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Efficacy of deltamethrin and *Bacillus thuringiensis* Berliner ssp *kurstaki* on larvae of winter moth, *Operophtera brumata* (L.) (Lepidoptera: Geometridae) attacking blueberry in the Lower Mainland of British Columbia

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ABSTRACT

Two pesticides were evaluated for control of the European winter moth, *Operophtera brumata* (L.), in blueberries in Richmond, British Columbia. The pyrethroid, deltamethrin (Decis), was effective against this pest. The *Bacillus thuringiensis* product Dipel (WP) was ineffective. Deltamethrin provides an alternative to the currently used organo-phosphate pesticides.

INTRODUCTION

The European winter moth, *Operophtera brumata* (L), was first introduced to the east coast of North America (Nova Scotia) as early as the 1930s (Cuming 1961, Embree 1965, 1970), and to southern Vancouver Island (Victoria, British Columbia) prior to 1970 (Gillespie *et al.* 1978, Roland 1988). Since then, the winter moth has spread to the mainland of British Columbia and is most prevalent in the southwestern communities of Ladner, Tsawwassen and Richmond.

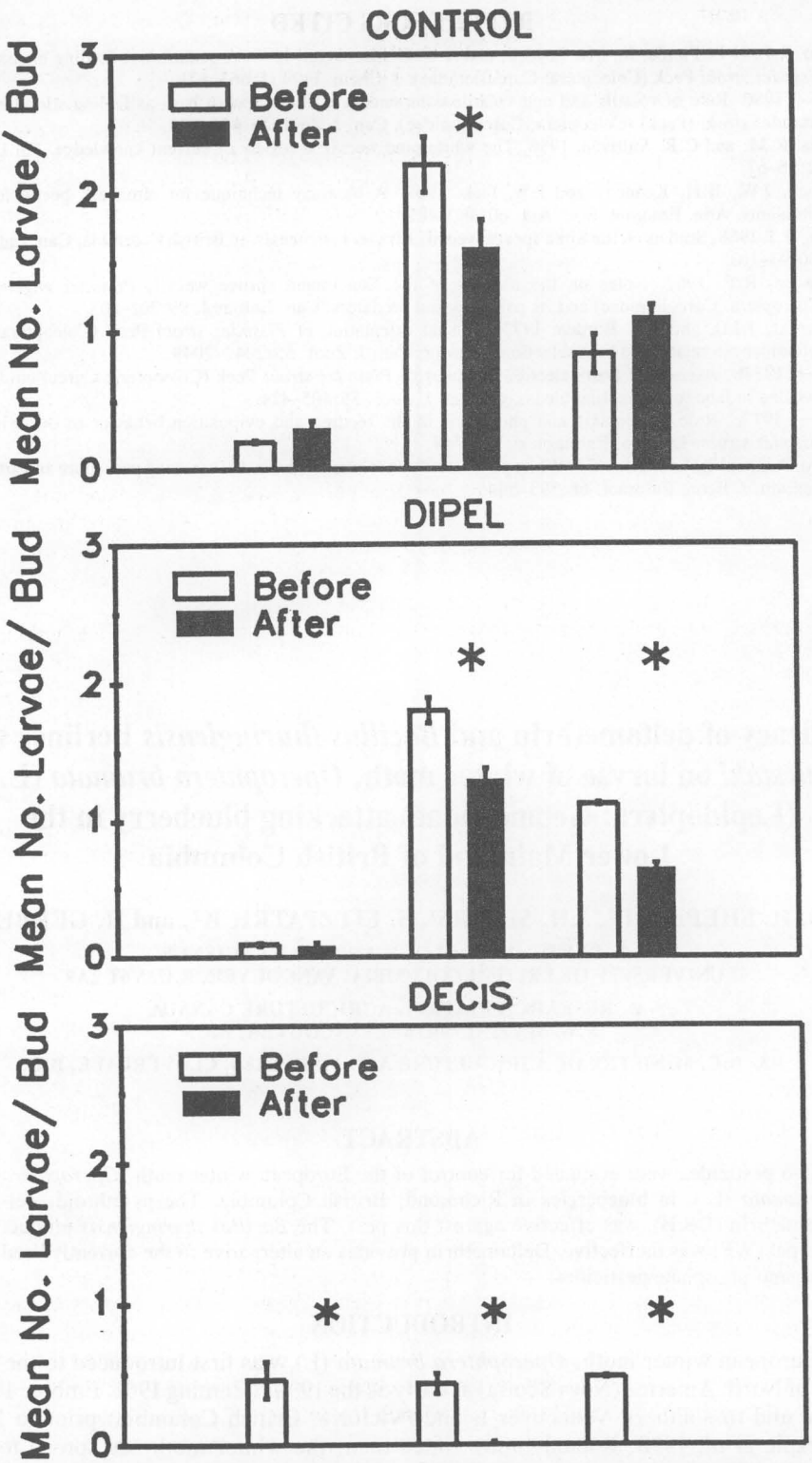

Fig. 1. Mean number of winter moth larvae/bud in 3 replicates of control, deltamethrin (Decis), and *Bacillus thuringiensis* plots before (April 11, 1990) and after treatment (April 18, 1990). * indicates plots that significantly declined in density over this period in t-test comparisons. S.E. bars given.

Winter moth eggs hatch in early April and larvae immediately begin to feed on new buds. In Richmond, *O. brumata* have reached high densities in *Betula* (birch) woodland, causing near total defoliation in some areas. Since 1988 winter moth larvae have severely damaged unsprayed commercial blueberries, *Vaccinium ovatum* L. Blueberry growers have had varied success combating this new pest with organo-phosphorus compounds such as malathion, carbaryl and azinphos-methyl. The time, method and number of applications of these compounds probably determined the success rate. This study evaluates the effectiveness of two insecticides with low toxicity to terrestrial vertebrates—the microbial pesticide *Bacillus thuringiensis* Berliner ssp *kurstaki* (Dipel WP), and the synthetic pyrethroid deltamethrin (Decis 2.5 EC)—for control of winter moth on commercial blueberry bushes.

MATERIALS AND METHODS

Studies were conducted in a 1/4 ha blueberry field in Richmond, south of Vancouver. The plants, mostly of the variety Blue Crop, had not been pruned or commercially harvested for several years. Nine plots, each containing three rows of three bushes, were allotted randomly to the two treatments (*B. thuringiensis* and deltamethrin) and the untreated control. From previous observations we knew that winter moth were not evenly distributed in the field so we attempted to locate plots so that each treatment was represented in different parts of the field. However, the treatments were not completely blocked. Each plot was bordered by two rows of unsprayed bushes to prevent spray drift, and pruned so that sprayed bushes did not contact unsprayed bushes.

From mid-March blueberry buds were searched every 3 or 4 days for hatched larvae. Larvae were first observed on 4 April, 1990. Pre-treatment larval counts were made on April 10, 1990, six days after the first larvae were found at the site. Counts were made by arbitrarily selecting 24 fruit buds from each bush, six from each side of the bush in the ordinal positions (216 per plot). Of the 24 buds selected from each bush, 15 were randomly chosen and a dissecting microscope used to count the number of larvae per bud. For the post-treatment counts on April 18 and May 1 only 16 buds per bush were selected. Sprays were applied using a hand-pumped backpack sprayer on April 11. Bushes were sprayed lightly, each receiving approximately 1/2 l of spray material. Dipel was applied at 1100 grams of active ingredient per hectare (approximately 0.5 g per bush). Decis was applied at 100 ml (2.5 g active ingredient) per hectare (approximately 0.13 ml or 32.5 mg active ingredient per bush).

The effect of *B. thuringiensis* was tested in a laboratory study. Twenty field collected larvae were placed in individual thin plastic cups and fed blueberry leaves dipped in the *B. thuringiensis* product Dipel. Cups containing larvae were placed in an open air insectary and fed fresh leaves after four days. New untreated leaves were provided every two days following the treatment. Death rates were compared to twenty control individuals fed fresh untreated leaves. This experiment was carried out twice, once beginning on April 23, 1990 and again beginning on May 14, 1990.

RESULTS AND DISCUSSION

The mean number of larvae/bud varied greatly among plots (Figure 1). By chance two of the three control and *B. thuringiensis* plots had approximately twice the density of winter moths prior to treatment than did the plots to be treated with Decis. Unfortunately, because we did not identify the bushes so as to identify pre- and post-treatment samples from the same bushes we were not able to carry out an analysis of covariance. We have therefore compared changes in density for each plot in each treatment using a t-test as indicated on Figure 1 and tested for overall change in larval density before and after treatment by using the three replicates for each treatment in a t-test (Table 1).

Overall, *B. thuringiensis* (Dipel WP) did not significantly reduce numbers of winter moth larvae (Table 1) although numbers of larvae were significantly lower on 18 April in two of the plots (Figure 1). Since larvae in the flower buds have a major impact on

Table 1
The effect of two insecticides against *Operophtera brumata* in blueberries. Richmond, B.C. 1990. N = 3 for all means.

	Mean Number of Larvae/Bud (S.E.)		
	April 10	April 18	May 1
Bacillus thuringiensis (Dipel WP)	1.00 (0.50)	0.67 (0.35)	0.83 (0.46)
Deltamethrin (Decis 2.5 Ec)	0.46 (0.01)	0.01 (0.01)*	0.00 (0.00)*
Control	1.07 (0.59)	1.0 (0.37)	0.67 (0.15)

* $t = 36$, $P < 0.01$ for both comparison of density after treatment to before.

blueberry production, for sufficient control, almost complete mortality is necessary. *Bacillus thuringiensis* did not provide this. Tonks *et al.* 1978, observed significantly lower densities of winter moth larvae as compared to controls in apple leaf buds following applications of Dipel W.P. and Thuricide HPC, but they do not report the date or how long after egg hatch these sprays were applied. In similar tests on filberts (*Corylus avellanae* L.) in Oregon, *B. thuringiensis* (Thuricide HPC) was also ineffective in the control of winter moth damage (AliNiazee 1986). *Bacillus thuringiensis* (Dipel) also did not control Bruce's spanworm (*Operophtera bruceata* [Hulst]) on the blueberry variety Rancocas (Raine and Clements 1984).

In our laboratory study, *B. thuringiensis* had no effect on the winter moth larvae fed on April 23 when compared with the controls, but survival was poor in both groups. However, in the second test, fourth and fifth instar larvae fed blueberry leaves soaked in Dipel died much more rapidly than the controls. In the first week 30% of the larvae fed with *B. thuringiensis* had died compared to only 5% of the controls (Chi-squared = 4.33, $P < 0.05$). By the end of the second week, 80% of the test larvae died compared to 40% of the controls (Chi-squared = 6.7, $P < 0.05$). By May 30, 10 control larvae had pupated while only 3 *B. thuringiensis* fed larvae pupated.

Deltamethrin provided complete control in this study. In the first count after treatment (April 18), only one larva was found alive (Figure 1) and the reduction in the density of winter moth larvae was significant ($t = 36$, $P < 0.01$ $N = 3$) (Table 1). If any larvae hatched after spraying, they did not survive and no winter moth larvae successfully invaded the bushes from the surrounding unsprayed plants. No live larvae were counted on May 1 on these plots. Tonks *et al.* 1978 found similar good control of winter moth with another synthetic pyrethroid, permethrin, on apples, and another synthetic pyrethroid, fenvalerate, significantly reduced winter moth on filberts (AliNiazee 1986). Raine and Clements (1984) found that deltamethrin significantly reduced the number of Bruce's spanworm in blueberry. Sanford (1985) obtained good control of winter moth on the McIntosh variety of apples with deltamethrin.

Growers in Richmond who have successfully controlled the winter moth during the last few years have applied organo-phosphate sprays several times between initial and final egg hatch in early to mid-April. The timing of different chemical sprays has been shown to be important in the control of winter moth on filberts (AliNiazee 1986). AliNiazee recommended that sprays should be applied at 90–95 percent hatch to prevent damage from larvae that hatch after spraying. This, of course, risks damage to the crop from the initial outbreak. Multiple applications of organo-phosphates can prevent early and late damage (personal communication from growers).

However, a single spray of deltamethrin (Decis) was sufficient in our tests to provide complete control, and the synthetic pyrethroid fenvalerate, was equally successful on filberts (AliNiazee 1986). Although no data are available from our study to show percentage hatch at the time of spray, Embree (1970) found mid-hatch to occur approximately seven days after initial hatch. We sprayed seven days after the first larvae were observed.

The advantage of using the synthetic pyrethroids is that they are less toxic to mammals (lethal oral dose for a rat is 135 mg/kg for Decis and 4.4 mg/kg for Guthion, a spray commonly used by blueberry growers [Thompson 1989]). Dead vertebrates (ring-necked pheasants, eastern cottontail rabbits and numerous small mammals) have been found in the blueberry fields suggesting that a side effect of the potency of some of the organo-phosphate pesticides used (Sheppard, personal observation). However, of concern is the toxicity of pyrethroids to fish and the dangers of contamination of water from the marshy habitat in which blueberries are grown. Also, while pyrethroids currently successfully control winter moth larvae, the high mortality will undoubtedly rapidly select for resistant strains of moths. Because winter moth eggs hatch early in April and only a single application is necessary, deltamethrin can be used before pollinators are active in the blueberry fields. Therefore, deltamethrin should have little impact on this important component of the system.

Our laboratory study of *B. thuringiensis* also suggests that winter moth larvae are more susceptible to this pesticide at later instars. This may be related to the greater consumption of leaf material and therefore more *B. thuringiensis* by the larger caterpillars. Although *B. thuringiensis* has little potential as a control agent in blueberries, it may be a safe and sufficiently effective agent to be used in urban areas to reduce damage from later instars of winter moth larvae on non-crop plants. This potential application needs further study.

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