.

Development times for the several immature stages given in Table 1 were obtained in the period from June to September. The shortest time for complete development occurred in December and was 23 days, comprising 3 days for incubation, 12 days for larval development and 8 days for the duration of the pupal stage.

TABLE 1

Duration of Immature Stages of *H. vagella* on Macadamia

Stage	Duration (days)	Approximate Range of Daily Temperature (°C)
Egg	4–9	21–15
Larva instar I	3–5	21–16
Larva instar II	2–3	
Larva instar III	2–5	
Larva instar IV	2–4	
Larva instar V	6–14	
Pupa	10–23	26–17

IV. DESCRIPTION AND HABITS

Eggs.—The egg is oval, averaging 0·48 mm x 0·31 mm, and moderately flattened, with a finely punctate surface. The colour is at first white, then darkens to yellow, and just before eclosion the dark brown larval head capsule is visible.

Eggs are laid singly or in groups of up to four (Figure 1). They may occur anywhere on a raceme but often are hidden under the small ligule-like process between adjacent pairs of floret stalks. Over 100 eggs may be laid on one raceme. In one instance 337 eggs were found on a raceme 28 cm long and having 273 buds. The larger number of eggs per raceme and the higher percentages of infested racemes are found when the unopened floret buds are 3 mm to 7 mm long.

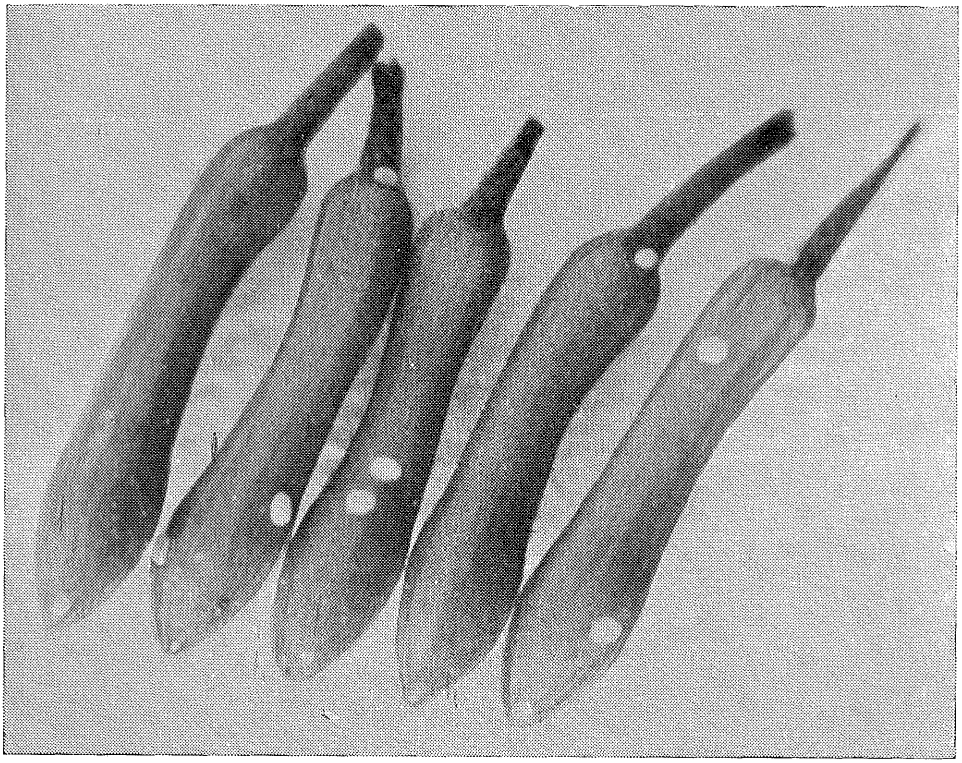

Fig. 1.—Eggs of *H. vagella* on macadamia flower buds.

Larva.—Head capsule measurements of a large number of individuals established the existence of five larval instars (Figure 2).

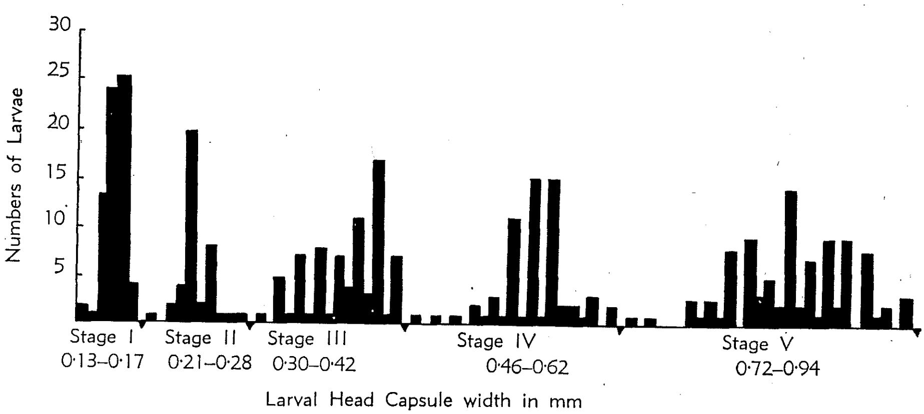

Fig. 2.—Histogram showing head capsule measurements of the larval stages of *H. vagella.* Each column for each stage corresponds to 0·008 mm.

I. The first instar larva is about 0·75 mm long, light yellow in colour and with a brown head capsule. This instar eats its way from the egg, leaving the chorion mainly intact, and soon enters a floret bud. The outer layers of the bud are rejected and the tiny larva feeds mainly on the anthers and stigma. Infested buds can be recognized by the drops of sap which ooze from the entry hole. Brown frass pellets may also protrude from the minute entry hole.

II. The second instar larva is pale lemon in colour, with a brown head capsule and prothoracic shield, and has setae visible under low magnification. If the food supply is exhausted the larva moves to another bud, and connecting buds together with webbing, commences to construct a silken tunnel. The preferred food is still the inner floral parts.

III. The third instar larva is prominently striped longitudinally by three light green, grey or light brown bands. The bases of the setae are surrounded by dark brown areas. The larva is now less selective in feeding habits and may destroy numerous buds. It may be concealed within a bud or in a silken tunnel incorporating bud fragments and frass.

IV. The fourth instar larva is darker in colour and often found resting in silken shelters with the head in an oblique semi-erect position. The stage in heavy infestations on a raceme may completely destroy all the buds.

V. Mature and active fifth instar larvae are about 12 mm long. The predominant colour ranges from green to slate-grey, being most commonly reddish-brown dorsally and light greenish-yellow ventrally. The head capsule is yellowish-brown. A pair of reddish-brown dorso-lateral bands with suffused yellow spots extend from the prothorax to the tenth abdominal segment. Below these bands is a narrow yellowish stripe merging into a light reddish-brown mid-lateral stripe. A mid-dorsal stripe extends from the prothorax to the ninth or tenth abdominal segment. On each side of this median stripe is a narrow yellowish stripe interrupted by a reddish-brown transverse suffusion towards the posterior margin of each segment. Body setae are now more noticeable. The legs are brownish-grey and the prolegs greenish-yellow.

In severe infestations damage is obvious when larvae reach the fifth instar, as racemes are reduced to a tangled mass of brownish coloured dead flowers or buds surrounding the rachis (Figure 3). The outer green layer of the rachis may be completely eroded by the larvae. The destroyed flower parts are held to the rachis by the profuse webbing, which is cluttered with the brown pellet-like excreta of the larva (Figure 4). In such racemes large numbers of mature larvae, camouflaged by their reddish-brown colour, as well as other stages, can be found within the silken and frass woven tunnels. In heavy infestations it is not uncommon to find that larvae will move from spent racemes and feed on other less damaged racemes, or earlier set nuts, or young foliage in the vicinity. Larvae are active, retreating along tunnels when disturbed or falling to hang by silken threads. This instar larva feeds for a short time, then usually leaves the tree to spin a closely woven silken cocoon in leaves and debris on the ground, where it changes to the pre-pupal stage and then to the pupa. Pupation can also occur at sheltered sites, as in leaf folds or old nut husks on the tree.

Pupa.—The pupa is 9–10 mm long, light brown dorsally and light yellowish-green ventrally. It darkens in colour until just before the moth emerges, when it is almost completely jet black.

Fig. 3.—Macadamia racemes showing damaged (centre) and undamaged flowers (outer).

Adult.—The adult is a small grey moth 6–7 mm long and 14–18 mm across the outspread wings. Its main coloration is grey, formed by a series of light grey, dark grey or dark bluish-grey scales with a variable tinge of reddish-brown. When at rest the wings are held folded over the back so that three transverse darker

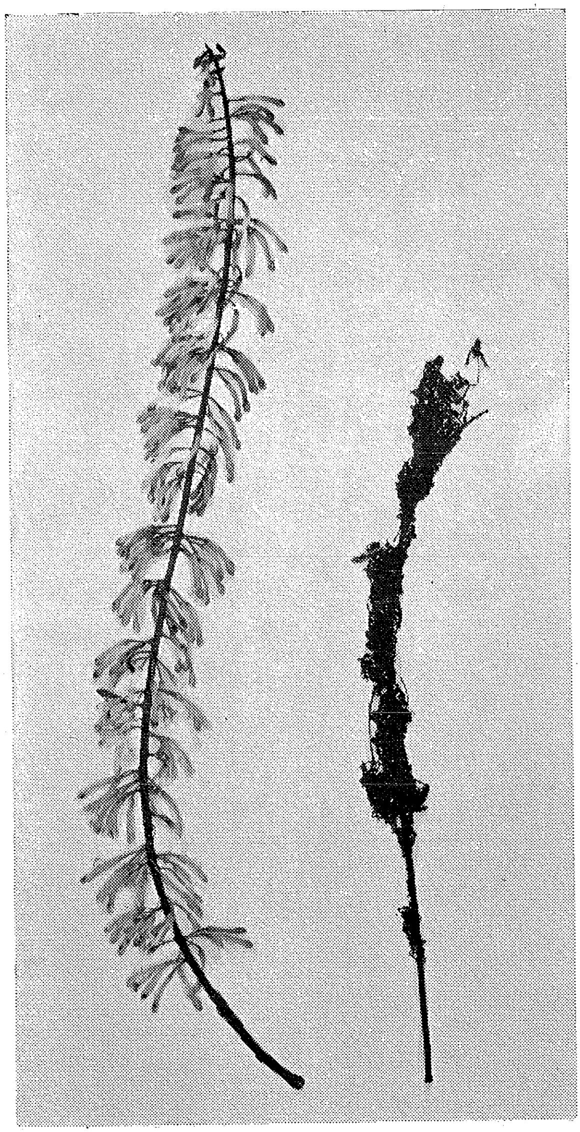

Fig. 4.—Undamaged macadamia raceme (left) and completely destroyed raceme (right).

grey stripes across the apical end of each forewing match to appear as inverted V-shaped marks. The forewing has a conspicuous oval dark grey spot on the lighter grey anterior area. The apical margin is fringed with two rows of long grey scales with white tips. The hindwing has many fewer scales, is greyish and translucent, and is fringed with long delicate hairs.

The sexes are readily distinguished. Dorsally the abdomen of the female is covered with dark grey scales to the tenth segment, which appears as a truncated cone terminating with a fine fringe of yellow scales, with the ovipositor often slightly projecting. In the male the abdomen is lighter grey dorsally, with a pinkish-yellow hue progressively becoming more marked in the last five segments, and terminating in the anal segment with a girdling tuft of yellow brush-like hairs covering the genitalia. The 595 adults reared in the laboratory included approximately equal numbers of males and females.

Both sexes of *H. vagella* are attracted to light. A light trap with a Philips MLL Blended-Light Lamp (consisting of a quartz mercury discharge tube connected in series with a tungsten filament) has been used for a number of seasons in the Beerwah district. Large increases in the number of moths trapped coincided with major increases in oviposition on flowers.

V. NATURAL ENEMIES

Several natural enemies have been found associated with larvae of *H. vagella.* Those below marked with an * were reared from collections including larvae of some other lepidopterous species.

BRACONIDAE

Agathus (Microdus) rufithorax Turner
Meteorus sp.
Microbracon gelecheae Ashmead
Microgaster sp. nr. *tomentosa* Wilkinson
Phanerotoma sp.
**Protomicroplitis* sp. (*spretus* group)

CHALCIDIDAE

**Brachymeria* sp.
Chalcis nigritibiae Gir.

CHRYSOPIDAE

Chrysopa innotata Brauer

ELASMIDAE

Elasmus sp.

ENCYRTIDAE

Coccidencyrtus sp.

ICHNEUMONIDAE

**Asphragis* sp.
**Eriborus* sp.
Exochus sp.
*Gen. et sp. indet. Campoplegini
Pristomerus sp.

MIRIDAE

Psallus sp.

REDUVIIDAE

Gminatus nigroscutellatus Bradd.
Pristhesancus melitus Dist.

TACHINIDAE

**Actia norma* Mall.

Strobliomya argentifrons Mall.

**Strobliomya* sp.

The most important natural enemies of *H. vagella* are the braconid parasite *A. rufithorax* and the mirid predator *Psallus* sp. Parasitism by the former as high as 61% was recorded from large numbers of field-collected larvae in March-April 1966. At the same time, numerous bright red nymphs and dark brown adults of *Psallus* sp. were found to be attacking and killing *H. vagella* larvae. Following the activity of these two natural enemies, populations of *H. vagella* were so reduced that no evidence of infestations could be found on flowering *M. integrifolia* during the month of May 1966. In June to August only light isolated infestations occurred and these were not capable of adversely affecting nut set.

During the spring flowering of 1969, infestations were much lighter than previously observed in main flowering seasons. The light infestation was accompanied by large numbers of the mirid predator, which was obviously suppressing the pest and limiting damage by killing larvae. On a study property at Beerwah, satisfactory yields were obtained without applying an overall insecticide spray.

The mirid would appear to have a potential as an agent in applied biological control of *H. vagella.* Large numbers could be reared in an insectary and released in *H. vagella* infestations prior to the main spring burst of blossoms.

VI. SEASONAL HISTORY

Field observations have shown that successive generations of *H. vagella* occur throughout the year. Eggs or larvae can be found on flowering *M. integrifolia* in every month of the year.

Low populations are often evident in autumn, particularly in May, probably due to the activity of the natural enemies. This pattern was shown in each of the years from 1963 to 1969. From the low populations in autumn there is a slow build-up in numbers over the winter months. In spring, population build-up can be rapid. If conditions are favourable, infestations may become so severe during September and October that very few nuts are set. During these severe infestations eggs and all larval stages occur simultaneously on the one raceme. In some winters the incidence of *H. vagella* is more general than in others, indicating that the measure of control effected by natural enemies varies from year to year.

VII. CONTROL MEASURES

Field trials have yet to be carried out to demonstrate the economic damage threshold for *H. vagella* infestations in macadamia flowers with respect to subsequent nut yield. However, it is obvious that as macadamia produces vastly more florets than can possibly set nuts, a moderate population of flower caterpillar resulting in considerable destruction of florets could probably be tolerated without its having any effect on yield. The following points therefore are pertinent to more detailed experimental work on plantation control measures.

(1) *Selection of varieties.*—The selection of varieties of *M. integrifolia* should be directed towards those flowering heavily during the winter months, from May to August. Trees flowering during those months usually encounter flower caterpillar populations at a low level, probably due to the effect of natural enemies in autumn and the cold weather in winter. The heaviest bearing trees in a plantation of mixed types are often found to be those which have this habit.

(2) *Use of biological control.*—Investigations into the practicability of rearing and liberating parasites or predators, particularly the mirid *Psallus* sp., are warranted. Manipulation of populations of natural enemies in this way could have application in large plantations of uniformly bearing trees.

(3) *Insecticidal control.*—Smith (1946) reported that DDT and lead arsenate each gave effective control of *H. vagella* in tests when applied at 14-day intervals from the beginning of the flowering period. The use of insecticides such as DDT could cause the breakdown of natural control and introduce new pest problems. It is desirable to avoid widespread use of persistent insecticides in macadamia plantations.

Honey bees are important pollinators of macadamias. It is therefore essential than an insecticide used to control the flower caterpillar be of low toxicity to bees.

In recent experiments the organophosphate trichlorphon, applied as a 0·05% high-volume spray, gave effective control of *H. vagella.* Larvae in all stages were killed, including those concealed within the buds. Comparative tests showed that it is also ovicidal. Trichlorphon is relatively non-toxic to bees and has the added advantage of low toxicity to man and wildlife, including birds and fish.

The timing of spray application for a given macadamia variety is governed by flower development and the progress of the infestation. For flowers that reach anthesis from late August to mid September in south-eastern Queensland, a single application just prior to full bloom will give effective control. Later flowerings may require a first application when 80% of the racemes are infested with eggs, and a second application prior to full bloom. Applying the final spray prior to full bloom should minimize loss of pollinating bees on the wing at the time of spraying. It is also desirable to apply the spray at a time of the day when bees are least active.

An effective insecticide with less serious effect on natural enemies is still required, as trichlorphon is almost certainly toxic to the mirid *Psallus* sp. Further investigations should also be made to determine at what levels populations of *H. vagella* begin to have an effect on macadamia nut yield, and secondly to devise a method, possibly by routine egg counts in conjunction with light trapping, of deciding when such levels have been reached and if spraying is necessary.

VIII. ACKNOWLEDGEMENTS

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