Impact of Selected Insecticides Used in Eggplant Production on *Edovum puttleri* Grissell (Hymenoptera: Eulophidae)[1]

George C. Hamilton, James H. Lashomb and Joseph M. Patt

Department of Entomology, P. O.Box 231, Cook College
Rutgers University
New Brunswick, NJ 08903 U.S.A.

J. Entomol. Sci. 31(4): 432-439 (October 1996)

ABSTRACT The impact of insecticides currently used in commercial eggplant fields to control the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), on the egg parasitoid *Edovum puttleri* Grissell was evaluated. Mortality from contact exposure to leaf residues and ingestion of contaminated honey, and parasitoid emergence from treated egg masses were compared for the following insecticides: esfenvalerate alone and in combination with piperonyl butoxide (PBO), oxamyl, PBO, and rotenone alone and in combination with PBO. Studies were conducted using concentrations of 1.0X, 0.75X, 0.5X, and 0.25X of the maximum labeled rate. Mortality was high and significantly different from controls for all chemicals and rates in both the leaf residue tests and feeding studies. Emergence of *E. puttleri* from treated egg masses also was significantly impacted by all materials and rates with the exception of PBO. The data suggest that the use of these materials in a pest management program that utilizes *E. puttleri* may reduce the survival of adults and emergence from eggs, thereby slowing parasitoid establishment.

KEY WORDS *Edovum puttleri*, Colorado potato beetle, insecticides, eggplant, IPM

In New Jersey, eggplant, *Solanum melongena* L., is an important component in a fresh market vegetable production system (Lashomb 1989) due to consistent yield and prices each year relative to other shorter-season vegetable crops. The Colorado potato beetle, *Leptinotarsa decemlineata* (Say), is a key pest in eggplant and, if left uncontrolled, subsequent defoliation can completely destroy the crop (Cotty and Lashomb 1982). Colorado potato beetle populations have become resistant to most chemical insecticides resulting in difficulty in protecting the crop (Forgash 1985).

The egg parasitoid *Edovum puttleri* Grissell was first collected from *L. undecemlineata* (Stahl) in Colombia, South America (Grissell 1981) and subsequently from *L. decemlineata, L. undecemlineata*, and *L. typographica* Jacoby in Mexico (Logan et al. 1987). Since being introduced into the U. S.,

[1] Received 02 August 1995; Accepted for publication 24 August 1996.

E. puttleri has been shown to effectively parasitize Colorado potato beetle egg masses in eggplant fields (Jansson et al. 1988). During the late 1980's, a Colorado potato beetle pest management system using *E. puttleri* as the primary control tactic was implemented to reduce grower reliance on chemical control of the beetle (Lashomb 1989). This program utilizes field scouting, weekly parasitoid releases, and insecticide applications pre- and post-release if either egg mass or larva/adult economic thresholds are reached. Prior to release of the parasitoid, the decision of which insecticide to apply is made at the discretion of growers. Once releases are begun, the use of rotenone in combination with piperonyl butoxide (PBO) is recommended (Mayer and Walker 1988). for each situation, the insecticides used may leave residues deleterious to *E. puttleri* and compromise parasitoid effectiveness. The impact of insecticides used on potatoes on *E. puttleri* was investigated by Obrycki et al. (1986). These researchers found that cryolite, rotenone, fenvalerate and methamidophos were highly toxic to *E. puttleri* immatures and adults. These chemicals, however, with the exception of rotenone, are not widely used in eggplant (Hamilton and Meyer 1992). This study evaluated the impact of insecticides commonly applied to eggplant on the feeding, survival and egg parasitism by *E. puttleri*.

Materials and Methods

All *E. puttleri* adults utilized in these studies were reared following the protocol developed by the New Jersey Beneficial Insect Laboratory (Palmer 1990). Before each study, newly-emerged adults were held in a vented 41 glass container containing 1:1 (v/v) honey:water food source in a Precision® growth chamber maintained at 26 ± 1°C, 45 ± 5% RH and 15:9 (L:D) light phase regime.

Three commonly used insecticides, esfenvalerate (Asana XL®, Dupont, Wilmington, DE), oxamyl (Vydate L®, E. I. Dupont, Wilmington, DE), and rotenone (Rotenox®, Fairfield American, Frenchtown, NJ) and 1 synergist, PBO (Butoxide®, Fairfield American, Frenchtown, NJ) were tested. Combinations of esfenvalerate and PBO, and rotenone and PBO also were tested. All studies were conducted using concentrations (g [AI]/l) of approximately 1.0, 0.75, 0.50 and 0.25X the maximum labeled rate recommended for controlling Colorado potato beetle (esfenvalerate - 0.12, 0.09, 0.06, and 0.03, respectively; oxamyl - 1.20, 0.90, 0.60, and 0.30, respectively; PBO - 2.39, 1.79, 1.20, and 0.60, respectively; rotenone - 7.66, 5.75, 3.83, and 1.92, respectively) and a distilled water control. No surfactant was used. Data were converted to arcsine values (Snedecor and Cochran 1978) and analyzed by analysis of variance (ANOVA) (SAS 1987). Means were separated by a least significant difference test (LSD).

Feeding Tests. *Edovum puttleri* will feed on aphid honeydew and floral nectaries for sustenance. Therefore, we tested the impact of feeding on insecticide-contaminated nectar on parasitoid mortality. Each insecticide was incorporated into 1:1 (v/v) honey:water solution used as a food source for adults. For each material and rate, 50 ml of the prepared solutions were placed into each of 100 plastic Solo® condiment cups (59.1 ml) and covered with a lid containing a cotton dental wick (Crosstex® No. 2) inserted into it. Each cup was then placed into an individual Tri-State® Plastic container (18.3 × 12.7 × 9.4 cm) fitted with a vented lid (8.9 × 12.7 cm organza mesh screen). Fifty unfed adult wasps were then introduced into each of 100 containers and allowed to feed for 48 h. Mortality was recorded at 24 and 48 h post-exposure. At 48 h post-exposure, all adults were removed from the container, recounted and the mean % mortality was determined.

Leaf Exposure Tests. The impact of insecticide leaf residues on *E. puttleri* was evaluated using treated leaf disks. For each material and rate, 100 eggplant leaves were excised and the petioles inserted into an Oasis® rootcube moistened with water and trimmed to 63.5-cm^2 leaf disks using a 9-cm plastic Petri dish placed over the midrib. Each leaf disk was dipped into 100 ml of the respective concentration for each material, air dried, and placed into a vented plastic box (18.3 × 12.7 × 9.4 cm). Fifty adult wasps were introduced along with 50 ml of a 1:1 (v/v) honey:water solution into each of 100 boxes and held for 48 h. Mortality was recorded at 24 and 48 h post exposure. Adults were removed from the container after 48 h, recounted, and the mean percent mortality was determined.

Parasitoid Emergence Tests. The impact of insecticides topically applied to *L. decemlineata* egg masses on parasitism by *E. puttleri* was determined. Egg masses were obtained by rearing Colorado potato beetle larvae to adults and allowing them to lay eggs on caged potato plants maintained in the greenhouse under 25.0 ± 2.0°C temperature and a photoperiod of 12:12 (L:D) light phase regime. Egg masses were collected from plants and trimmed to 10 eggs per mass. One hundred trimmed egg masses per concentration per chemical were treated with 10 µl of material per egg mass using a metered micro-syringe applicator, allowed to air dry, and placed into vented plastic boxes (18.3 × 12.7 cm) prior to exposure to *E. puttleri*. Ten 3-day-old mated and fed adult female wasps were introduced into each of 100 boxes along with 50 ml of 1:1 (v/v) honey:water solution and allowed to freely parasitize eggs over a 48-h period. Exposed egg masses were transferred to sealed Solo® plastic condiment cups (59.1 ml) (1 egg mass per cup) and held until adult emergence. The total number and percent of individuals emerged was determined.

Results and Discussion

Feeding Tests. All insecticide treatments negatively impacted the survival of *E. puttleri* adults in both the 24 and 48 h counts (n = 100, $P \leq 0.05$) (Table 1). The highest mortality levels observed at 48 h were for adults fed honey containing oxamyl (0.25X - 96.8; 0.5X - 97.3; 0.75X - 99.7; 1.0X - 96.1) and rotenone alone (0.25X - 60.3; 0.5X - 95.7; 0.75X - 95.2; 1.0X - 97.9). The lowest mortality levels observed were for PBO alone (0.25X - 4.5; 0.5X - 4.1; 0.75X - 5.2; 1.0X - 11.6). Esfenvalerate in combination with PBO caused higher mortality for all but the 0.5X rate (48h) than esfenvalerate alone. This increase in mortality, however, was not observed when PBO was combined with rotenone. The data suggest that ingestion of contaminated nectar in the field would be detrimental to parasitoid survival. This impact has been observed with other parasitoids. Barlett (1996) reported high mortality levels with *Aphytus melinus* DeBach and *Metaphycus luteolus* (Timberlake) when exposed to honey treated with 61 different insecticides.

Table 1. Mortality of *Edovum puttleri* fed on honey-water treated with selected insecticides for 24 and 48 hrs.

	Percent Mortality (± SE)*											
	esfenvalerate		esfenvalerate and PBO		rotenone		rotenone and PBO		oxamyl		PBO	
Rate**	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h
0	0.0 (0.0) b	0.0 (0.0) b	0.0 (0.0) c	0.0 (0.0) d	0.0 (0.0) d	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) b	0.0 (0.0) b	0.0 (0.0) b	0.0 (0.0) b	0.0 (0.0) b
25	32.0 (6.0) a	62.4 (6.3) a	54.0 (5.4) b	83.9 (2.7) bc	29.2 (5.6) c	60.3 (5.6) b	59.7 (5.9) b	84.5 (3.1) a	68.7 (2.8) c	96.8 (0.9) a	2.7 (1.6) ab	4.5(2.1) b
50	40.9 (5.4) a	74.9 (4.3) a	67.7 (4.8) a	68.8 (3.7) c	65.1 (4.7) b	95.7 (1.2) a	63.0 (5.6) ab	87.3 (2.1) a	73.5 (2.5) bc	97.3 (0.8) a	2.5 (1.5) ab	4.1 (1.5) b
75	33.2 (6.6) a	63.8 (6.5) a	68.3 (5.2) a	91.3 (1.9) b	63.6 (5.8) b	95.2 (1.5) a	53.5 (7.9) b	91.5 (2.3) a	78.8 (2.3) b	99.7 (0.2) a	4.7 (1.6) a	5.2 (1.8) b
100	41.4 (7.4) a	72.0 (6.0) a	64.1 (5.2) ab	98.7 (0.5) a	88.9 (2.8) a	97.9 (0.9) a	76.0 (4.8) a	92.0 (3.2) a	86.5 (2.5) a	96.1 (1.7) a	5.8 (1.9) a	11.6 (2.2) a

* n = 100. Means followed by the same letter within a column are not significantly different at $P > 0.05$, LSD.
** Rates are based on a percentage of maximum labeled field rate.

Leaf Exposure Tests. Exposure of *E. puttleri* adults to leaf residues of the materials tested also resulted in high levels of mortality (Table 2). For each insecticide, controls (0X) had significantly lower mortality levels when compared with any of the rates tested (n = 100; $P \leq 0.05$). Overall, for each rate tested, mortality at 48 h for all treatments except PBO alone (0.25X - 7.2; 0.5X - 6.0; 0.75X - 7.7; 1.0X - 8.8) and esfenvalerate in combination with PBO (0.25X - 84.4; 0.5X - 85.5; 0.75X - 94.1; 1.0X - 90.9) ranged from 90 to 100%. Exposure to leaves treated with esfenvalerate (0.25X - 96.4; 0.5X - 98.9; 0.75X - 100.0; 1.0X - 100.0) resulted in the highest mortality levels observed for any of the materials tested, followed by rotenone in combination with PBO (0.25X - 96.5; 0.5X - 98.7; 0.75X - 99.5; 1.0X - 98.8). Obrycki et al. (1986) found similar results when subjecting *E. puttleri* to contact residues of various insecticides registered for control of Colorado potato beetle on potato and showed that *E. puttleri* was highly susceptible to rotenone in combination with PBO, as well as other insecticides not used in this study.

Parasitoid Emergence Tests. Parasitoid emergence was low for all insecticides and rates tested (24.5 to 0.9 adults) (Table 3). Piperonyl butoxide alone had little or no impact on emergence (0% - 16.9; 0.25X - 16.0; 0.5X - 24.1; 0.75X - 7.1; 1.0X - 22.6), however, emergence was reduced by all other materials tested. Although emergence did not differ among rates, it was significantly lower (n = 100; $P \leq 0.05$) on insecticide-treated eggs compared with nontreated controls. Several authors have documented effects of insecticides on parasitoid survival. Hsieh and Allen (1986) found that field rates of diazinon and malathion reduced survival of *Diaeretiella rapae* (M'Intosh) by 1.0X and 85%, respectively. Obrycki et al. (1986) found that insecticide treatments 1-2 days and 7-8 days following oviposition into Colorado potato beetle eggs caused significant mortality to *E. puttleri* immatures. While our test did not examine the basis for reduced emergence, the differences observed may be due to parasitoid mortality following oviposition. Other possible causes include reduced oviposition due to insecticide repellency or mortality of treated eggs prior to being offered to females.

Our results show that *E. puttleri* is highly susceptible to chemical insecticides commonly used to control Colorado potato beetle in commercial eggplant fields. This finding has serious implications for the implementation of pest management programs that use *E. puttleri*. The use of these insecticides prior to parasitoid releases may reduce adult survival and slow initial establishment due to contact with leaf residues or ingestion of insecticide-contaminated nectar. Applications made to reduce Colorado potato beetle populations below threshold levels may also diminish the effectiveness of *E. puttleri* by decreasing the survival of parasitized eggs. These data suggest that the use of alternative insecticides for Colorado potato beetle control may be warranted when applied in conjunction with parasitoid releases. Materials, such as *Bacillus thuringiensis* Berliner, have little or no impact on *E. puttleri* (unpublished data) making them more compatible with parasitoid releases.

Table 2. Mortality of *Edovum puttleri* exposed to foliar residues of selected insecticides for 24 and 48 hrs.

	Percent Mortality (± SE)*											
	esfenvalerate		esfenvalerate and PBO		rotenone		rotenone and PBO		oxamyl		PBO	
Rate**	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h
0	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) d	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) d	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) c	0.0 (0.0) a	0.0 (0.0) a
25	81.1 (3.2) b	96.4 (0.6) b	69.9 (4.5) c	84.4 (3.0) b	70.8 (5.9) b	92.6 (2.0) b	89.7 (1.5) c	96.5 (0.9) b	70.8 (4.4) b	90.2 (2.0) b	1.5 (1.1) a	7.2 (2.2) a
50	85.1 (3.4) ab	98.9 (0.5) a	75.7 (3.2) bc	85.5 (1.7) b	70.0 (4.7) b	94.0 (1.4) b	89.9 (1.4) bc	98.7 (0.5) a	82.8 (2.3) a	95.2 (1.3) a	0.0 (0.0) a	6.0 (1.6) a
75	93.4 (1.5) a	100.0 (0.0) a	83.0 (2.7) a	94.1 (1.3) a	86.6 (2.4) a	98.4 (0.5) a	93.9 (1.4) a	99.5 (0.2) a	82.0 (2.3) a	96.5 (1.2) a	1.3 (1.2) a	7.7 (2.1) a
100	92.3 (1.5) a	100.0 (0.0) a	82.6 (2.0) ab	90.9 (1.3) ab	87.8 (2.6) a	98.4 (0.7) a	93.3 (1.5) ab	98.8 (0.7) a	79.8 (2.6) ab	99.1 (1.4) a	0.0 (0.0) a	8.8 (2.2) a

* n = 100. Means followed by the same letter within a column are not significantly different at $P > 0.05$, LSD.
** Rates are based on a percentage of maximum labeled field rate.

Table 3. Emergence of *Edovum puttleri* adults from CBP eggs treated with selected insecticides.

	Percent Mortality (± SE)*					
Rate**	esfenvalerate	esfenvalerate and PBO	rotenone	rotenone and PBO	oxamyl	PBO
0	21.3 (2.1) a	17.9 (2.6) a	15.7 (1.5) a	24.5 (3.1) a	15.8 (1.4) a	16.9 (0.9) b
25	4.9 (1.1) b	5.4 (0.8) b	3.5 (0.7) b	5.7 (1.3) b	9.4 (3.1) b	16.0 (0.3) b
50	3.6 (1.3) b	3.5 (1.0) b	4.3 (0.5) b	3.3 (0.9) b	6.0 (1.0) b	24.1 (1.5) a
75	5.1 (0.5) b	2.6 (0.5) b	5.6 (1.8) b	8.9 (2.5) b	10.0 (1.6) b	7.1 (2.8) c
100	2.2 (0.9) b	3.4 (1.3) b	3.3 (1.0) b	0.9 (0.5) b	5.1 (0.9) b	22.6 (2.0) a

* n = 100. Means followed by the same letter within a column are not significantly different at $P >$ 0.05, LSD.
** Rates are based on a percentage of maximum labeled field rate.

Acknowledgments

We thank M. E. Balzer and the undergraduate students who assisted with this project. This study was supported by USDA agreement TPSU-RU-3361-527, CSRS NE-NAPIAP Special Projects. New Jersey Agricultural Experiment Station Publication Number D-08930-13-95, supported by State funds and U. S. Hatch Act.

References Cited

Bartlett, B. R. 1966. Toxicity and acceptance of some pesticides fed to parasitic Hymenoptera and predatory Coccinellids. J. Econ. Entomol. 59: 1142-1149.

Cotty, S., and J. Lashcomb. 1982. Vegetative growth and yield response of eggplant to varying first generation Colorado potato beetle densities. J. N. Y. Entomol. Soc. 90: 220-228.

Forgash, A. J. 1985. Insecticide resistance in the Colorado potato beetle, Pp. 33-53. *In* D. N. Ferro and R. H. Voss (eds.), Proceedings of the symposium on the Colorado potato beetle. XVIIth International Congress of Entomol. Res. Bull. #704, Mass. Agric. Expt. Sta., Amherst.

Grissell, E. E. 1981. *Edovum puttleri,* n. g., n. sp. (Hymenoptera: Eulophidae), an egg parasite of the Colorado potato beetle (Chrysomelidae). Proc. Entomol. Soc. Wash. 83: 790-796.

Hamilton, G. C. and L. Meyer. 1992. Agricultural pesticide use in New Jersey - a survey of private applicators. RCE Bull. E155.

Hsieh, C. Y. and W. W. Allen. 1986. Effects of insecticides on emergence, survival, longevity, and fecundity of the parasitoid *Diaeretiella rapae* (Hymenoptera: Aphidiidae) from mummified *Myzus persicae* (Homoptera: Aphididae). Environ. Entomol. 79: 1599-1602.

Jansson, R. K., J. Lashomb, E. Groden and R. Bullock. 1988. Parasitism of *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae) by *Edovum puttleri* (Hymenoptera: Eulophidae) in different cultivars of eggplant. Entomophaga 32: 503-510.

Lashcomb, J. 1989. Use of biological control measures in the intensive management of insect pests in New Jersey. Amer. J. Alternative Agric. 3: 77-83.

Logan, P. A., R. A. Casagrande, T. H. Hsiao and F. A. Drummond. 1987. Collections of natural enemies of *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae) in Mexico, 1980-1985. Entomophaga 32: 249-254.

Mayer, M. and S. Walker. 1988. Pest management recommendations for eggplant IPM growers. N. J. Dept. of Ag. Trenton, NJ. 2 p.

Obrycki, J. J., M. J. Tauber and W. M. Tingey. 1986. Comparative toxicity of pesticides to *Edovum puttleri* (Hymenoptera: Eulophidae), an egg parasitoid of the Colorado potato beetle (Coleoptera: Chrysomelidae). J. Econ. Entomol. 79: 948-951.

Palmer, D. 1990. Notes on laboratory rearing of *Edovum puttleri* - internal protocol. N. J. Dept. of Ag. Trenton, NJ. 9 pgs.

SAS Institute. 1987. SAS/STAT guide for personal computers. SAS Institute, Inc. Cary, N.C.

Snedecor, G. W. and W. G. Cochran. 1978. Statistical methods. Iowa Univ. Press. Ames. 593 p.