MORTALITY OF THE LEAFROLLER PARASITOID *DOLICHOGENIDEA TASMANICA* (HYM: BRACONIDAE) EXPOSED TO ORCHARD PESTICIDE RESIDUES

I.C. NEWMAN, J.T.S WALKER and D.J. ROGERS

HortResearch, Private Bag 1401, Havelock North, New Zealand
Corresponding author: inewman@hortresearch.co.nz

ABSTRACT

A laboratory bioassay was used to evaluate the effect of residues from 10 orchard pesticides on mortality of *Dolichogenidea tasmanica*, a parasitoid of leafrollers. Adult parasitoids were caged in Petri dishes that had been sprayed with the field rate of the pesticides. Mortality was assessed over 7 days and classified using the laboratory criteria defined by the International Organization for Biological and Integrated Control of Noxious Animals and Plants. Residues of buprofezin, emamectin benzoate, lufenuron, tebufenozide and thiacloprid were harmless (<30% mortality) to *D. tasmanica* adults in the 7 days after treatment. Indoxacarb and lime sulphur residues were moderately harmful (80-99% mortality), while carbaryl, diazinon and spinosad residues were harmful (>99% mortality). The implications for leafroller control in pipfruit production programmes are discussed.

Keywords: *Dolichogenidea tasmanica*, leafroller, pesticides, parasitoid, bioassay.

INTRODUCTION

Dolichogenidea tasmanica (Cameron) (Hymenoptera: Braconidae) is a specific endoparasitoid of leafrollers (Lepidoptera: Tortricidae), which are serious pests of commercial horticulture in New Zealand. *Dolichogenidea* sp. is the most abundant parasitoid attacking leafrollers on apple foliage (Rogers et al. 2003). In the absence of disruptive pesticides, *Dolichogenidea* sp. has been reported to cause 35% mortality of leafrollers on an apple orchard (Suckling et al. 2001).

Integrated Fruit Production (IFP) is a systems-based approach to pipfruit production that encompasses an Integrated Pest Management (IPM) system based on biological control and selective insecticide applications to control pests. IFP is the minimum standard for export pipfruit production from New Zealand and is widely adopted within the apple sector (Walker et al. 2001). IFP allows insecticides to be applied to pest populations that are, or will reach, damaging or contaminating levels. The insecticide chosen should minimise disruption to natural enemies. Pesticide impacts have been determined for some important natural enemies such as predatory mites (Anon. 2003) and the woolly apple aphid parasitoid, *Aphelinus mali* (Bradley et al. 1997). There is no published information on the effects of the most commonly used pesticides on *D. tasmanica*.

This paper reports the results of a bioassay that investigated the effect of pesticide residues on the survival of adult *D. tasmanica*.

METHODS

A laboratory colony of *D. tasmanica* was established from parasitoids that emerged from field-collected leafrollers in Hawke's Bay, and maintained on the leafroller *Epiphyas postvittana* (Lepidoptera: Tortricidae). Testing was carried out on four separate occasions when sufficient newly emerged parasitoids were available. Solutions of 10 pesticides were mixed in water at the recommended field rates for pipfruit shown in Table 1.

Four replicates were included for each product and water controls were included on each testing occasion. Both the base and lid of 85 mm Petri dishes were sprayed in a Potter tower operated at 103 kPa, using 2 ml of solution with a settling period of 12 sec. Treated dishes were left until dry (15-20 min) then 15 *D. tasmanica* adults were selected at random from the colony and transferred into each dish with a sable hair brush. The transfer was carried out in a room cooled to 8-12ºC to reduce mobility of the parasitoids. A cotton wick containing 1.7 ml of 50:50 honey/water solution was placed into each Petri dish as a food source and was replenished in all dishes as necessary. The dishes were held at 20ºC for 7 days and mortality was assessed at 24 h intervals. Insects that did not move in response to probing with a sable hair brush were considered dead.

Data were adjusted for mortality in the water controls using Abbott's correction (Abbott 1925). Toxicity levels were assigned using the standard criteria defined by the International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC) for laboratory studies (Hassan 1985). This classification is considered as indicative of likely measurable effects in the field.

RESULTS

The mean mortality in the water controls on the four testing occasions ranged from 0 to 17% after 7 days. Corrected cumulative mortalities for the pesticides tested are presented in Table 1 and toxicity is classified on a scale from harmless to harmful based on the IOBC ratings for laboratory assays. Residues of buprofezin, emamectin benzoate, lufenuron, tebufenozide and thiacloprid were harmless (<30% corrected mortality) to *D. tasmanica* adults in the 7 days after treatment (DAT). Indoxacarb and lime sulphur residues were moderately harmful (80-99% corrected mortality), while carbaryl, diazinon and spinosad residues were harmful (>99% corrected mortality). The speed of action of the chemicals showing toxicity was variable (Fig. 1). Spinosad was slightly slower acting than carbaryl and diazinon, but at least 95% of parasitoids exposed to these insecticides were dead within 48 h. Exposure to indoxacarb resulted in a large increase in mortality between 3 and 4 DAT whereas there was a steady progression in mortality with exposure to lime sulphur.

TABLE 1: Mean corrected cumulative mortality (±95% confidence interval) of *D. tasmanica* adults after 7 days of exposure to chemical residues.

Active ingredient	Product	Chemical group	Field rate g ai/ha[1]	(%)	Toxicity[2]
Buprofezin	Applaud 25WP	Thiadiazine	250	16 ± 5	+
Emamectin benzoate	Proclaim 5WG	Macrocyclic lactone	4	2 ± 3	+
Lufenuron	Match 5EC	Benzoylurea	100	-4 ± 4	+
Tebufenozide	Mimic 70WP	Ecdosteroid agonist	181	-11 ± 4	+
Thiacloprid	Calypso 48SC	Chloronicotinyl	288	0 ± 0	+
Indoxacarb	Avaunt 30WG	Oxadiazine	120	93 ± 5	+++
Lime sulphur	15% sulphur SC	Inorganic sulphur	3000	80 ± 5	+++
Carbaryl	Sevin Flo 50SC	Carbamate	1200	100 ± 0	++++
Diazinon	Diazinon 50WP	Organophosphate	1000	100 ± 0	++++
Spinosad	Success 12SC	Macrocyclic lactone	96	100 ± 0	++++

[1]Based on water rate of 2000 litres/ha.
[2]Toxicity classification from IOBC criteria for laboratory studies: + (<30% mortality) harmless, ++ (30-79%) slightly harmful, +++ (80-99%) moderately harmful, ++++ (>99%) harmful.

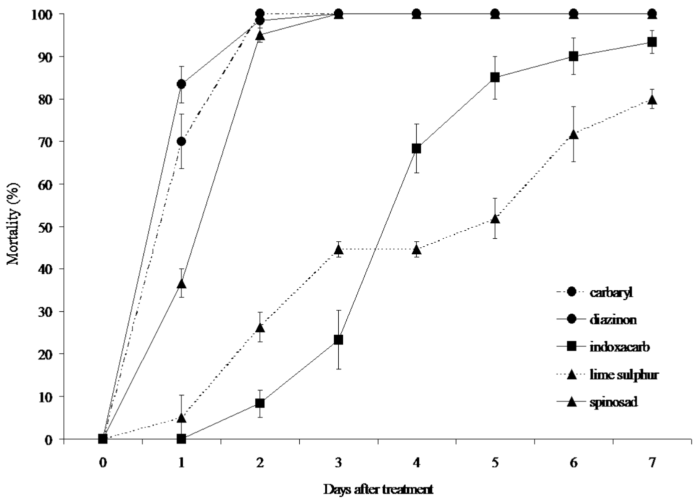

FIGURE 1: The cumulative time-mortality response of *D. tasmanica* adults exposed to five chemical residues over 7 days. Error bars show standard error of the mean.

DISCUSSION

Chemicals deemed harmless in this study have been similarly classified by other researchers as follows. The effect of buprofezin on *D. tasmanica* is within the upper range reported for *Aphelinus mali* (Hymenoptera: Aphelinidae) (Bradley et al. 1997). The result for lufenuron and tebufenozide is similar to reports on other parasitic Hymenoptera (Bradley et al. 1997; Hill & Foster 2000; Brunner et al. 2001). Emamectin benzoate is reported to provide ecological selectivity to a wide range of beneficial arthropods (Dunbar et al. 1998). Likewise, thiacloprid is deemed to be of limited risk to non-target arthropods (Schmuck 2001).

The high toxicity of carbaryl and diazinon against *D. tasmanica* in this study is consistent with the broad-spectrum activity of these insecticides, which poison the central nervous system of insects. Their replacement within the pipfruit IFP programme is dependent on the availability of suitable alternative products for fruit thinning and woolly apple aphid control respectively.

The bioassay demonstrated high mortality of *D. tasmanica* following exposure to spinosad residues. A review of spinosad toxicity to beneficial species by Williams et al. (2003) determined that the substance was harmful or moderately harmful in 78% of 45 laboratory studies on hymenopteran parasitoids, but not harmful in 71% of 59 laboratory trials against a wide range of predators. All studies reviewed by Williams et al. (2003) agreed that spinosad residues degrade quickly in the field.

Hymenoptera are reported to be sensitive to indoxacarb under laboratory conditions (Haseeb et al. 2004; Dinter & Wiles 2000), but again the toxicity is short-lived in the field. Toxicity of indoxacarb in this study remained low until 4 DAT, but effective sub-lethal toxicity was much higher as insects recorded alive from day 2 onwards were unable to walk. Lime sulphur residues were moderately harmful to *D. tasmanica* in this study. There is limited literature on the toxicity of lime sulphur on hymenopteran parasitoids, although detrimental effects have been documented on predaceous mites (Daniel et al. 2002).

For stable management of pests residing within fruiting trees (e.g. mites and woolly apple aphid) it is important to avoid pesticides that are toxic to their natural enemies. However leafroller pest management is different, as the nil tolerance for larvae within export consignments requires highly effective insecticidal control. Parasitoids developing within leafroller larvae are likely to be killed from insecticides acting against leafrollers, which limits the opportunity for managed biological control of leafrollers within orchards. Nevertheless, both leafroller and their parasitoid populations are invasive and colonise orchard trees from surrounding vegetation (J.G. Charles, unpubl. data; P.L. Lo & J.T.S. Walker, unpubl. data). *Dolichogenidea tasmanica* is responsible for significant parasitism in these areas (e.g. shelter, headland vegetation) (Suckling et al. 1998) and therefore plays an important role in leafroller population regulation by limiting orchard invasion. This may contribute to resistance management by reducing the need for chemical control, while parasitism within leafroller populations may also suppress the frequency of resistant genotypes. The present study suggests care should be taken with the application of spinosad and indoxacarb to minimise natural enemy disruption. Growers should avoid unjustified use, target applications to just the orchard canopy and avoid application on non-crop areas that may provide important refugia for hymenopteran parasitoids. Applications of products that may reduce the parasitoid population but not the pest (e.g. lime sulphur) should also be avoided.

The results of this study suggest that buprofezin, emamectin benzoate, lufenuron, tebufenozide and thiacloprid can be successfully integrated into leafroller biological control programmes while spinosad and indoxacarb should be used with an understanding of their potential impact on leafroller biological control. While harmful chemicals remain in the IFP programme, future studies could be carried out to ensure that disruption to biological control is minimised, taking into account the different methods of exposure and sublethal effects.

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