THE BIOLOGY, BIONOMICS, AND CONTROL OF *Parlatoria pittospori* Mask. (HEMIPTERA, DIASPIDIDAE): A PEST ON APPLES IN NEW ZEALAND

BY J. S. TIMLIN

Entomology Division,
Department of Scientific and Industrial Research,
Auckland

(Received 30 April 1964)

ABSTRACT

The habits, host range, and life cycle of *Parlatoria pittospori* Mask. are dicussed.

Pinus shelter belts infested by *Parlatoria* proved to be the source of the scale insects on apples. Topping the trees in the shelter belts to a height of approximately 45 ft, and then spraying with a 3 per cent intermediate oil, reduced the scale insect population to a low level and kept the fruit free from scale insects.

Dispersal of the crawlers of *P. pittospori* was studied. Greased plates which were placed throughout the orchard trapped windborne crawlers up to a distance of 250 yd from the host *Pinus radiata* Don. Weekly counts showed crawlers moving from November to May, with peak numbers in December. The maximum number of crawlers trapped/12 in. sq. in a 24-hour period was 130.

Preventive sprays of both carbaryl and azinphos-methyl, which were applied during the season to apple trees, were not successful in keeping the fruit free of scale insects.

INTRODUCTION

Parlatoria pittospori Mask. was first described by Maskell in 1890 from Australia on *Pittosporum undulatum* Vent., and has since been recorded from South Africa, California, United States of America, and New Zealand (Morrison 1939). Recent inquiries in Australia produced the following comment: "Although it is widely distributed on a variety of native and introduced hosts there is no record of it being a pest." In 1937 Dr W. Cottier (pers. comm.) identified *P. pittospori* on an apple from Hawke's Bay. The author observed heavy infestation of the scale insects on fruit throughout orchards in Nelson and Marlborough districts in 1952, and it has been recorded on apples in the Auckland province (Richards 1960).

Strict international quarantine barriers designed to reduce the spread of pest species have meant that our fruit for export must be virtually scale insect-free. The incidence of *P. pittospori* in Nelson and Marlborough, particularly during the 1960–1 season (Timlin 1964), has meant that frequently fruit had to be rejected for export by the local Inspectors of the Department of Agriculture. The present study was initiated with a view to obtaining information on which to base control recommendations.

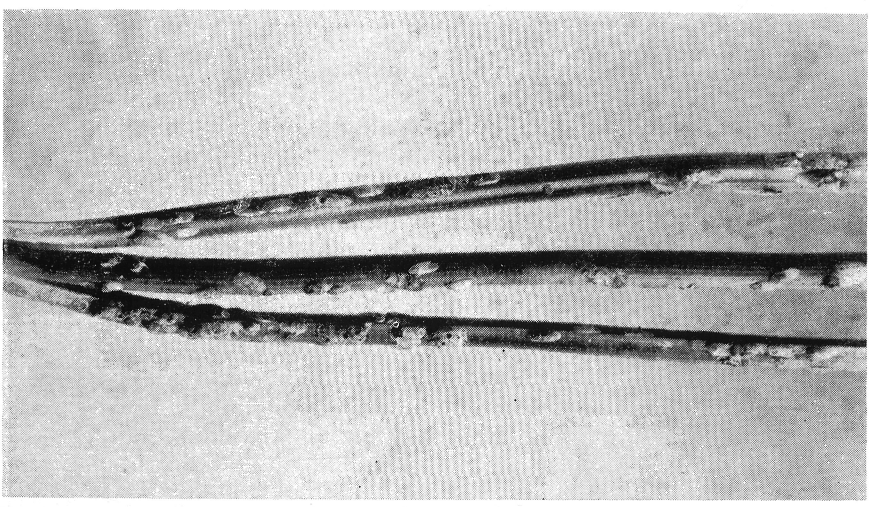
HOST RANGE

P. pittospori has a wide host range. Morrison (1939) lists the following hosts: *Pittosporum undulatum* Vent., *Pittosporum* sp. (Pittosporaceae), *Banksia* sp. (Proteaceae), *Dracaena draco* Linn. (Liliaceae), *Dryandra* sp. (Proteaceae), *Hakea* sp. (Proteaceae), *Viburnum tinus* Linn. (Caprifoliaceae), *Macrozamia corralipes* Hook. f. (Cycadaceae), *Melaleuca* sp. (Myrtaceae), *Nuytsia floribunda* R. Br. (Loranthaceae), *Mimosa* sp. (Leguminosae), *Petrophila linearia* R. Br. (Proteaceae), *Pimelea linifolia* Smith (Thymelaeaceae), *Pinus halepensis* Mill., *Pinus radiata* Don. (Pinaceae), *Xanthorhoea* (Liliaceae), *Pyrus malus* Linn. (Rosaceae).

Additions to this list are *Phoenix* sp. (Palmaceae) (Ferris 1942), *Callistemon* sp. (Myrtaceae), *Cycas* sp. (Cycadaceae), *Leptospermum laevigatum* F. Muell. (Myrtaceae), and *Podocarpus elongata* L'Her. (Taxaceae) (McKenzie 1945).

Further hosts recorded in this study were gorse (*Ulex europaeus* L.) on leaves and stems, broom (*Cytisus scoparius* Link.) on leaves and stems, *Acacia decurrens* Willd. and *Acacia Baileyana* F.v.M. on leaves, tree lucerne (*Cytisus proliferus* L.) on wood, (Leguminoseae), *Pyrus communis* L. (Rosaceae) on fruit and wood, and *Chamaecyparis lawsoniana* Parl. (Cupressaceae) on leaves.

Parlatoria occurs on the leaves of *Pinus radiata* Don. (Fig. 1), which



D. Read

Fig. 1.—*Parlatoria pittospori* on *Pinus radiata* needle leaves.

is without doubt the most important host in New Zealand, the scale insect seeming to favour the inner surface of the needle leaf. However, when dense populations are present, solid incrustation builds up to such an extent that new crawlers are forced to establish on the outer surfaces of the leaves.

In the field, only one instance was recorded of *Parlatoria* on the wood of apple. This was from a home garden orchard, and it would therefore seem that the apple tree itself does not act as a permanent host for *Parlatoria* in commercial orchards. As well as the one record of *Parlatoria* on wood already referred to, further experimental evidence was obtained. Young unsprayed apple trees were artificially infested with *P. pittospori* crawlers in late December. Some of these crawlers established on the wood, although by far the greater percentage settled on the fruit. From this establishment on the wood crawlers of the next generation emerged in the following October to infest the new season's fruit. Despite this evidence, however, a prolonged and thorough search failed to find a single instance where *Parlatoria* had established on the wood of apple trees in commercial orchards. When the scale insect does settle on wood, it seems to favour a smooth, succulent type of bark, and, unlike San José scale, does not settle under old bark or in cracks and crevices. This makes it particularly vulnerable to sprays and could be the reason why it does not survive on apple wood in the orchard.

An important aspect of attack on apples is that *P. pittospori* frequently gives a reddish discolouration or staining to the skin of the fruit. This varies in intensity from a faint pinkish tinge to a deep red. However, the discolouration is not always present, some apples, particularly green varieties such as Granny Smith, rarely showing any staining, while the intensity of the staining by individual scale insects may vary considerably even on the one fruit.

DESCRIPTION

(FIG. 2)

The scale of the female up to 3 mm long, oval elongate or slightly spatulate; greyish-brown in colour; the exuviae terminal and yellowish-green. The scale of the male elongate and smaller. The eggs and various stages of the insect are mauve in colour.

LIFE CYCLE

In the field, all stages of *Parlatoria* are found throughout the year.

Young *Pinus radiata* trees were artificially infested with crawlers on 18 December 1960, and 10 months elapsed before crawlers of the next generation appeared on 28 October 1961. However, *Parlatoria* developed much more quickly on apples. Crawlers were recorded in March emerging from the eggs of mature *Parlatoria* females removed from fruit. As the original crawlers could not have settled on the newly formed apple until about November, the life cycle was thus completed in approximately four months.

Checks revealed that during August and September the majority of females were mature and laying eggs, egg counts per female averaging 46,

D. Read

Fig. 2.—*Parlatoria pittospori* on fruit (artificial infestation).

with a maximum of 62. The main crawler emergence starts at the end of October and reaches a peak in December. (Table 1). Although their numbers diminish somewhat later in the season, at no stage were crawlers entirely absent from the orchard.

BIOLOGICAL CONTROL

Emergence holes made by parasites were obvious in practically all field samples of this scale insect. Two parasites were reared, these being *Aspidiotiphagus citrinus* Crawford and *Aphytis chilensis* (?) Howard (determinations by E. W. Valentine, Entomology Division, D.S.I.R.). Sometimes samples were found to be heavily parasitised, at other times only lightly so.

Samples taken from different levels in pine trees showed a wide variation in the degree of parasitism. The scale insects from the lowest levels of the trees were often heavily parasitised, whereas at an intermediate level (30–50 ft) parasitism was much less obvious, and samples from the highest levels were practically free from parasitic attacks. Apparently the parasites do not establish in the tops of pine trees, due perhaps to the intensity of the wind. This could be an important factor in future attempts at biological control of *Parlatoria*. On the other hand, reduction of the height of the trees by topping might increase the over-all effectiveness of the parasites present.

In the sampling of the chemical trials reported below it was observed that many parasites, particularly those in the pupal stage, survived chemical treatment. (See Table 3).

DISPERSAL OF THE SCALE INSECT

There is little published work relating to the dispersal of scale insects. Armoured scale insects are immobile for the greater part of their life, but after they hatch from the egg into the first nymphal instar or crawler stage, they are free-moving, and actively search for a suitable site on which to settle. At this time these extremely small and delicate forms are liable to be blown or shaken from their host. Quayle (1916) found that crawlers of *Saissetia oleae* Bernard were windborne to a distance of 150 yd from host trees which were only 5 ft in height.

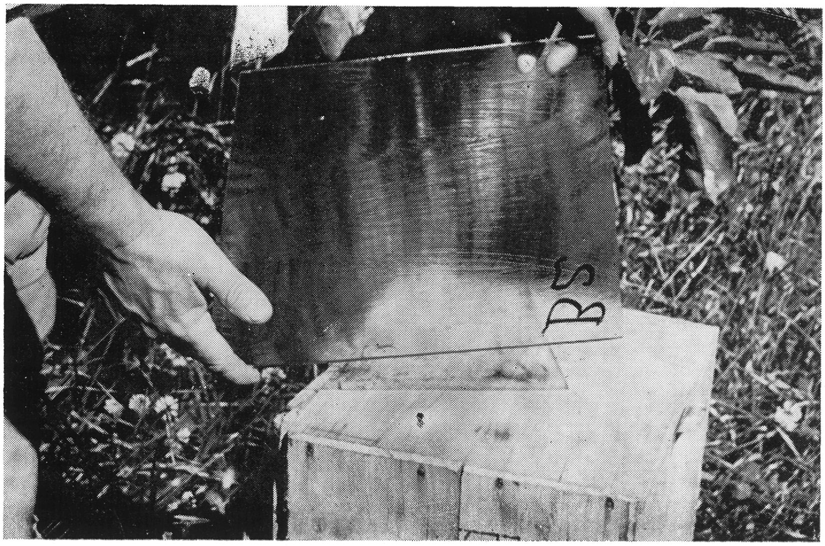
Parlatoria-infested *Pinus* shelter belt trees are responsible for scale insect infestation of fruit throughout the orchard, and the dispersal of the scale insect is, without doubt, caused by wind.

The height of the pine trees, many over 120 ft, combined with the whipping movement of the tops in a strong wind, make this host an almost perfect vehicle from which to shower crawlers into the orchard. These shelter belts being mainly single rows of trees, although reducing the wind velocity considerably, must still allow considerable volume of air to pass through to the orchard, carrying with it large numbers of crawlers.

To obtain information on the dispersion of *P. pittospori* by the wind, greased plates were placed throughout an orchard block of Delicious trees. The fruit from this block had been infested the previous season by *Parlatoria* from the adjoining shelter belt. The glass plates were 12 in. sq. and secured by clips in a horizontal plane to the end of a wooden case, 20 in. high. (Figs. 3 and 4). The cases, weighted with stones to hold them in position against wind, were placed close to the base of apple

D. Read

Fig. 3.—View of orchard showing placement of greased slides.



D. Read

Fig. 4.—Twelve in. sq. glass slide coated with grease used to trap crawlers.

trees at set distances through the orchard from the *Pinus* shelter trees. (Fig. 5). The shelter belt, about 5 chains in length, contained a double row of trees approximately 120 ft high.

The glass plates were coated with Shell brand cup grease ("Compound 0"), as recommended by Close (1959) for his cylindrical sticky aphid-traps. This proved satisfactory, although heavy rain and occasionally a jet of irrigation water washed some plates free of grease. However, this did not affect the over-all picture obtained. Because of the low viscosity of cup grease only the very small insects etc. are held; the large moths and flies, which could obscure the crawlers and so make counting difficult, are able to escape.

Seven plates, A1 to F7, were placed initially in position leeward of the shelter belt for the prevailing northwest wind. A test plate 250 yd distant from the shelter belt trapped crawlers, indicating that dispersal was much more widespread than thought. The downwind row of plates was then extended by the addition of a further seven plates, F8 to F14. Four more plates were also included in the layout, these being G1 and 2 and H1 and 2, placed in contradistinction to the A1–F14 row, in a position windward of the shelter belt. At the beginning of February, with catches diminishing, the number of plates was reduced to six (A1–F6), the experiment being continued mainly to check how long crawlers would continue to be trapped.

Plate A1, which lay nearest to the shelter belt, was situated 12 yd distant from the pine trees, and the farther-most plate (F14) was approximately 180 yd away.

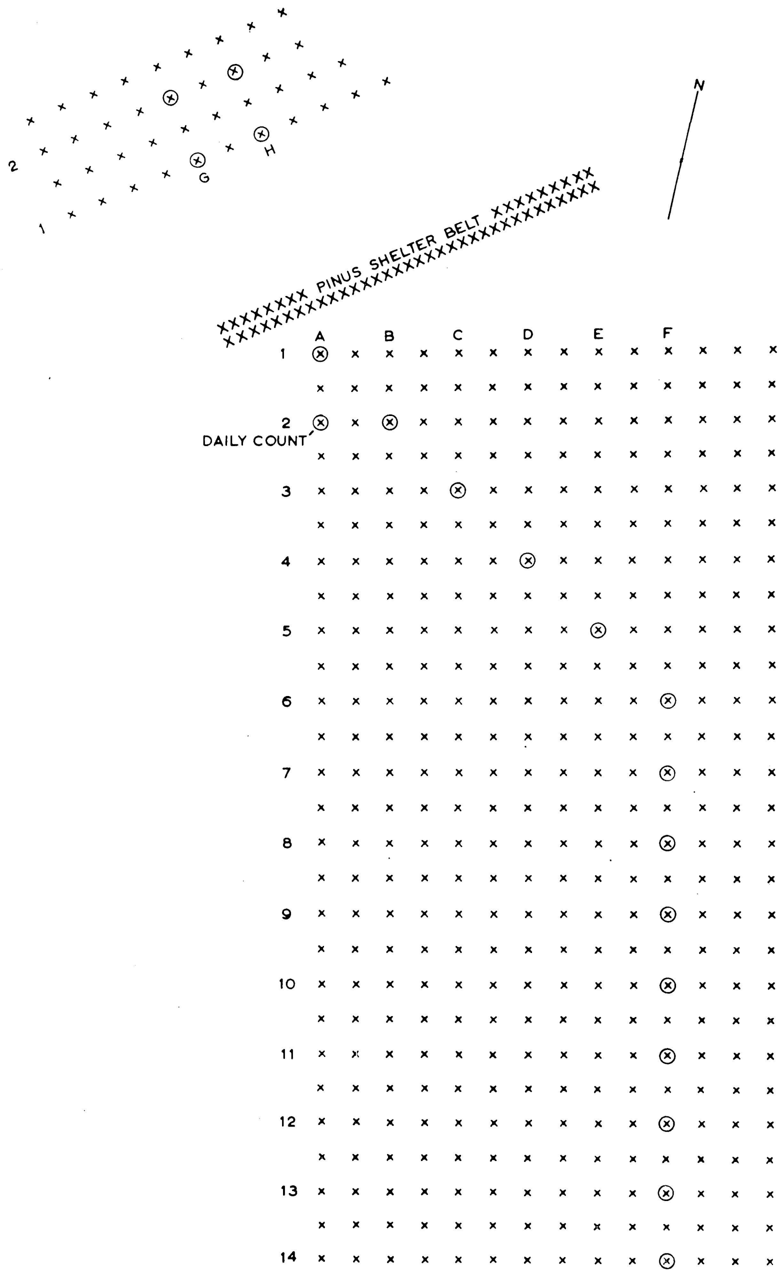


Fig. 5.—Plan of orchard showing layout of greased slides in relation to the *Pinus* shelter belt. Cross in circle indicates location of each individual slide; cross indicates apple tree.

The greased plates were exposed for a period of nine days before being replaced. They were taken back to the laboratory and the number of *Parlatoria* crawlers counted, using a microscope mounted on an extension arm. The glass plate was placed over a grid, the lines of which were spaced to suit the width of the viewing field. Total counts were made by counting the trapped crawlers along each row successively from top to bottom of the plate, the mauve-coloured crawlers being easily identified against a white background.

RESULTS

The total catches for each plate covering the nine-day periods are shown in Table 1. Crawlers had been coming into the orchard for several weeks before the plates were first put out, and numbers built up quickly to reach a peak in the middle of December. High numbers were recorded on plates for about a further three weeks, but after the middle of January the total catches began to drop, although crawlers continued to be trapped until the end of May when, because of the small numbers being caught, the experiment terminated.

The number of crawlers trapped diminished with increasing distance, but a surprising number were trapped at some distance from the shelter belt.

The numbers trapped on the plates G1 and 2 and H1 and 2, which had been placed windward of the shelter belt, were comparable to those similarly placed on the leeside, suggesting that all shelter belts surrounding the orchard, regardless of their aspect to the prevailing wind, must be considered as sources of infection. The numbers taken to windward were not surprising, however, as official meteorological records for this period show marked diurnal variation of the wind in the area.

DAILY PLATE
(TABLE 2)

Running concurrently with the main experiment for the period 20 December to 1 March was a single greased plate (see A2 in Fig. 5) which was changed every day. The maximum number of crawlers caught in a 24-hour period was 130 (on 4 January).

It is interesting to speculate on the density of crawlers coming into the orchard. For the first 30 days that this particular slide was exposed (20 December—18 January), the average daily catch was 44.6 crawlers. This figure represents on a per acre basis something close to two million crawlers daily.

CONTROL

The amount of *Parlatoria* on fruit has made it necessary to find practical and economic methods of eliminating, or at least drastically reducing, the scale insect population. Control investigations will be considered under the following headings:—(A) Cultural, and (B) Chemical.

TABLE 1. *Nine-day counts of* Parlatoria pittospori *crawlers on 12 in. sq. greased plates Marlborough 1960/1 (See Fig. 5)*

Slide number	Nov.	December			January				February	
	22–30	1–9	10–18	19–27	28–5	6–14	15–23	24–1	2–10	11–19
A1	266	337	430	263	273	116	111	58	64	38
B2	238	246	362	284	70	25	17	58	79	28
C3	109	180	445	200	7	27	21	46	44	21
D4	123	313	391	233	30	68	107	66	49	42
E5	71	249	280	250	170	35	23	50	22	19
F6	26	194	×	223	190	75	19	32	36	12
F7	79	168	267	220	320	18	115	57		
F8	—	139	221	160	220	24	15	44		
F9	—	147	203	216	290	38	9	35		
F10	—	125	194	131	122	94	18	34		
F11	—	137	194	136	140	81	9	31		
F12	—	119	158	150	110	75	4	11		
F13	—	121	183	143	102	24	3	17		
F14	—	97	168	137	110	40	12	13		
G1	—	394	241	215	200	61	20	33		
G2	—	360	107	146	160	70	13	36		
H1	—	315	334	250	291	80	48	55		
H2	—	386	226	224	250	55	14	16		
Totals		4,027	4,404	3,581	3,055	1,006	578	692		

(× plate washed clean by irrigation water)

A. Cultural control

Removal of shelter trees. The simplest, and, without doubt, the most effective, control is the complete removal of the scale-infested *Pinus* shelter belts. This would remove the source of infection. *Pinus* shelter belts have been removed in a few Nelson orchards where it was felt that the probability of wind damage within the orchard was not great. Even with the complete removal of the shelter belt it must not be overlooked that host trees beyond the periphery of the orchard could still act as a source of scale insects. Because of the danger of wind damage to the fruit trees, shelter belt eradication is not possible for the majority of orchards.

Scale insect-resistant shelter trees. Apropos the removal of a shelter belt, a number of different species of trees were artificially infested with *P. pittospori* crawlers to see if any would be a suitable substitute for *P. radiata*. The only two trees of those screened on which *Parlatoria* did not establish were *Populus × berolienensis* Dipp. "Strathglass Poplar" and *Populus generosa* Henry. The following trees were found to have *Parlatoria* established on them: *Populus trichocarpa × Populus maximowiczii* Schreiner & Stout, "Androscoggin Poplar," *Pinus nigra* Arnold, *Pseudotsuga taxifolia* Brit., *Cupressus arizonica* Greene, *Larix decidua* Mill., *Thuja plicata* Mast., *Cryptomeria japonica* Don., *Abies grandis* Lindl., *Cupressus macrocarpa* Hartw., *Picea mariana* B. S. P., *Casuarina cunninghamii* Miq., and *Pinus pinea* Linn.

March				April				May		
20–28	1–9	10–18	19–27	28–5	6–14	15–23	24–2	3–11	12–20	21–30
19	4	8	9	5	7	6	6	5	1	1
25	6	5	8	3	2	7	2	4	3	2
14	7	8	0	3	2	11	4	1	4	1
24	12	8	4	4	2	10	3	3	1	2
21	4	9	0	4	3	8	1	0	1	3
9	4	4	3	3	5	8	2	0	0	0

TABLE 2. *Daily counts of* Parlatoria pittospori *crawlers on 12 in. sq. greased plate (A. 2 in Fig. 5)*

MARLBOROUGH 1960/1

20 December 1960—1 March 1961

December	January		February	
	1st 27	17th 3	1st 5	17th 29
	2nd 22	18th 8	2nd 7	18th ×
	3rd 50	19th 1	3rd 3	19th 5
20th 71	4th 130	20th 5	4th 5	20th 9
21st 82	5th 17	21st 13	5th 0	21st 7
22nd 74	6th 30	22nd 19	6th 11	22nd 3
23rd 68	7th 37	23rd 16	7th 4	23rd 4
24th 70	8th 34	24th 16	8th 8	24th 3
25th ×	9th 30	25th 3	9th 7	25th 1
26th 64	10th 48	26th 17	10th 2	26th 4
27th 28	11th 118	27th 3	11th 11	27th 8
28th 58	12th 10	28th 4	12th 11	28th 9
29th 50	13th 65	29th 23	13th 6	1 Mar 0
30th 57	14th 19	30th 2	14th 6	
31st 26	15th 8	31st 19	15th 6	
	16th 34		16th 8	

× plates not exposed on these dates.

In regard to the two species which remained scale insect-free, it is difficult to decide on this one test if these trees could be considered host-resistant to the scale. Drought conditions existing at the time might easily have made establishment difficult. Although scale insects settled on one species of poplar (*P. trichocarpa* × *P. maximowiczii* Schreiner & Stout, "Androscoggin Poplar") on both the leaf and the bark, generally speaking, *Populus* species do not seem to be preferred hosts. Poplars closely associated with infested pine trees were found, when examined, to be free of *Parlatoria.*

Topping shelter belt trees. This really is a prerequisite to chemical treatment. Topping entails the reduction of the height of the pine trees to about 40–50 ft (Fig. 6), which height is commensurate with spraying

J. S. Timlin

Fig. 6.—Partially topped *Pinus* shelter belt.

from the ground, yet still conferring adequate protection against wind. Two orchards, where topping had been carried out on the shelter belts to these heights, suffered no abnormal damage even though very strong winds were experienced during the season. Spraying tall untopped pine trees from the ground proved difficult, and the percentage kill of scale insects obtained from a preliminary trial was very low. To obtain a good control of this scale insect with chemicals it was found necessary to put on sufficient spray to wet thoroughly the needle leaves and ensure complete coverage. The fact that many crawlers settle on the inner faces of the needles (which are in clusters of three) makes complete spray contact difficult.

An important advantage to be gained by topping is that the reduction in height of the pine trees must lessen the distance the windborne crawlers can travel. The height of the pine tree host must be an aid to the wide dispersal that is known to occur throughout the orchard.

Furthermore, the movement of the tops in a high wind produces a vigorous whipping action which must help considerably in "peppering" the orchard with crawlers, so that as well as the reduction in height, the rigidity obtained through topping should help considerably to reduce the distance the windborne crawlers can travel.

B. Chemical control

In July 1960, a number of different insecticides were tested against *Parlatoria*. A heavily infested *Pinus* shelter belt was chosen, and half-chain strips sprayed with a knapsack sprayer. The results, which are presented in Table 3, show that all the oil treatments were very successful.

TABLE 3. *Results of preliminary insecticide trial for* Parlatoria pittospori *on* Pinus radiata *shelter belt, D. Watson's orchard, Fairhall*

Treatment	*Parlatoria pittospori*			Parasites	
	Alive	Dead	% dead	Alive	Dead
Control	1,740	551	24.05	170	47
Winter oil 1/17	23	2,405	98.8	40	65
Intermediate oil 1/33	65	1,626	96.16	77	141
Parathion 1/33 & intermediate oil 8 oz/100	56	1,391	96.13	49	135
Intermediate oil 1/33 azinphos-methyl 1 lb/100	41	2,241	98.21	47	75
Parathion 8 oz/100	691	671	49.27	24	15
Lime sulphur spreader 1/10	568	958	62.78	96	26
Carbaryl 2/100	1,866	610	24.64	41	10
Lime sulphur 1/10 & winter oil 1/17*	32	2,652	98.81	37	36

Sprayed 2 June 1960. Sampled 29 June 1960.
* Applied 10 days later.

In view of this initial success in killing the scale on the pine trees, the work was expanded to test the efficacy of spraying with oil on a field scale. Windward shelter belts on two separate orchards were topped to a height of 40–50 ft and sprayed with a 3 per cent intermediate oil at the rate of approximately 60 gal/chain length of trees. Although intermediate oil had not given the best results in the preliminary trial, it was little inferior to the other treatments, and it was used because of lower cost and the late date of spraying (18 October), when the use of winter oil could have caused damage to apple trees.

Samples taken four weeks later at various heights along the shelter belt confirmed the results obtained in the preliminary trial. From one shelter belt a total of 12,000 scale insects was counted and a mortality of 96.8 per cent recorded. Counts from the second orchard—approximately 10,000 scale insects—showed a 98.8 per cent mortality.

These figures, however, represented a very small sample of the total population, and further evidence to support these results was desired. Periodic examinations were made of the fruit for the presence of scale insects on apple trees in the proximity of the treated shelter belt. Fruit from both orchards had been heavily infested with scale insects the previous season, and the *Pinus* shelter belts carried large numbers of *Parlatoria,* much of this population aggregated in the tops. After the treatment no scale insects were found on fruit in one orchard, and, in the other, three scale insects only were located. These were found on apples situated close to where young trees (about 80 ft high) had been sprayed but not topped. Topping, followed by spraying with intermediate oil, had been most successful in keeping the fruit free of scale insects.

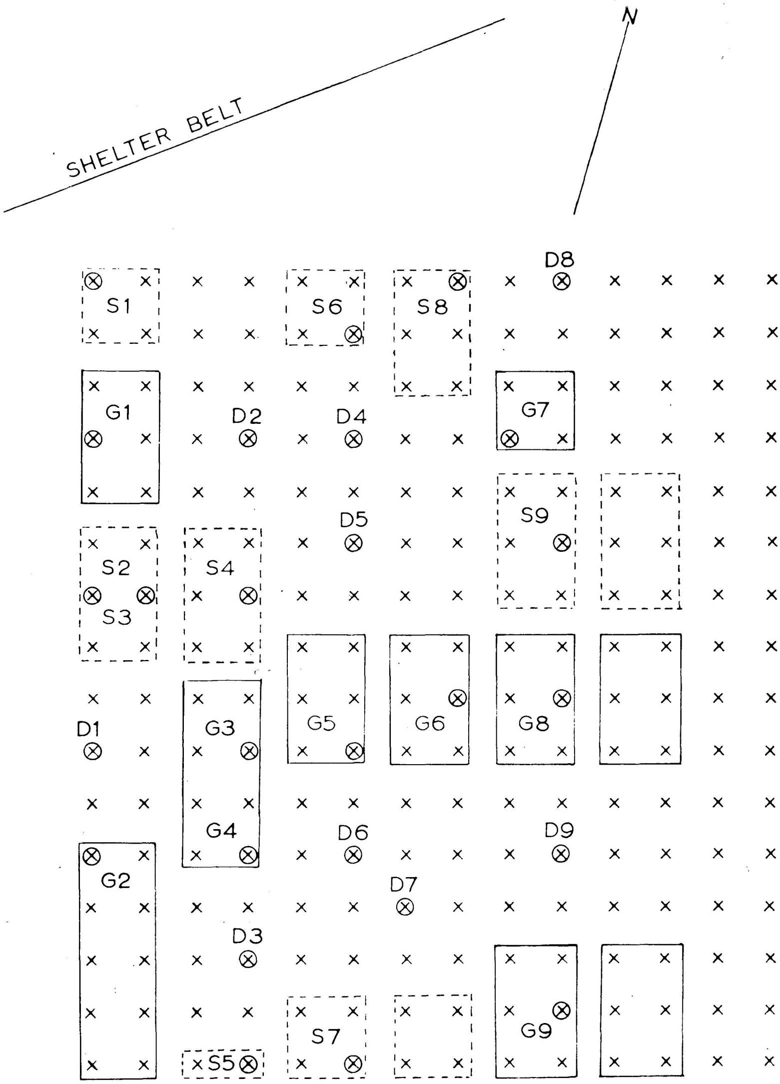


Fig. 7.—Randomised block layout for orchard spray trial. ....S = carbaryl; ———G = azinphos-methyl; D = control; cross in circle = tree harvested and examined for scale; cross = apple tree.

Orchard spray trial. A trial was carried out to see if it was possible to keep fruit free from scale insects by frequent spraying of apple trees known to be subject to infestation from an adjacent *Pinus* shelter belt. The selected block of Delicious trees was the one in which the distribution of crawlers was studied. It lay close to the infested shelter belt, and the density of crawlers coming into the area was known. (See Table 1).

Two insecticides, carbaryl and azinphos-methyl, were tested. The rate of application for both was $1\frac{1}{2}$ lb/100 gal water. The remainder of the block, including the control trees, was sprayed with DDT 1 lb/100 gal water and with DDD $\frac{1}{2}$ lb/100 gal water. DDT and DDD are included in the standard orchard spray programme for the control of Codling and Leaf-roller moths, and the use of these two insecticides in previous seasons had had little or no effect on the establishment of scale insects on the fruit.

The spraying dates were 12 December 1960, 29 December 1960, 11 January 1961, 24 January 1961, 7 February 1961, and 23 February 1961. Spray cover was thus applied at approximately fortnightly intervals except for the period between final spraying and harvesting the fruit. Fruit was not picked until 21 March 1961, an interval of 30 days elapsing between spraying and harvesting. The treatments were randomised (Fig. 7) and block-sprayed. Each treatment was replicated nine times, the selected trees harvested, and the total crop of fruit examined for scale insects.

A total of 17,866 apples was examined, and of these 1,925 were found to be scale-infested. This figure does not represent the total number of scale insects on the fruit, as fruits bearing more than one scale insect were frequently observed. Results of the trial are set out in Table 4.

TABLE 4. *Result of orchard spray trial*

Treatment	Mean % of apples infested	Standard error of mean ±	Range
Carbaryl	5.6	1.5	0.7–16.1
Azinphos-methyl	12.5	1.1	9.4–18.0
Control	12.8	1.5	6.6–22.1

It will be seen that the azinphos-methyl treatment proved no better than the control. Carbaryl reduced the incidence of scale insects considerably (the difference being statistically significant at the 1 per cent level), but the numbers of scale insects still present on the fruit were considered to be much too high to suggest that the treatment was successful.

CONCLUSION

The scale *P. pittospori* does not appear to establish on the apple tree wood in orchards. Infestation of the fruit with scale insects is due to large numbers of windborne crawlers emanating from the *Pinus* shelter trees surrounding the orchards. Studies show that at no stage is an orchard free from the scale insect, crawlers hatching continuously from October until the fruit is harvested.

P. pittospori with a single annual generation does not have the high reproductive potential of a species such as San José scale; neither does it affect the health of the apple tree itself.

Trial work has shown that it is both possible and practical to top and spray the *Pinus* shelter belt. Spray treatment of apple trees in close proximity to infested pine trees was not sufficient in itself to produce scale-free fruit. It is therefore felt that the problem must be attacked at the source, i.e., the pine tree host. Because of the wide host range for *Parlatoria* it is unlikely that a suitable substitute tree will be found to replace *Pinus* shelter belts.

ACKNOWLEDGMENT

The author wishes to record his indebtedness to the Horticulture Division of the Department of Agriculture, who co-operated most willingly in this study, particularly Mr D. McCallum and Mr D. Millier, who carried out the spraying programme and assisted with the sampling.

REFERENCES

CLOSE, R. 1959: Sticky traps for winged aphids. *N.Z. J. agric. Res. 2(2):* 375–9.

FERRIS, G. F. 1942: "Atlas of the scale insects of North America." Ser. IV, Serial No. SIV-402. Stanford Univ. Press, Stanford, Calif.

MCKENZIE, H. L. 1945. A revision of *Parlatoria* and closely allied genera (Homoptera: Coccoidea: Diaspididae). *Microentomology 10:* 47–121.

MORRISON, H. 1939: Taxonomy of some scale insects of the genus *Parlatoria* encountered in plant quarantine inspection work. *Misc. Publ. U.S. Dep. Agric. 344.* 34 pp.

QUAYLE, H. J. 1916: Dispersion of scale insects by wind. *J. econ. Ent. 9:* 486–92.

RICHARDS, AOLA M. 1960: Scale insect survey on apples 1959–1960. *N.Z. J. agric. Res. 3(4):* 693–8.

TIMLIN, J. S. 1964: The distribution and relative importance of some armoured scale insects on pip fruit in the Nelson/Marlborough orchards during 1959/60. *Ibid. 7:* 531–5.