PINEAPPLE SCALE INVESTIGATIONS.

By A. R. BRIMBLECOMBE, M.Sc., Senior Entomologist, Division of Plant Industry.

SUMMARY.

Studies on seasonal breeding and control of Diaspis bromeliae **(Kerner) were conducted at Rochedale, near Brisbane.**

Throughout a period of 18 months the percentage of living mature females was generally low. The peak occurred in summer and a secondary peak in early winter.

Egglaying by more than 20% of living females occurred in every month except one, with peaks in summer and winter.

A white spraying oil-nicotine sulphate mixture (16-1-640) as single applications at intervals through the year did not consistently reduce the living-insect percentage. Parathion emulsion (0.1%) gave better results than dispersible BHC (0.1%) and chlordane emulsion (0.5%). Parathion (0.025%) as single and double applications combined with thinning of plants did not reveal any early advantages and populations were too low for the differences shown later to be reliable.

The percentage of living insects and the percentage of insects dead from natural causes were generally higher in leaf bases than on leaf laminae; they were not affected by applications of oil-nicotine sulphate. Thinning of plants did not appear to alter the percentage of living insects.

None of the chemicals used influenced flowering of pineapple plants, but technical and deodorised BHC as aerial applications five or more weeks before harvesting tainted fruit.

Parasitism by Aphytis **sp. amounted to a mean of 16.4% of total insects, while predators, mainly ladybirds, which were markedly more active on leaf laminae than in leaf bases, accounted for a mean of 22.8%. The effect of the oil-nicotine sulphate on both parasites and predators was negligible.**

I. INTRODUCTION.

The pineapple scale (*Diaspis bromeliae* (Kerner)) was described from Europe and has been recorded from pineapple and related plants in many countries. Turner (1891, p. 84) in New South Wales stated "the only insects . . . . . seen preying upon the pineapple are the Mealy Bug and the Scale," but gave no indication of the locality. Froggatt (1914, p. 880) remarked that the insect "is doubtfully identified from Queensland." Tryon (1928, p. 34) reported that "This insect was to be met with in the Brisbane area infesting plants of the pineapple family (Bromeliaceae). Fortunately it has spontaneously disappeared."

In 1942 the insect was found heavily infesting a few commercial plantations in the Rochedale district near Brisbane (Jarvis 1944). Light infestations continued for several years but in the second half of 1948 populations increased and, apparently accompanying the post-war expansion of pineapple growing, the insect became dispersed. It was then located in a number

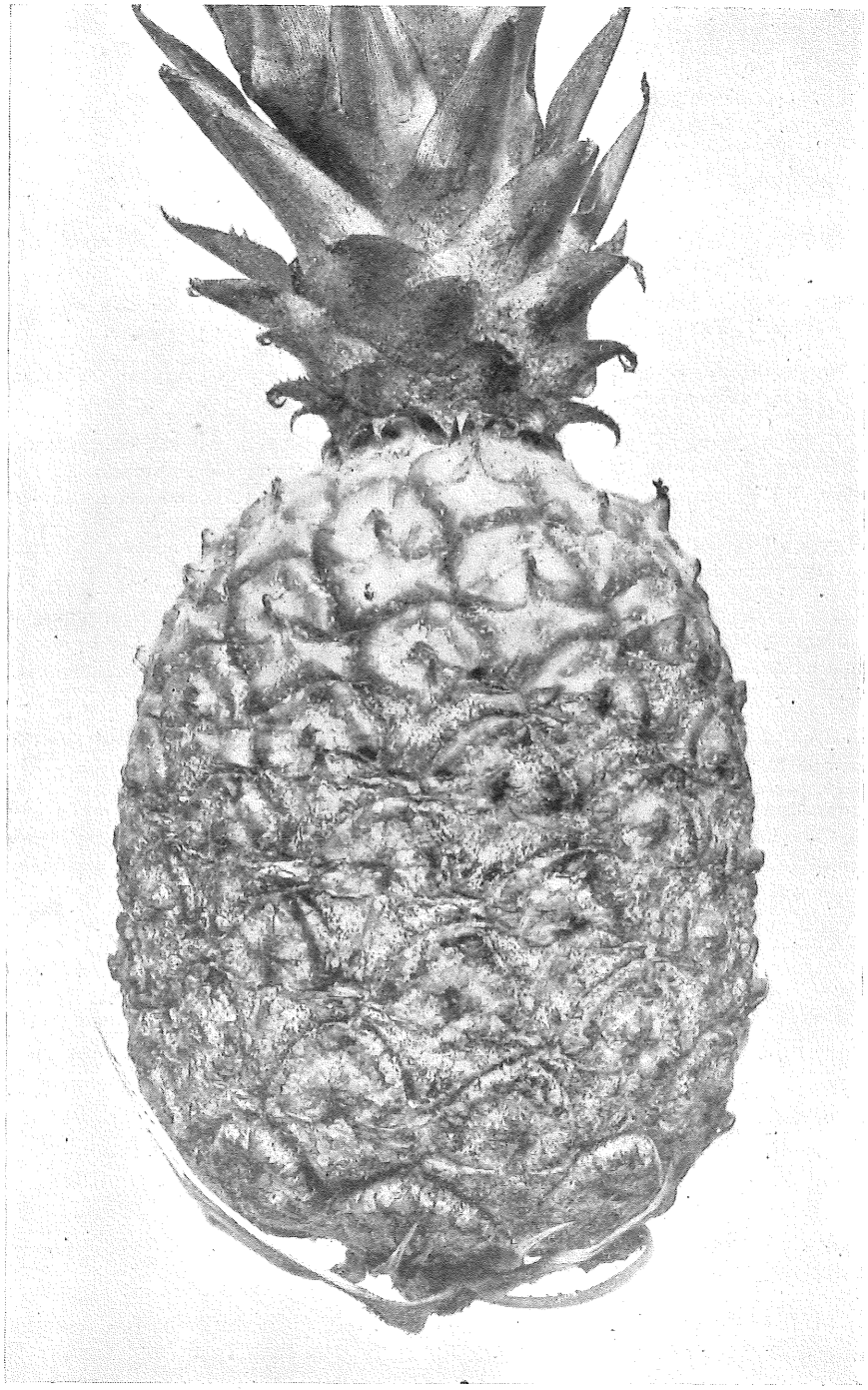

Fig. 1.

Pineapple Scale Infestation on Fruit and Top.

of plantations in the Rochedale district, in several areas in adjoining districts and in two plantations further afield. Another infested plantation outside the Rochedale district was recorded in February 1955. This and some of the other instances of spread were traced to planting material from Rochedale.

Infestations have occurred in plantations of both rough-leaved and smooth-leaved varieties of the pineapple (*Ananas sativa* (L.) Merr.), and in two Brisbane parks on *Billbergia* spp.

II. SEASONAL BREEDING.

Studies of seasonal breeding were made by taking regular samples from 10 sites in a 5-acre plantation of 5-year-old rough-leaved pineapples. Initially two moderately infested leaves were selected from each site. On these 25 mature females, taken at random, were determined as either living or dead, and the living were examined for evidence of egglaying. When sampling commenced in May 1950 insects were numerous and full counts were possible on 10 leaves. Populations gradually declined until more than 120 leaves were required to provide 250 mature insects. After 18 months, populations were so low that counts were discontinued.

Generally the percentage of living insects was low (Fig. 2), and exceeded 50 in only 5 of the 18 months. The peak occurred in summer and a secondary one in early winter.

Egglaying occurred in every month of the year and except for January 1951 the percentage of living insects with eggs was consistently over 20 (Fig. 2). Peaks were shown in both summer and winter. Furthermore, observations made in connection with the oil-nicotine sulphate control trial, dealt with later, revealed extensive egglaying in the early winter of 1949.

III. CONTROL TRIALS.

Three control trials and a fruit taint trial were undertaken. The first control trial was mainly for the purpose of checking the value of the oil-nicotine sulphate mixture in use by Rochedale growers, the second to evaluate parathion, BHC and chlordane, and the third as a further test with parathion and to determine the influence of plant density on chemical control.

(1) First Control Trial.

Method.

This trial consisted of duplicated blocks in 3 acres of 4½-year-old rough-leaved pineapples (Fig. 3). The treatment comprised 16 parts of white spraying oil (80% mineral oil), 1 part of nicotine sulphate (40% nicotine) in 640 parts of water. This was applied in June and December 1949 and March 1950 by a power sprayer at 150 lb. pressure and 150 gal. per acre. The spray filled to capacity all leaf bases but in some places the density of plants prevented complete cover on all leaves.

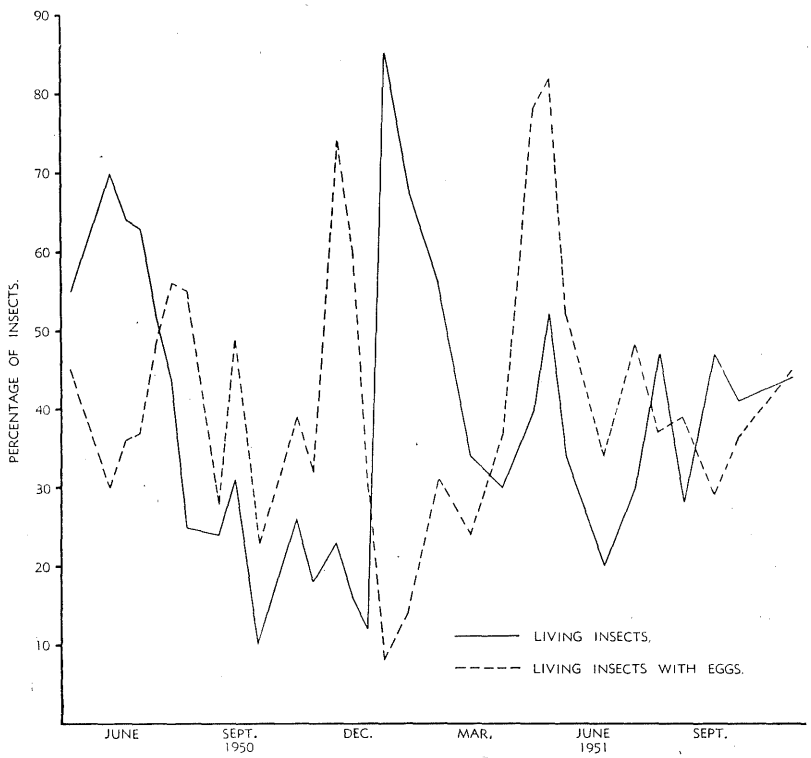

Fig. 2.

Percentages of Living Insects, and Insects With Eggs.

Pretreatment and post-treatment counts of insects were made for each of the three applications. Leaves representing two leaf laminae and two leaf bases were taken from 10 positions of moderate infestation in each block and on these 25 consecutively placed mature females were determined as living, dead or parasitised. Later counts included insects killed by predators.

Discussion.

In June 1949, the percentage of living insects in the untreated areas was 64·2 (Fig. 4). This showed an early decline and then a gradual downward trend continued until July 1950 when only 9·4% of the insects were alive and populations were low.

In the treated areas the percentage of living insects in June 1949 was 57·4 (Fig. 4). The first application of oil-nicotine sulphate had an immediate slight benefit which was still evident in July. The second application made in December did not have any apparent beneficial effect, but this may have been associated in some way with increased activity of natural enemies, which are discussed later. A third application, in March 1950, like the first seemed to exercise a slight insect kill but the effect had diminished by the following July. Except for the initial count, the percentage of insects dead from causes other

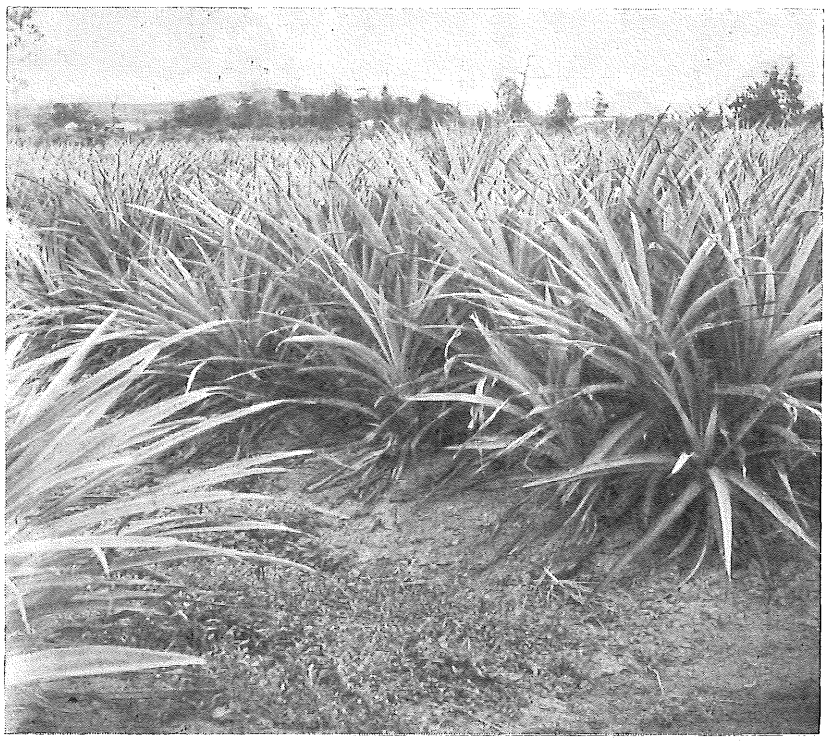

Fig. 3.
Pineapple Plants in First Control Trial.

than natural enemies was practically uniform in the untreated areas (Figs. 4 and 6), and other than for slightly increased differences following the June and March applications, the results for both treated and untreated areas were more or less parallel. Single applications of oil-nicotine sulphate, although repeated, were therefore of little economic value.

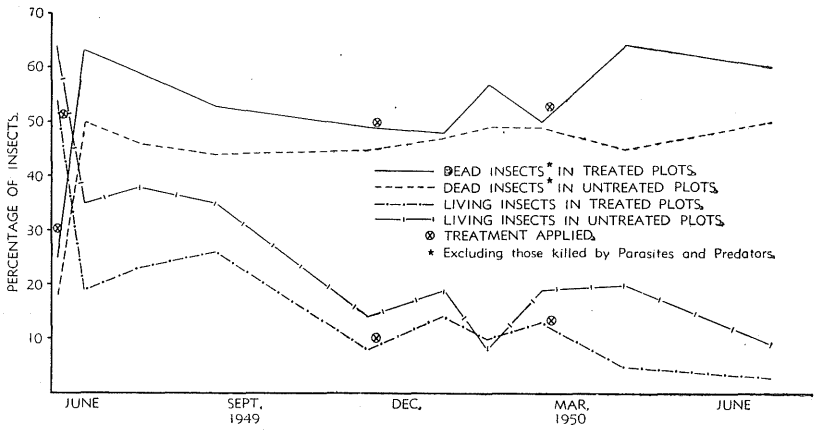

Fig. 4.
Percentages of Living and Dead Insects in Treated and Untreated Plots.

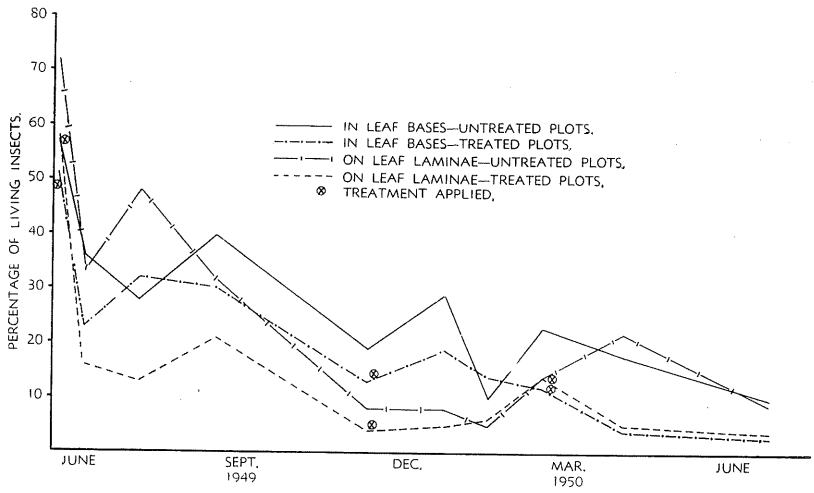

Fig. 5.

Percentages of Living Insects in Leaf Bases and on Leaf Laminae in Untreated and Treated Plots.

The greater proportion of insects occurred on the upper leaf surface within the protection of the ensheathing leaf bases and the data showed that the percentage of living insects and the percentage of dead insects except those killed by natural enemies were greater in this position than on leaf laminae (Fig. 5). Furthermore, the spray applications caused a slightly greater kill of insects in leaf bases than on the laminae (Fig. 6).

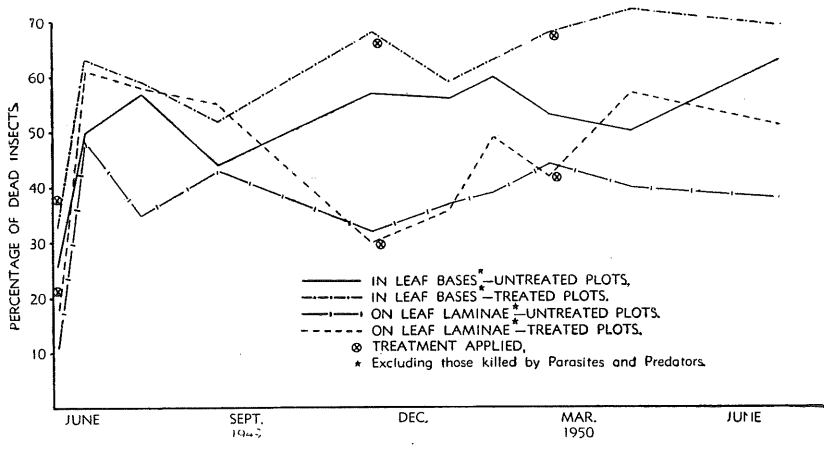

Fig. 6.

Percentages of Dead Insects in Leaf Bases and on Leaf Laminae of Untreated and Treated Plots.

(2) Second Control Trial.

Method.

This trial covered part of three acres of 18-months-old smooth-leaved pineapples (Fig. 7). The area was divided into three sites and on each five treatments were arranged in a latin square, unit plot being five yards of single-plant row. Treatments were as follows.—(*a*) oil-nicotine sulphate (16-1-640); (*b*) chlordane emulsion (0·5%); (*c*) untreated; (*d*) dispersible powder BHC (0·5% gamma isomer); (*e*) parathion emulsion (0·1%).

Fig. 7.

Pineapple Plants in Second Control Trial.

Single applications were made in August and December 1949 with a knapsack and bucket pump respectively, using on each occasion 188 gal. per acre for each treatment. The spray was first directed along the sides of the row of plants and finally over the top. The side application covered the lower leaf surfaces and filled the lower leaf bases, while the top application covered the upper leaf surfaces and filled the throat of the plants.

At each sampling 10 leaves were taken from each plot, five from each side of the row. The initial samples were taken prior to the first application in August 1950 and subsequent samples approximately at monthly intervals.

Discussion.

The anticipated rise in populations did not occur. In fact, populations generally decreased, and did so to such an extent over two of the sites that

results of insect counts from these were of no value; therefore only one site is included in the following discussion.

The insects in this area were almost entirely in the leaf bases and parasites and predators were practically absent. Counts were made for living and dead only, and comparisons were made directly between total numbers of insects and percentages of dead.

The number of insects in the untreated plots (Fig. 8) increased from 89 in August 1950 to 337 in September. In November it had decreased to less than 150 and by the following February the expected extensive summer breeding provided little increase. The numbers in the several treated plots (Fig. 8) showed the same general trends but the decline in comparison with the untreated plots was particularly noticeable after the December application. The oil-nicotine

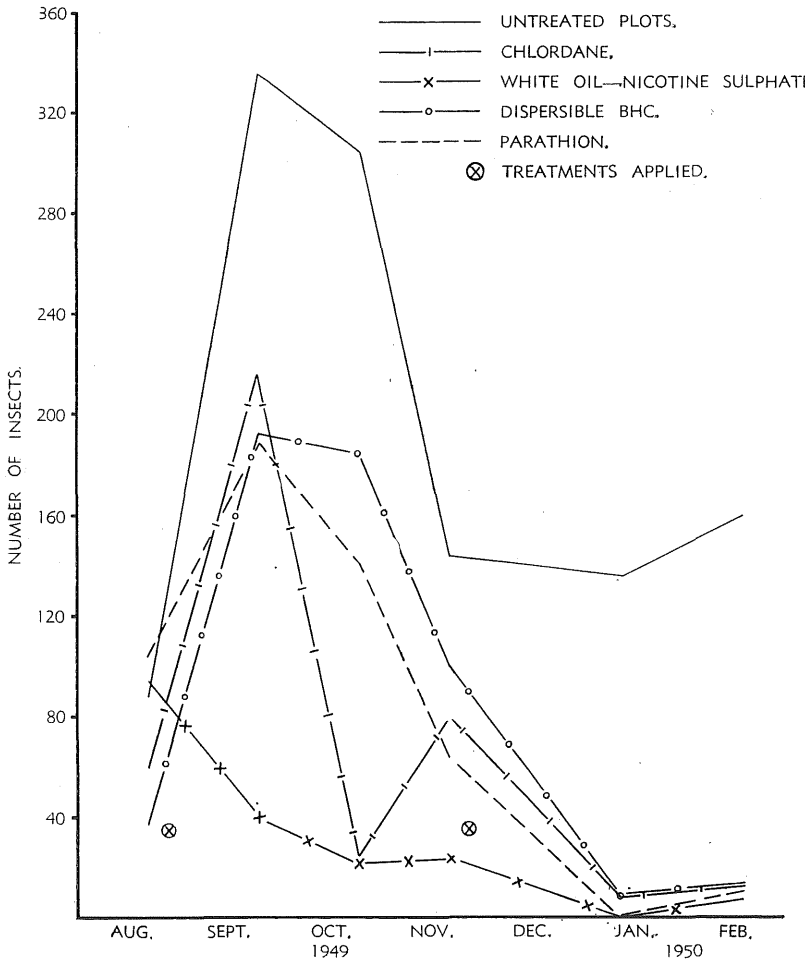

Fig. 8.

Numbers of Insects in Treated and Untreated Plots.

sulphate treatment appeared to give an immediate marked reduction not shown by the other treatments, but finally the numbers of insects present were comparable for all treatments and averaged 6·2% of the number in the untreated plots.

The percentage of dead insects (Fig. 9) increased slightly after the first sampling in the untreated plots, then decreased gradually until November. From January to February an increase was again shown, making the dead-insect percentage comparable to that of the previous September. All spray treatments caused an early marked increase in the percentage of dead insects

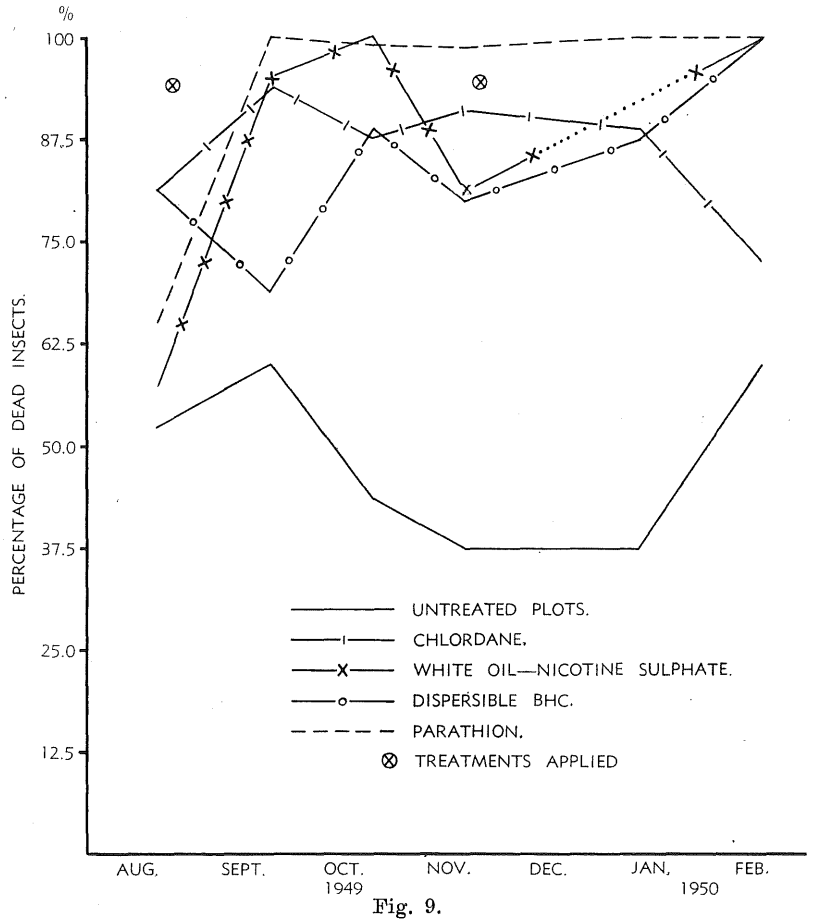

Fig. 9.

Percentages of Dead Insects in Treated and Untreated Plots.

except the dispersible BHC. Parathion maintained throughout the remainder of the trial a high dead-insect percentage. BHC and oil-nicotine sulphate varied, but again gave a marked increase after the second application and at the final sampling all insects were dead. Chlordane also varied and finally showed a downward trend.

Counts of the number of parent plants with suckers, flowers and fruit were made for each site at the commencement and a month before completion of the trial to determine whether any treatments influenced flowering. An analysis of the counts of flowers and fruit is given in Table 1.

Table 1.

INCREASES OF FLOWERS AND FRUIT EXPRESSED AS PERCENTAGES.

Treatment.	Transformed Values.				Equivalent Percentage Increase.			
	Sites.			Mean.	Sites.			Mean.
	1	2	3		1	2	3	
Oil-nicotine sulphate	28·4	31·8	24·4	28·2	22·7	27·8	17·0	22·4
Chlordane	41·6	29·8	23·5	31·6	44·1	24·7	15·9	27·5
Untreated	27·1	30·9	20·0	26·0	20·8	26·4	11·7	19·3
Disp. BHC	38·4	36·6	30·3	35·1	38·6	35·5	25·4	33·0
Parathion	34·7	30·7	29·3	31·6	32·4	26·0	23·9	27·4
Means	34·1	32·0	25·5	30·5	31·4	28·0	18·5	25·8
S.E.	±5·01			±2·89	..	..	..	..

Differences are not significant.

The BHC treatment was responsible for slight injury to young leaves but not enough to affect their growth.

(3) Third Control Trial.

Method.

The area in this trial comprised part of three acres of 5½-year-old rough-leaved pineapples and consisted of four rows each 75 yards long of densely growing plants. Six treatments were randomised in four replicates, unit plot being 10 yards of double row. The treatments were no application, and single and double applications of parathion on thinned and unthinned plants. The strength of the spray was 0·025% and where double applications were made a two weeks' interval intervened. Applications were made in June and December 1950 by means of a bucket pump and averaged 250 gal. per acre on the unthinned plants and 180 gal. on the thinned plants, an endeavour being made to cover all leaf surfaces and to fill the leaf bases and throats of all plants.

The sampling in this trial initially comprised 20 infested leaves from each plot, 10 from each side of the row. On these, living and dead were recorded from a total of 250 scales, not exceeding 15 on any one leaf.

To determine whether the number of leaves taken represented a sufficient sample, an analysis using a transformed variate was made of the counts of living insects from the pretreatment samples. Taking into consideration

variations from leaf to leaf and from plot to plot it was possible to determine the necessary differences for significance of various numbers of leaves combined with different numbers of replicates. These differences are given in Table 2.

Table 2.

DIFFERENCES FOR SIGNIFICANCE IN COUNTS OF LIVING INSECTS.

Replicates.	Number of Leaves.						
	5	10	15	20	25	30	∞
4	16·0	13·7	12·8	12·3	12·1	11·9	10·8
6	13·1	11·2	10·5	10·1	9·8	9·7	8·9
8	11·3	9·7	9·1	8·7	8·5	8·4	7·7
10	10·1	8·7	8·1	7·8	7·6	7·5	6·9

It was shown that replication was more effective for all sizes of sample and that increases beyond 15 leaves per plot provided little improvement in accuracy. The trial had already commenced with four replicates and therefore 15 or more leaves were taken at each sampling.

Discussion.

In July 1950, a month after the applications of parathion, the percentage of living insects dropped for all treatments but was more than twice as high in the respective unsprayed plots as in those sprayed (Fig. 10). In September

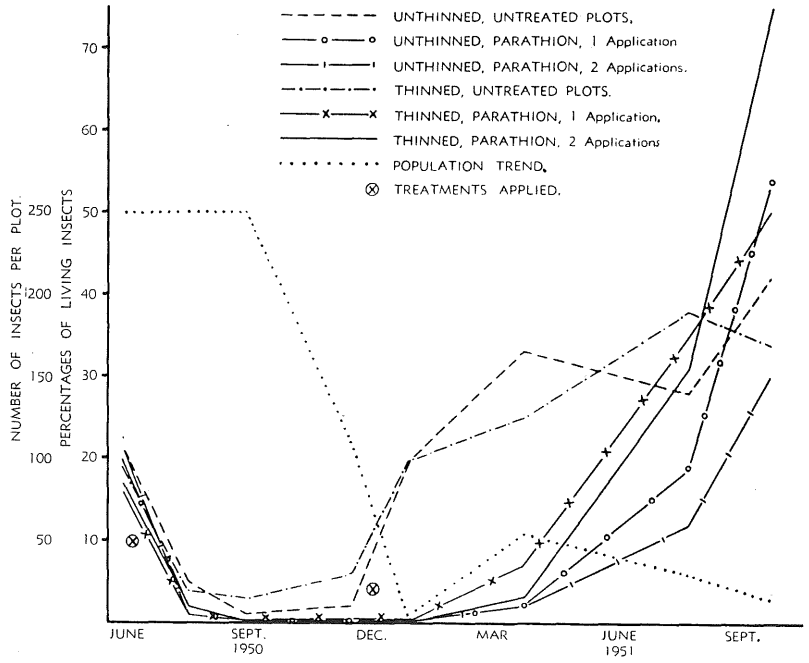

Fig. 10.

Percentages of Living Insects in Treated and Untreated Plots, and Population Trend.

and in November and December no living insects could be found on any sprayed plot. A few living were present in the unsprayed plots in September and this increased markedly in the following four months, but at the same time populations were declining throughout the whole area (Fig. 10). Populations remained so low that further applications were not made and the trial was discontinued in October 1951.

From the counts made, the difference shown between the sprayed and unsprayed plots may be taken to indicate benefit from some of the treatments. Differences between thinned and unthinned plots, however, were not consistent.

(4) BHC Taint Trial.

At Nambour early in 1952 field applications of a dust and a spray of technical BHC and sprays of lindane emulsion and dispersible powder were made on pineapple fruit. The dust contained 0·05% and the sprays 0·033% of gamma isomer. One series of fruit was treated in February and harvested when ripe 7-9 days later, while another series was treated in January with maturity and harvesting extending from 5 to 12 weeks later. Each fruit was submitted to a tasting panel.

No taint was detected in any untreated or treated fruit maturing and harvested up to 5 weeks after treatment, but most of the later maturing fruit were tainted. The younger fruit apparently can readily absorb BHC, whether crude or deodorised, and retain it in the tissue. Maturity and harvesting of pineapple fruit normally extends over a long period and any aerial application of BHC would result in some tainted fruit. As off-flavour or taint in food is not tolerated by the public, aerial application of BHC should not be made to pineapples.

IV. PARASITES AND PREDATORS.

(1) Parasites.

An Aphelinid (*Aphytis* sp.) was consistently active on the pineapple scale and counts were made of the insects killed by this parasite in the first control trial. These are shown in Figs. 11 and 12 as percentages of total

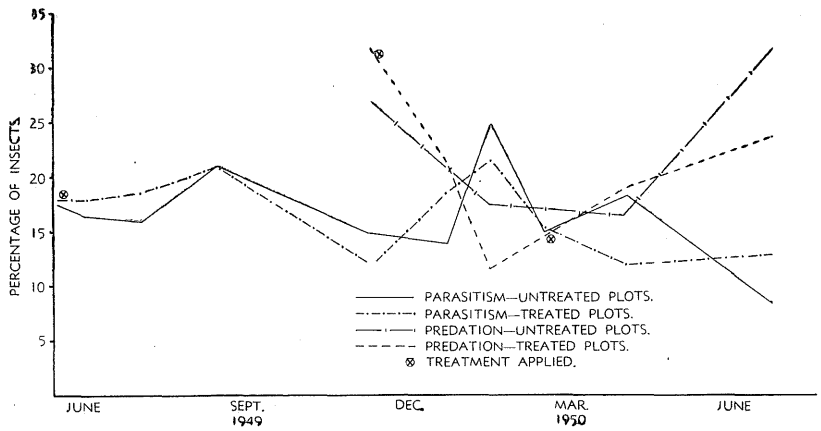

Fig. 11.

Percentages of Insects Killed by Parasites and Predators in Untreated and Treated Plots.

insects. From June 1949 to July 1950 these percentages ranged from 8·4 to 25·2, being high in late winter and late summer.

In the areas treated with oil-nicotine sulphate the percentage of parasitism varied from 11·8 to 21·2. The oil-nicotine sulphate applications therefore had little effect on the work of the parasites.

The differences in parasitism on leaf laminae and in leaf bases were negligible (Fig. 12).

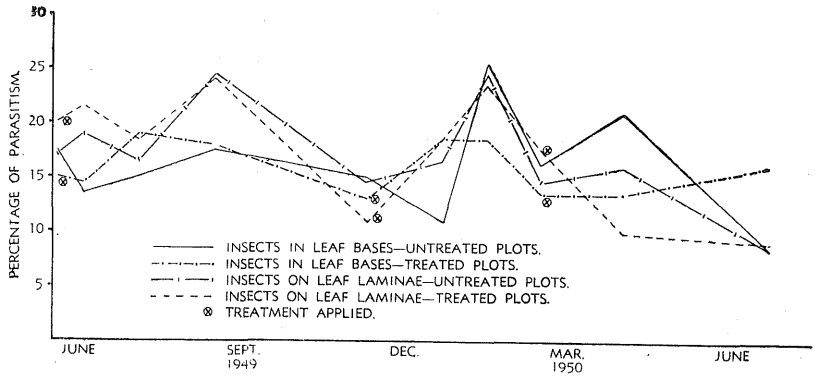

Fig. 12.

Percentage of Parasitism in Leaf Bases and on Leaf Laminae on Untreated and Treated Plots.

(2) Predators.

During the progress of the oil-nicotine sulphate trial it was noticed that predators, mainly ladybirds in the genera *Rhizobius* and *Orcus*, increased as important factors in reducing the percentage of living insects. Consequently, commencing with the November 1949 samples, counts were made of insects

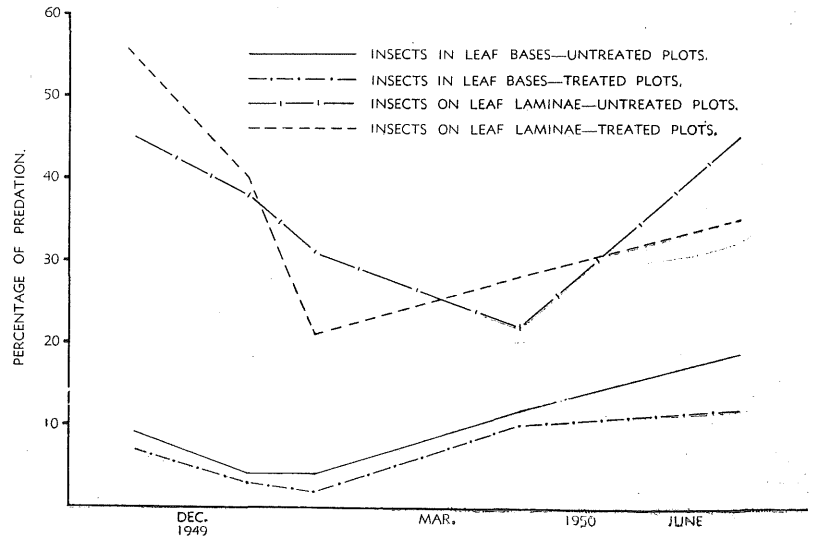

Fig. 13.

Percentage of Predation in Leaf Bases and on Leaf Laminae in Untreated and Treated Plots.

killed by these enemies (Figs. 11 and 13). The data showed that predators accounted for an average of 22·8% of total insects present in the untreated areas and 21·7% in the treated areas. An outstanding feature was the difference between activity on leaf laminae and in leaf bases (Fig. 13). In the untreated areas the percentage of scale insects killed by predators on the leaf laminae ranged from 21·7 to 45·0, and in the leaf bases from 4·0 to 19·0. Similarly, in the treated areas the range was from 21·4 to 55·6% on leaf laminae and from 1·9 to 12·3% in the leaf bases. The figures also showed that the treatment did not have any noticeable effect on the work of the predators.

V. GENERAL DISCUSSION.

Infestations of the pineapple scale in 1948 were severe, but in the second half of 1949, due largely to biological and other natural agencies, populations generally began to decline and then became so low that satisfactory experimental work could not be continued. Such a decline apparently is not unusual, because Tryon, when first recording the insect from this State, found that it had "disappeared," and the severe infestations observed in 1942 later became light.

The records suggest that the pineapple scale is not of major importance. The occasional severe infestations, however, have been sufficient to reduce yields and curtail the economic life of plantations. Such occurrences could have serious repercussions in the industry if the insect were to spread to the large pineapple growing districts.

Control trials have shown that a mixture of white spraying oil and nicotine sulphate (16-1-640) gave only a small kill of insects and dispersible BHC (0·1%) and chlordane emulsion (0·5%) were ineffective. Parathion (0·1%) showed some promise but results from the lower concentration (0·025%) were inconclusive. The problem of chemical control therefore requires further investigation when adequate populations of the insect appear.

VI. ACKNOWLEDGEMENTS.

Thanks are due to Mr. G. Knot and Mr. D. R. Vanstone of Rochedale for making experimental areas of pineapples available. Mr. T. Manefield (Assistant Entomologist) conducted the field work for the BHC taint trial, and Mr. P. B. McGovern (Biometrician) analysed data obtained.

REFERENCES.

FROGGATT, W. W. 1914. A descriptive catalogue of the scale insects ("Coccidae") of Australia. Agric. Gaz. N.S.W. 25: 875-82.

JARVIS, H. 1944. Pineapple scale. Qd Agric. J. 59: 26-9.

TRYON, H. 1928. Pineapple disease investigations. Interim Report. Qd Agric. J. 30: 26-34.

TURNER, F. 1891. New commercial crops for N.S.W. Agric. Gaz. N.S.W. 2: 82-90.

(Received for publication May 26, 1955.)

A. H. TUCKER, Government Printer, Brisbane.