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Indirect non-target effects of insecticides on Tasmanian brown lacewing (*Micromus tasmaniae*) from feeding on lettuce aphid (*Nasonovia ribisnigri*)

M.K. Walker *, M.A.W. Stufkens, A.R. Wallace

New Zealand Institute for Crop and Food Research Limited, Private Bag 4704, Christchurch, New Zealand

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Abstract

Tasmanian brown lacewing, *Micromus tasmaniae* (Walker) (Neuroptera: Hemerobiidae), is an indigenous aphid predator in New Zealand and Australia. Lacewing mortality can result directly from contact with insecticides and/or indirectly from the consumption of insecticide-intoxicated prey. Laboratory bioassays were set up to examine the indirect non-target effects of insecticides on *M. tasmaniae* populations feeding on lettuce aphid, *Nasonovia ribisnigri* (Mosley). Larvae of *M. tasmaniae* were initially tested against three commonly used insecticides at two dose rates (approximate recommended field rate and half field rate). 1st to 4th instar aphids were fed on insecticide-treated lettuce for 24 h and then fed to 1st instar *M. tasmaniae* larvae. Pirimicarb (Pirimor® 50) caused 30–40% mortality of *M. tasmaniae* larvae exposed at 1st instar for 3 days. Pymetrozine (Chess® WG) showed less than 20% mortality, while imidacloprid (Confidor®) caused over 96% mortality of *M. tasmaniae* larvae over this period. A dose–response bioassay was then set-up to determine the impacts of lower doses of imidacloprid through until pupal development of *M. tasmaniae* larvae. There was no increase in mortality due to low doses (one sixth field rate or less) but from days three to eight, *M. tasmaniae* larvae showed significant evidence of delayed developmental rate from 3rd instar larvae into pupae. These results demonstrate that the use of imidacloprid, pirimicarb and pymetrozine for control of lettuce aphid has indirect non-target effects on *M. tasmaniae.* These effects need to be considered in developing Integrated Pest Management (IPM) systems for the New Zealand lettuce industry.

Keywords: Tasmanian brown lacewing (*Micromus tasmaniae*); Lettuce aphid (*Nasonovia ribisnigri*); Pirimicarb; Imidacloprid; Pymetrozine; Predator/prey relationships; Indirect non-target effects; Larvae; Pupae

1. Introduction

Tasmanian brown lacewing, *Micromus tasmaniae* (Walker) (Neuroptera: Hemerobiidae), is an indigenous predator of aphids in New Zealand and Australia (Workman et al., 2004). In New Zealand, *M. tasmaniae* is common and abundant on low vegetation and shrubs, often in association with aphids on roses, lucerne (*Medicago sativa* L.), brassicas and cereals, as well as other crops (Minks and Harrewijn, 1988). *M. tasmaniae* is a generalist polyphagous predator, feeding mainly on aphids with a preference for wingless over winged forms, but also attacking mealy bugs (Scott, 1984). All three larval instars and the adult are predaceous (Hilson, 1964; Leathwick, 1989). In contrast, only the larvae of green-winged lacewings (Neuroptera: Chrysopidae) are predaceous (Workman et al., 2004). *M. tasmaniae* larvae also exhibit conspecific cannibalism, sucking the contents of eggs and attacking and consuming other larvae (Harcourt, 1996). It is thought that cannibalism in lacewing larvae might occur as a survival mechanism when prey is scarce (New, 1975).

Non-target effects of pesticides are extremely important in predator/prey systems for integrated pest management

* Corresponding author. Fax: +64 3325 2074.
E-mail address: walkerm@crop.cri.nz (M.K. Walker).

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(IPM) (Dent, 2000). There is wide knowledge about the direct lethal and sublethal non-target effects of various pesticides on this predator (Rumpf and Penman, 1993; Rumpf et al., 1997, 1998; Hodge and Longley, 2000). However, little is known about the indirect non-target effects of pesticides on *M. tasmaniae*, aside from a recent study investigating the indirect non-target effects of imidacloprid and thiamethoxam on *M. tasmaniae* in Australia (Cole and Horne, 2006). In New Zealand, *M. tasmaniae* is a very important natural enemy of the newly established pest lettuce aphid, *Nasonovia ribisnigri* (Mosley) (Cameron et al., 2007; Workman et al., 2004). *M. tasmaniae* is active in cool periods when few other predators are, and is particularly effective in controlling aphid populations as they build up in spring. It has successfully controlled lettuce aphid populations in spring crops in Pukekohe (Auckland, New Zealand) for four consecutive years (Cameron et al., 2007; Workman et al., 2004), and in spring and summer crops in Canterbury and Horowhenua (New Zealand) (M. Stufkens and G. Walker, unpubl. data) without the use of insecticides. However, many dead lacewing larvae and adults have been observed in crops where insecticides have been applied (M. Stufkens, pers. observ.).

Larvae and adult *M. tasmaniae* are particularly effective predators in lettuce due to their ability, particularly the larvae, to move down into the heart of a lettuce plant where lettuce aphid feeds and reproduces (Cameron et al., 2007; Workman et al., 2004). By inhabiting the heart of the lettuce both species are protected from topically applied, contact insecticides. However, aphids are affected by systemic insecticides through leaf-feeding. Thus, there is a need to establish the indirect non-target effects of systemic insecticides on *M. Tasmaniae* through feeding on insecticide-intoxicated prey (i.e., aphids that have been feeding on insecticide-treated lettuce plants), so that the combined use of insecticides and natural enemies can be maximized in IPM programs.

The insecticides pirimicarb and pymetrozine are applied to lettuce crops as foliar sprays and imidacloprid is applied as a seedling drench. All three insecticides are commonly used to control aphid species on lettuce in New Zealand. Previous studies have concentrated on determining the direct non-target effects of these insecticides on beneficial predators. There is no published data on the effects of pirimicarb on Tasmanian brown lacewing. However, most of the published data on the effects of pirimicarb on other natural enemies (including green lacewing, *Chrysoperla carnea* (Stephens)) suggest that this chemical is reasonably safe (e.g., Gautam and Tesfaye, 2002; Jansen, 2000). In other laboratory tests, pirimicarb was given a high toxic effect rating for the egg parasitoid *Trichogramma* spp and was assessed as being moderately harmful to syrphid larvae (Franz et al., 1980; Hassan et al., 1987; Walsh, 2005).

Pymetrozine is a selective chemical that is designed specifically to control homopterous pests (Follas and Bland, 1994) causing aphids to cease feeding within hours of application (New Zealand Agrichemical Manual, 2005). Again, there are no published studies on the effects of this chemical on *M. tasmaniae*. However, in laboratory tests pymetrozine demonstrated full selectivity against predaceous Coleoptera, Heteroptera, Neuroptera and the predatory mite *Typhlodromus pyri* (Scheuten) when individuals were exposed directly to the spray deposit (Sechser, 1993; Sechser et al., 2002). Syngenta Crop Protection regulatory studies also indicated that *C. carnea* larvae were unaffected following exposure to residues of pymetrozine (G. Follas, pers. comm.). These results suggest that pymetrozine is an ideal compound to control aphids in situations where natural enemies can play a significant role as complementary control tools in an IPM programme (Sechser et al., 2002).

Imidacloprid is an insecticide commercially applied through the roots (cell transplants) in lettuce crops as seedlings at a dose rate of 20–30 ml/1000 plants to control aphids in lettuce (Product label, Bayer CropScience). It is registered and widely used as a seedling drench to control lettuce aphid in susceptible cultivars of lettuce in New Zealand. Reports of the direct non-target effects of imidacloprid on natural enemies of pests vary throughout the literature. Some studies have shown that it has low toxicity to spiders, some predatory beetles, some predatory bugs and green lacewing (Elzen, 2001; Gautam and Tesfaye, 2002; Hough-Goldstein and Whalen, 1993; James, 1997; Kunkel et al., 1999; Varghese and Beevi, 2004). Other studies show that imidacloprid is highly toxic to other species within most of these same insect families (Delbeke et al., 1997; Huerta et al., 2003; James and Coyle, 2001; Mizell and Sconyers, 1992; Sclar et al., 1998; Stark et al., 1995).

There has been one recent study which tested the indirect non-target effects of imidacloprid on 2nd instar (L2) *M. tasmaniae* larvae. Imidacloprid was found to be highly toxic to lacewing larvae that consumed aphids from the treated lettuce seedlings (Cole and Horne, 2006). The indirect non-target effects of pirimicarb, pymetrozine and imidacloprid on beneficial insects (through feeding on insecticide-intoxicated prey) need to be determined to verify the degree of selectivity of these insecticides.

The objective of this study was therefore to examine the potential indirect non-target effects of insecticides on *M. tasmaniae* through feeding on insecticide-intoxicated aphids. Three insecticides were chosen (pirimicarb, pymetrozine and imidacloprid) and were selected as representatives of insecticides commonly used against aphid species on lettuce in New Zealand. We followed the impacts of the three insecticides on mortality in the early stages of larval development and through to pupal development for imidacloprid. Our aim was to investigate the indirect non-target effects of these chemicals on *M. tasmaniae* larvae, and the impacts of these effects on predator populations, predator/prey relationships and IPM systems for the lettuce industry of New Zealand.