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TOXICITY OF SELECTED INSECTICIDES TO *CATOLACCUS HUNTERI* (HYMENOPTERA: PTEROMALIDAE) IN THE LABORATORY

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The pepper weevil, *Anthonomus eugenii* Cano, is a serious economic pest of cultivated *Capsicum* spp. peppers and is widely distributed throughout the southern United States (Elmore et al. 1934; Goff & Wilson 1937; Riley & King 1994), Mexico (Laborde & Pozo 1984), Central America (Andrews et al. 1986), and the Caribbean (Abreu & Cruz 1985). Eggs are deposited in flower buds and fruit, where larvae and pupae complete their development. Infested buds and fruit often abscise, but larvae and pupae can complete development if fallen buds and fruit do not desiccate. Yield losses can reach 90% in Florida, if the weevil is not controlled (Schuster & Everett 1982).

Catolaccus hunteri Crawford (Hymenoptera: Pteromalidae) is the most abundant parasitoid recovered from the pepper weevil in Florida (Riley & Schuster 1992). While natural enemies generally are regarded as contributing little to control of the pest (Elmore & Campbell 1954), 50% parasitism of pepper weevil larvae by *C. hunteri* was observed in fallen jalapeno buds and over 20% parasitism in fallen bell pepper buds (Schuster et al. 1988). Augmentative releases of *C. hunteri* on the alternative host plant American black nightshade (*Solanum nigrum L. var. americanum*, Solanaceae) during the off-season and on pepper at the initiation of flowering have resulted in reduced or delayed damage by weevil larvae (Schuster 2007). To be effective such releases must be compatible with applications of insecticides targeting the pepper weevil as well as other insect pests. The purpose of the present investigation was to evaluate the residual and topical toxicity of selected insecticides to adults of *C. hunteri*.

The insecticides selected for study included chlorpyriphos (99% technical, Dow AgroSciences), methomyl (98% technical, DuPont Crop Science), oxamyl (Vydate 24%, DuPont Crop Science), spinosad (90.4% technical, Dow AgroScience), indoxacarb (56% technical, DuPont Crop Science), and tebufenozide (97.1% technical, Dow AgroSciences).

To evaluate residual toxicity, 0.5 ml of serial dilutions with acetone were added to 20 ml disposable scintillation vials (Gerresheimer Glass Inc., Vineland, NJ) which were then rotated horizontally for at least one hour on a commercial hot dog cooker with the heating element disconnected. Three laboratory-reared parasitoid adults (Vasquez et al. 2005) about 4 d of age were anesthetized by chilling and were put into each of the vials. The vials were sealed with their nontreated screw caps and were placed upside down in a room at about 26 °C. There were at least 4 replications of at least 5 concentrations plus an acetone only control. The numbers of moribund and dead adults were counted 24 h later.

To evaluate topical activity, serial dilutions with 95% ethanol were placed in a pressurized chromatogram sprayer oriented at 45° in a Plexiglas stand. Ten laboratory-reared adult parasitoids were anesthetized by chilling and were placed on a filter paper disk lightly moistened with deionized water in the bottom of a standard, plastic Petri dish. The plane of the dish was oriented perpendicular to the 45° angle of the sprayer and spaced such that the circumference of the spray pattern was the same as that of the Petri dish. The sprayer was discharged until 0.5 ml of solution had been applied. As the anesthetic effects of chilling dissipated and the alcohol dried, the adults were gently tapped into the bottom of another Petri dish and the lid put in place. The lids had a single, 2.5 cm diam hole covered with organdy to provide ventilation. The numbers of dead and moribund adults were counted 24 h later. There were at least 5 Petri dishes (replications) in addition to an alcohol alone control. Both residual and topical data were subjected to standard probit analyses (SAS Institute 2008).

Based upon LC_{50} values, chlorpyriphos and methomyl were both highly toxic residually (Table 1). Oxamyl and spinosad were less toxic, having LC_{50} values about 100 times that of chlorpyrifos and about 20 times that of methomyl. Indoxacarb and tebufenozide were least toxic, with the latter being essentially non-toxic (no adults killed even at a dose of 135,940 µg[ai]/mL.

Chlorpyrifos and tebufenozide were highly toxic topically (Table 1). Although methomyl, oxamyl, and spinosad were less toxic, LC_{50} values were only about 4-10 times higher than those of chlorpyrifos or tebufenozide. Indoxacarb was again least toxic, with an LC_{50} value over 750 times those of chlorpyrifos or tebufenozide.

The topical toxicity of tebufenozide was unexpected. This insecticide mimics the action of the molting hormone ecdysone, thus triggering premature molting of immature lifestages, particularly of Lepidoptera larvae. The primary mode of exposure to insects is oral. Thus, direct topical activity on adults should be minimal.

The results suggest that, when targeting control of lepidopterous species, indoxacarb would be

TABLE 1. TOXICITY OF SELECTED INSECTICIDES TO *C. HUNTERI* ADULTS.

Insecticide	n[1]	Slope (SE)	LC_{50} (µg[ai]/mL)	95% Fiducial limits	P^2
			Residual		
Chlorpyrifos					
Methomyl	156	5.05 (0.74)	0.139	0.122-0.156	0.37
Oxamyl	240	1.91 (0.27)	2.126	1.680-2.671	0.73
Spinosad	120	2.76 (0.51)	2.331	1.837-3.147	0.29
Indoxacarb	348	2.13 (0.22)	42.842	35.652-50.888	0.59
Tebufenozide	50	—	>135940	—	—
			Topical		
Chlorpyrifos					
Methomyl	141	1.05 (0.19)	3.321	1.652-5.722	0.84
Oxamyl	122	1.74 (0.31)	1.847	1.153-2.747	0.79
Spinosad	120	1.08 (0.19)	1.299	0.704-2.291	0.76
Indoxacarb	120	1.89 (0.32)	225.961	164.202-317.305	0.20
Tebufenozide	121	1.14 (0.20)	0.221	0.128-0.372	0.53

[1]The number of adults tested, not including the controls.
[2]A P value of > 0.05 indicates the data fit the probit model.

the least disruptive to *C. hunteri*. Tebufenozide could be applied prior to augmentative releases of the parasitoid, but could be disruptive when adults are present. The use of methomyl should be avoided because of its higher residual toxicity. Spinosad was intermediate in both residual and topical toxicity and could be useful in rotations with indoxacarb. While chlorpyrifos has demonstrated activity in controlling the pepper weevil (Schuster et al. 2009), it would be very disruptive to *C. hunteri*. Oxamyl is a standard for control of the pepper weevil and would be less disruptive than chlorpyrifos in conserving the parasitoid.

SUMMARY

Selected insecticides were evaluated in the laboratory for residual and topical toxicity to *Catolaccus hunteri* Crawford, a parasitoid of the pepper weevil, *Anthonomus eugenii* Cano. Based on predicted LC_{50} values, chlorpyrifos was highly toxic to the parasitoid both residually and topically, with LC_{50} values of 0.029 and 0.292 µg[ai]/mL, respectively. Indoxacarb was non-toxic, with LC_{50} values of 42.842 and 225.961 µg[ai]/mL, respectively, for residual and topical exposure. Tebufenozide was non-toxic residually (LC_{50} value of >135,940 µg[ai]/mL) but relatively toxic topically (LC_{50} value of 0.221 µg[ai]/mL). LC_{50} values of oxamyl and spinosad both residually (LC_{50} values of 2.126 and 2.331 µg[ai]/mL, respectively) and topically (LC_{50} values of 1.847 and 1.299 µg[ai]/mL, respectively) were intermediate between those of chlorpyrifos and indoxacarb. Methomyl was more toxic residually (LC_{50} value of 0.029 µg[ai]/mL) than topically (LC_{50} value of 0.292 µg[ai]/mL).

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