**THE TOXICITY OF FOUR INSECTICIDES TO THE MITE
HEMISARCOPTES COCCOPHAGUS AND ITS HOST SCALE
*HEMIBERLESIA LATANIAE***

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SUMMARY

The insecticides chlorpyrifos, permethrin/pirimiphos-methyl, diazinon and phosmet were tested on hypopode of *HemisarcOPTES COCCOPHAGUS* (Meyer) (Acari: Astigmata: HemisarcOPTidae) and on crawlers of its host, the armoured scale, *Hemiberlesia lataniae* (Signoret) (Homoptera: Coccoidea: Diaspididae). All insecticides elicited avoidance responses from hypopode after direct spraying in a Potter precision spray tower. Toxicity was determined by fixing crawlers and hypopode to slides with adhesive tape and immersing them in insecticide for 1 minute. Hypopode were more resistant than crawlers with respective LC₅₀'s (g ai/litre) of 8.89 and 0.017 for chlorpyrifos, 23.6 and 0.017 for permethrin/pirimiphos-methyl, 25.3 and 0.007 for diazinon, and 64.8 and 0.126 for phosmet.

INTRODUCTION

Armoured scale *Hemiberlesia lataniae* (Signoret) is a major pest on kiwifruit and avocado. It was first identified in New Zealand in Gisborne in 1987 (Morales 1988) and now constitutes about 90% of scale on these fruit in Gisborne and Kerikeri and 30% in Auckland (Berry *et al* 1989). Attempts to control it in New Zealand have involved several hymenopteran parasites, the introduced predacious lady beetles *Chilocorus cactae* (L.) and *C. bipustulatus* (L.), and the use of insecticides and oils. Insecticides do not provide good (economic) control (D. Steven pers. comm.). This scale survives above the spray height on shelter belt trees and causes a continual problem by reinfesting crops (Hill 1990).

The parasitoid (both predaceous and parasitic) mite *HemisarcOPTES COCCOPHAGUS* Meyer (Acari: Astigmata: HemisarcOPTidae) was introduced into New Zealand 2 years ago to control armoured scale (M.G. Hill pers. comm.). It has successfully controlled armoured scale elsewhere (Gerson and Schneider 1981; Gerson 1971) but is not reported to attack the other two horticulturally important scales *Hemiberlesia rapax* (Comstock) or *Aspidiotus nerii* (Bouche) (Beardsley and Gonzalea 1975).

The object of this research was to screen some insecticides used against armoured scale for their effect on *H. COCCOPHAGUS*. Any insecticides found to have little effect on *H. COCCOPHAGUS* could be used in an integrated pest management programme for armoured scale.

METHODS

An initial culture of armoured scale and mites was obtained from Mt Albert Research Centre, D.S.I.R. They were cultured on 'Whangaparoa Crown' pumpkins at optimum temperature (24-25 °C) and humidity (50-60%) (Beardsley and Gonzalez 1975; D. Allan pers. comm.).

Four insecticides (Table 1) widely used for armoured scale in New Zealand were tested on both crawlers (1st instar larvae) of armoured scale and on hypopode of the mite. These stages are the most likely to be found on exposed surfaces and are therefore the most likely to be affected by sprays.

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TABLE 1: Chemicals tested against *H. coccophagus* and concentrations used.

Chemical	Concentration (g ai/100 litres)							
chlorpyrifos	0.3	53	37.5*	150	375	500	1000	2000
diazinon	0.5	5	50*	250	500	800	1000	1500
p/p**	0.5	5	50*	250	500	—	—	2000
phosmet	1.5	15	112.5*	750	1500	—	—	—

**permethrin/pirimiphos-methyl

*denotes usual field rate

Direct spraying of insecticides

Pieces of pumpkin 2 cm x 2 cm (2 test and 2 untreated control) with similar numbers and stages of live scale and hypopode were removed from the cultures. A barrier of 'Tack Trap' was then applied to the lower edge of each piece to catch any hypopode moving off. Each set of pieces (treatment and control) were then sprayed with an insecticide at field application concentration in a Potter precision spray tower (1 ml at 0.7 kg/cm²). After the spray had settled for 1 minute the pieces of pumpkin were placed in a constant temperature cabinet at 24-25 °C and 70-90% RH. After 48 hours mites on surfaces and under scale were counted and their presence in the 'Tack Trap' noted.

Immersion in insecticide

The slide dip method of Anon. (1967) was used to test active, fat (not withered), lightly coloured hypopode and active, pale yellow crawlers. Twenty subjects per test slide and 40 per control (five replicates) were gently agitated for 5 seconds in insecticide dilutions or distilled water. They were then lightly blotted with absorbent tissue and rested at an angle of 30 degrees, subject uppermost, in a constant temperature cabinet at 70-90% RH and 25 °C. Mortality was assessed after 24 and 48 hours according to the criteria of Flexner *et al* (1988). Any mite or crawler that showed repeated movements when gently touched with an artist's paintbrush was considered alive but any that did not move or gave a single twitch were considered dead.

Probit regression analysis was done with "POLO-PC" (Finney 1971).

RESULTS

Analysis of the culture showed that hypopode were the stage in the mite life cycle most likely to be found not sheltering under scale (thus directly sprayed). Only 16.7% of a sample of 150 hypopode were found under the shelter of scale, compared to 96% of deutonymphs, 92.2% of tritonymphs and 91.7% of adult mites.

Spray trials

Significantly fewer hypopode remained on the exposed pumpkin surface 48 hours after spraying with insecticide than after spraying with distilled water ($P < 0.05$, Table 2). Hypopode moved under scale when sprayed with diazinon but tried to move off the pieces of pumpkin when sprayed with the other insecticides and were caught in the 'Tack Trap'. Few hypopode were caught in 'Tack Trap' after exposure to diazinon and none were caught in 'Tack Trap' after spraying with distilled water.

TABLE 2: Numbers of *Hemisarcophyes coccophagus* hypopode found above and beneath scale 48 hours after spraying with insecticide.

	diazinon		chlorpyrifos		p/p		phosmet	
	T	C	T	C	T	C	T	C
surface	0	51	0	64	0	13	8	46
under scale	31	5	3	6	2	1	8	6
'Tack Trap'	P	A	P	A	P	A	P	A
Chi-square*	65.46		14.59		4.747		7.802	

*Degrees freedom = 1, $P < 0.05$ at Chi-square > 3.84

pp = permethrin/pirimiphos-methyl; T = insecticide treated; C = control totals; P = present; A = absent.

Direct immersion trials

The LC_{50} for crawlers was more than 100 times greater than the LC_{50} for hypopode for all four insecticides after both 24 and 48 hour exposure (Figs 1, 2a-d, Table 3). The data did not produce 95% confidence limits (variation in responses being too large) but the 90% confidence limits of LC_{50} 's for hypopode and crawlers did not overlap (Fig. 1). In addition, all insecticides gave significant dose responses ($P < 0.05$) with crawlers but hypopode did not show significant dose responses to diazinon and phosmet (Fig. 2a-d). In no case did 100% of hypopode die within 24 hours, even when 100 times the field rate of an insecticide was used. Control mortality was less than 20% in all cases and averaged 6.6% for hypopode and 10.8% for crawlers. The relative toxicities of insecticides for crawlers were diazinon > chlorpyrifos > permethrin/pirimiphos-methyl > phosmet and all LC_{50} 's occurred well below field rates. The relative toxicities of the insecticides for hypopode were chlorpyrifos > permethrin/pirimiphos-methyl > diazinon > phosmet. Crawlers generally responded more homogeneously to the insecticides than hypopode. Heterogeneity was especially high for hypopode treated with diazinon (Table 3).

Fig. 1: LC_{50} 's with 90% confidence limits for hypopode and crawlers, 24 hours after application.

TABLE 3: LC_{50} and LC_{90} values for four insecticides against hypopode of *H. coccophagus* and crawlers, of armoured scale.

Insecticide		n	LC_{50} (g ai/litre)		Het
			24 hr	24 hr	
chlorpyrifos	hyp	660	8.891	77.50	4.28
	cra	280	0.017	0.146	0.77
diazinon	hyp	710	25.34	220.9	7.49
	cra	288	0.007	0.063	0.00
p/p	hyp	600	23.69	206.5	0.88
	cra	280	0.017	0.147	1.50
phosmet	hyp	420	64.88	565.5	2.05
	cra	280	0.126	1.087	2.86

Het = Heterogeneity, hyp = hypopode, cra = crawlers, p/p = permethrin/pirimiphos-methyl

Fig. 2: Insecticide dose effects on crawlers and hypopode 24 hours after application.

DISCUSSION

The slide dip method of assessing insecticides is a rapid and relatively easy way of comparing relative toxicities. It is possible that *H. coccophagus* would be less exposed to insecticides in the field because of intervening plant material and because they often live under scale in rough cracked surfaces. Their behavioural avoidance responses would further reduce the insecticide's potency. However, it is not known what effect wetting agents, fungicides, or oils may have when added to insecticides as is often done in orchards. Diazinon, with oil, for example, is expected to give better scale control (D. Steven pers. comm.). Further work is required to find what effects combinations of chemicals have on these mites. One possible reason why hypopode are more tolerant to insecticides than crawlers is that they possess a hard sclerotized cuticle (Gerson and Schneider 1982), which directly affects penetration by chemicals (Danka *et al* 1986), whereas crawlers lack such a thick covering. Hypopode also lack functional mouth parts (Gerson and Schneider 1982) and this may further reduce their uptake of

insecticides. Differential metabolism may also play a part in the selective toxicity of insecticides, many mites being well endowed with active oxidases, esterases, and transferases which degrade foreign chemicals (Hamed and Knowles 1988). For example, such enzymes confer immunity to diazinon in the bulb mite, *Rhizoglyphus echinopus* (Hamed and Knowles 1988).

While *H. coccophagus* has shown good tolerance to the four insecticides commonly used against armoured scale, other biocontrol agents are not so tolerant. For example, *Phytoseiulus persimilis*, although resistant to diazinon and phosmet, is susceptible to chlorpyrifos and permethrin/pirimiphos-methyl (Bryham 1985; Anon. 1989).

If good biocontrol is available it may not be sensible to attempt to maximise chemical control as well. Controlling a pest at low levels rather than eradication with additional chemicals may be more economically and environmentally sound in the long term.

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