Monitoring Adult Emergence, Ovary Maturation, and Control of the Black Vine Weevil (Coleoptera: Curculionidae)[1]

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ABSTRACT Pitfall traps captured 8-10 black vine weevils, *Otiorhynchus sulcatus* (F.), per trap, while trap-boards and cardboard wafers averaged less than 2 adults per trap. In addition, the trapboards and cardboard wafers were not effective for determining the onset of adult emergence. In 1988, pitfall traps captured 16.6 adults per trap while deep-pan traps captured 5.7 adults per trap. However, deep-pan traps, constructed from dog food dishes, were as effective as pitfall traps in capturing the first adults to emerge, and they captured adults throughout the summer. Their simple design and easy installation may make them more useful for detecting infestations. Emergence traps, consisting of pitfall traps surrounded by a circular barrier, did not result in accurate estimates of density. The number of females with mature ovaries peaked in late July and early August, 1988, about 30 days after the peak in trap captures. Removal of overwintered females and those that emerged early, by applying a short residual insecticide (acephate), had no impact on subsequent larval infestation. However, single applications of Evercide Concentrate 2357 (fenvalerate plus d-cis, trans allethrin and N-octyl bicycloheptene dicarboximide), Asana (esfenvalerate) and Mavrik (fluvalinate), to control adults, significantly reduced the infestation.

KEY WORDS Ornamentals, monitoring; pitfall traps; insecticides, *Otiorhynchus sulcatus*, Black Vine Weevil.

The black vine weevil, *Otiorhynchus sulcatus* (F.), is the most important insect pest of ornamental nurseries in Connecticut. Adults are flightless, parthenogenetic insects that require 28-30 days for their ovaries to mature. Because of this extended maturation period, monitoring adult emergence has been suggested as a means of timing insecticide applications and for detecting infestations (Nielsen et al. 1978). Although black vine weevil adults are polyphagous (Smith 1932, Masaki et al. 1984), they prefer yew, *Taxus* spp., and strawberry, *Fragaria* x *ananassa* Duchesne, foliage when ovipositing (Hanula 1988a). Because larvae are rarely found on other hosts in Connecticut, monitoring for black vine weevil in field-grown nursery stock can be restricted to yews. Pitfall traps (Nielsen et al. 1978) and trapboards (Maier 1983) have been proposed for this purpose, but little is known about their relative effectiveness for detecting the first adults to emerge when populations are low. In addition, nursery operators have been reluctant to use pitfall traps, so other monitoring devices would be useful.

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Most insecticides registered for control of black vine weevil adults are not utilized because of their high cost, short residual activity, or high mammalian toxicities. Nielsen and Montgomery (1977) reported laboratory trials of field-weathered residues of a number of insecticides for black vine weevil control. They found fenvalerate to have the longest residual activity and suggested that one application might be sufficient to control adults throughout the summer. Hanula (1988b) tested fenvalerate in the field and found that one application was as effective as two to four applications on yews, but fenvalerate is no longer registered for this insect. Recently, a product containing fenvalerate in combination with synergists (Evercide Concentrate 2357, McLaughlin Gromley King Co., Minneapolis, MN) has been granted a minor use, special local needs registration in Connecticut. However, the efficacy of this product was unknown and laboratory bioassays were inconclusive (Hanula, unpublished data).

I report here efficacy of a number of monitoring devices for black vine weevil adults, as well as seasonal abundance of adults and timing of ovary maturation during 1988. In addition, results of field tests comparing the insecticide Evercide Concentrate 2357 to Asana (esfenvalerate) and Mavrik (fluvalinate) also are reported.

Methods and Materials

Monitoring Trials. Monitoring devices were tested in 1986 and 1988. Although different devices were tested each year, pitfall traps were included in all trials for comparison. Pitfall traps consisted of 480 ml plastic cups with a funnel covering the mouth that directed weevils into a 240 ml plastic cup inside. Holes in the bottoms of both cups allowed water to drain out. The funnel and interior cup were coated with Fluon (Polytetrafluorethylene; Northern Products Co., Woonsocket, RI) to facilitate weevil capture and to prevent weevils from leaving the smaller cup. Pitfall traps were inserted into the soil beneath the canopies of yews, *Taxus cuspidata* Siebold and Zuccarini, as close to the mainstem as possible (2-5 cm).

Emergence traps consisted of pitfall traps surrounded by circular, 10-cm wide aluminum barriers. The barriers were coated with Fluon and inserted in the soil so that ca. 5 cm remained above the soil line. The barriers were placed beneath the canopy as close to the mainstem of the plants as possible. Pitfall traps were placed so that the rim of the cup was in contact with the inside of the barrier. Each barrier enclosed ca. 230 cm^2 of soil surface not including the area occupied by the pitfall trap. The tops of the emergence traps were covered with wire screen to prevent weevils from falling in from above.

In 1986, pitfall traps were compared to emergence traps, trapboards (Maier 1983), and cardboard wafers. Black vine weevils are nocturnal and seek hiding places during the day, so trapboards and wafers were tested to determine if they were acceptable hiding places. Trapboards were 15 × 30 cm pieces of 6 mm thick hardboard placed directly on the soil beneath the plant canopy. Cardboard wafers were patterned after similar devices used by Fye (1985) to collect predators in fruit orchards. Wafers were composed of four 8 × 8 cm layers of corrugated cardboard separated by strips of 0.5 × 0.5 × 8 cm cardboard. The cardboard strips were glued along opposite edges and between cardboard layers to provide a space for weevils to crawl into. The completed wafers were dipped in paraffin wax to prevent deterioration. The wafers were placed in the plant canopy 10-20 cm above the soil and as close to the mainstem as possible.

Traps were placed in fields of yews in East Windsor and Meriden, CT during mid-May. At the East Windsor site (Field A), two plots of 200 yews (cv. 'Deniformis') each consisting of 10 rows of 20 plants were established in the center of a field of ca. 5000 plants. Each of the plant canopies was 30-40 cm in diameter. Fifty emergence traps were placed in one plot by randomly selecting five plants from each row and placing a trap beneath them. Two emergence trap locations were randomly selected from each odd-numbered row, and a pitfall trap, a cardboard wafer and a trapboard were placed in adjacent plants for a total of 10 replicates of each. In the second plot, 50 plants were randomly selected, and the soil beneath the canopy of each plant was examined in early May for black vine weevil immatures to obtain a density estimate for the field. The estimate was used to determine the efficacy of emergence traps in the adjacent plot.

In Meriden (Field B), 10 traps of each design were placed in a field of yews (cv. 'Capitata') ca. 1 m in height, and in another field (Field C) of yews (cv. 'Densiformis') with 40-50 cm diameter canopies. Trap locations were selected in the same manner as field A. Traps were checked twice per week throughout the summer in all fields.

In 1988, shallow- and deep-pan traps were tested along with pitfall traps. Shallow-pan traps were constructed from square plastic cat food dishes (10 × 10 cm) 2 cm deep. The outside of the dishes were covered with gray duct tape to provide a surface weevils could easily walk on. The inside of the dishes were coated with Fluon to prevent weevils from escaping. Holes drilled in the bottom of the dishes allowed water to drain out. Deep-pan traps were constructed from circular (10.5 cm diameter) dog food dishes, 4.5 cm deep, in the same way as shallow-pan traps. However, it was noticed during laboratory trials that weevils often walked around the tops of the deep-pan traps without falling in. To prevent this, 2 wedge-shaped Plexiglas® barriers (2 cm high) were glued into slots cut into the rim on opposite sides of the trap so that weevils were directed toward the center. Ten replicates of each design were tested in Field C. The traps were checked bi-weekly, and all weevils collected were dissected and the ovaries examined. Beginning 7 July, a sample of adults was collected biweekly by examining the leaf litter beneath infested plants until 20 weevils were collected or for 0.5 man-hr. These weevils were dissected and examined for ovary maturation within 24 hours.

Trap capture data were analyzed by analysis of variance and Duncan's (1955) multiple range test.

Insecticide Trials. Tests of the pyrethroids, fluvalinate (Mavrik), esfenvalerate (Asana), and fenvalerate plus allethrin and N-octyl bicycloheptene dicarboximide (Evercide Concentrate 2357), were conducted in 1988 in Clinton, Ct. In addition, a treatment consisting of a single application of acephate (Orthene) was applied to determine if overwintered adults and adults that emerged early contributed to subsequent infestations. Because acephate has a residual activity of 3-7 days on yews (Nielson and Montgomery 1977), weevils emerging shortly after the application should not have been affected. A plot of 200 yews (cv. 'Densiformis'; 30-40 cm diam. canopies) was established in a field of ca. 500 plants. The field was bordered on two sides by a mature woodlot of mixed oak, *Quercus* spp., and hemlock, *Tsuga canadensis* (L.), and on the other two sides by fields of hemlock (30-60 cm height). Sixty plants were randomly selected from the plot and each plant was surrounded by a Fluon coated aluminum barrier to prevent weevils from moving between treatments. The treatments consisted of the following registered rates: Mavrik, 0.08 g AI/liter; Asana, 0.03 g AI/liter; Evercide Conc., 1.3 g AI/liter; and Orthene 0.68 g AI/liter. Each insecticide was applied to the plants for 30 seconds with a Solo backpack sprayer at 30 psi, resulting in application of approximately 500 ml of insecticide solution to each plant. All plants were covered with plastic bags before and after spraying to prevent drift contamination. The treatments were applied on 30 June, ca. 23 days after the first weevils emerged from the soil. The plants did not receive any rainfall for at least 7 days, and they were not irrigated during the study. Treatment efficacy was evaluated during November, 1988 by examining the soil beneath each plant to a depth of 30 cm for larvae. The data were analyzed by analysis of variance and Duncan's (1955) multiple range test.

Results

Monitoring Trials. Pitfall traps caught more adult black vine weeils (Table 1), and they were more effective in catching early emerging adults than trapboards or cardboard wafers. The first adults were collected in emergence traps on 3 June, 1986 in all 3 fields. Weevils were collected in pitfall traps in fields A and B, and from a trapboard in field B on the same date. In field C, adults were collected from pitfall traps on 6 June and from trapboards 10 days later. The first adults were collected from cardboard wafers 7-10 days after the first adults were collected from emergence traps.

In 1988, pitfall traps again caught more weevils than shallow- or deep-pan traps (Table 1). However, deep-pan traps were effective in capturing early emerging adults (Fig. 1), and they caught weevils throughout the emergence period. Shallow-pan traps were relatively ineffective.

Table 1. Comparison of the mean number of black vine weevil adults, *O. sulcatus,* collected per year by traps of differing designs.

Year	Trap type	N	$\bar{X}$* no. of adults per trap (±SE)
1986	pitfall	30	8.5 ± 0.9a
	emergence	30	2.7 ± 0.5b
	trapboard	30	0.9 ± 0.3c
	cardboard wafer	30	0.6 ± 0.2c
1988	pitfall	10	16.6 ± 4.6a
	deep-pan	10	5.7 ± 1.3b
	shallow-pan	10	1.4 ± 0.3b

* Within each year, means followed by the same letter are not significantly different ($P < 0.05$; Duncan's (1955) multiple range test).

Emergence traps were useful in capturing newly emerged adults, but they were not effective for determining population density. Field A contained an average of 11.5 weevils/plant (SE = 0.89; n = 50) while emergence traps caught an average of 2.5 adults/trap (SE = 0.39; n = 49). Multiplying the average trap catch by 7.8, the area sampled for immatures divided by the soil surface area inside the traps, resulted in a predicted density of 19.5 weevils/plant.

Table 2. Mean number of black vine weevil larvae, *O. sulcatus,* collected from the roots of *T. cuspidata* plants treated with single applications of four insecticides on 30 June, 1988.

Insecticide	Rate (g AI/l)	$\bar{X}$* no. of *O. sulcatus* larvae (±SE)
Control	—	27.7 ± 7.72a
Orthene	0.90	29.3 ± 8.37a
Asana	0.05	6.3 ± 3.41b
Mavrik	0.08	5.0 ± 2.13b
Evercide Conc. 2357	1.60	3.4 ± 1.31b

* Means followed by the same letter are not significantly different ($P < 0.05$; Duncan's (1955) multiple range test).

The total number of weevils caught per week in all traps in 1988 increased to a peak of 97 on 7 July (Fig. 2). Two weeks later only a few weevils were captured. The numbers collected in leaf litter samples showed a similar decline and sampling rarely produced 20 weevils within the 0.5 hour time limit. No adults were captured in pitfall or deep-pan traps after 5 August.

The proportion of females with mature ovaries (Fig. 2) increased steadily from early July to mid-August. Those collected in early June were most likely overwintered adults.

Insecticide Trials. Mavrik, Asana and Evercide Concentrate 2357 were equally effective in controlling black vine weevil adults resulting in a significant reduction ($df = 4, 54$; $F = 5.53$; $P < 0.05$) in the subsequent larval population (Table 2). A single application of acephate had no effect.

Discussion

Pitfall traps were highly effective for monitoring adult black vine weevils. Trapboards, cardboard wafers and shallow-pan traps were ineffective. Maier (1983) found trapboards to be more useful than pitfall traps during midsummer. However, pitfall trap placement may be important. For example, the further the trap is located from the mainstem the less efficient it will probably be in capturing weevils. Traps in this study were placed 2-5 cm from the mainstem and always beneath the plant canopy. However, placing and checking traps in that location was time consuming because of interference from roots and branches. In addition, once in place, pitfall traps were not readily moved to other fields.

Deep-pan traps were as effective as the pitfall traps in capturing early emerging adults and, although fewer weevils were collected, black vine weevils appeared in both sampling devices simultaneously throughout the growing season. Deep-pan traps have the advantage of being easily constructed, and they can be installed quickly. The lower capture rate relative to pitfall traps could be compensated for by using more traps. Pan traps can readily be moved to other fields and may be useful in detecting black vine weevil infestations. Their effectiveness in capturing early emerging weevils suggests that they may be particularly useful in monitoring low density populations.

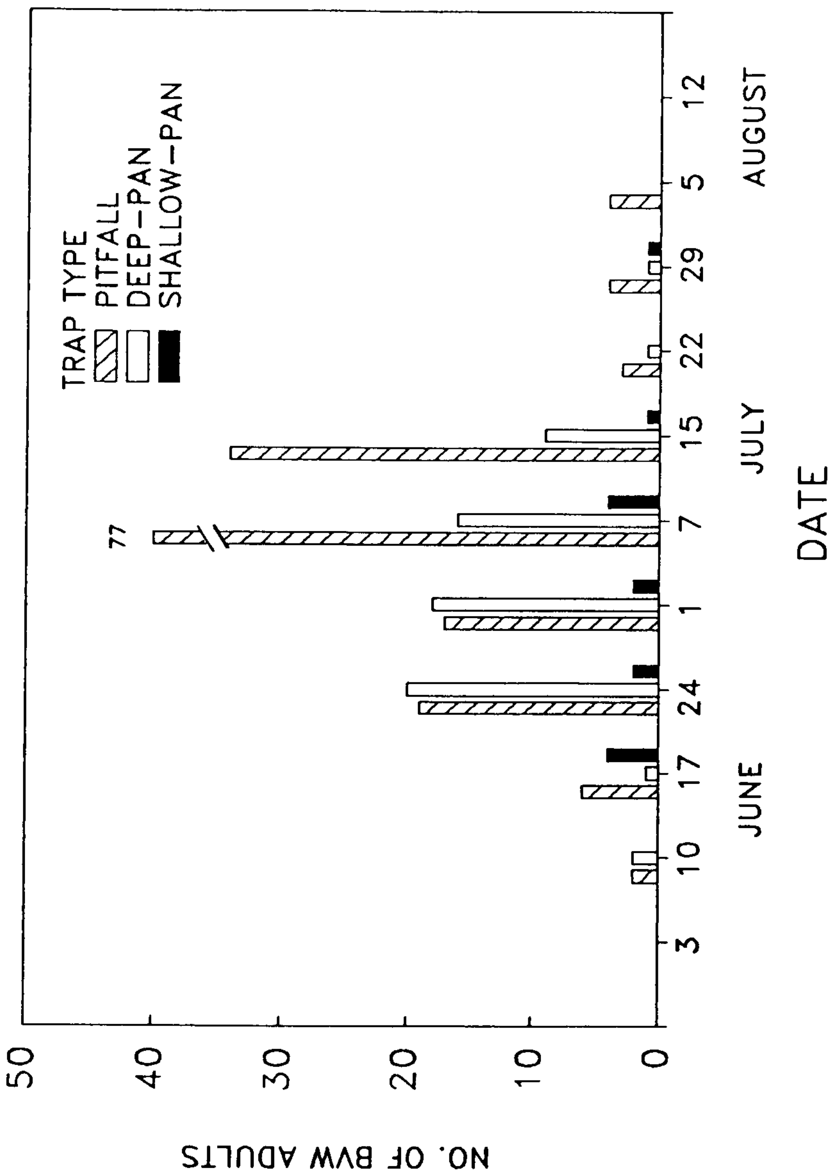

Fig. 1. Weekly totals of adult black vine weevils (BVW), *O. sulcatus*, captured in 10 traps of 3 different designs from June - August, 1988.

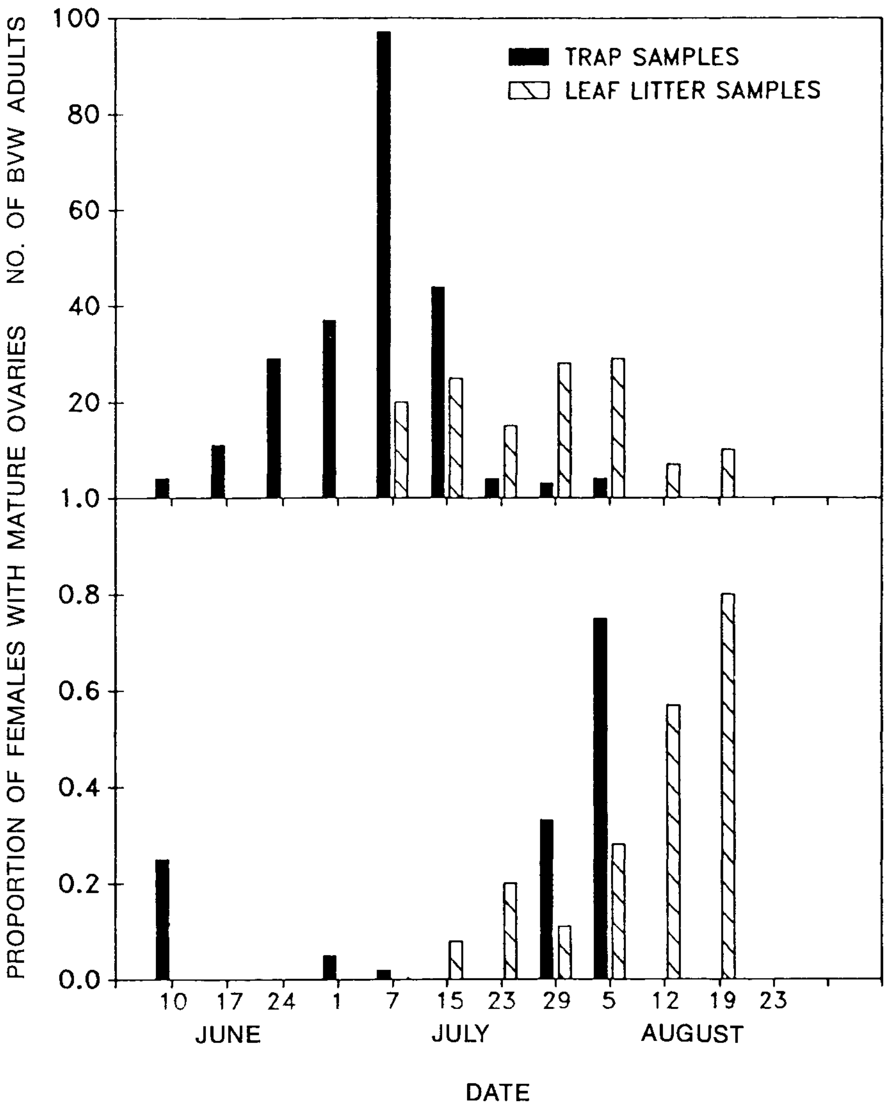

Fig. 2. Total number of black vine weevil (BVW) adults, *O. sulcatus,* collected per week during 1988 in pitfall traps, pan traps and leaf litter samples, and the proportion of them with mature ovaries at the time of collection.

Emergence traps readily captured weevils emerging from the soil but they were not effective for predicting density. The higher than expected predicted density values were surprising because the traps did not include the area directly beneath the mainstem where weevil larvae are often more abundant. However, weevils may have entered the traps from above. Wire screen was placed over the top of the traps to prevent black vine weevils from falling in, but it was not attached tightly enough to prevent those that fell unto the screen from crawling under. Emergence traps may be effective if the top of the plant is cut off just before adult emergence begins and the trap barrier encloses most of the soil surface above the roots. They also may be useful for studying other insect species that are unable to fly or are poor fliers.

Peak ovary maturation did not occur in Connecticut until late July and early August, approximately 30 days after the peak in weevil captures in pitfall traps. Black vine weevil ovaries mature in 28-30 days when adults are fed yew foliage (Smith 1932, Nielsen and Dunlap 1981), so pitfall or pan traps may be useful for predicting when peak ovary maturation occurs.

It is unclear why the number of adults declined at the time when oviposition was beginning. Numerous dead adults were found while collecting leaf litter samples, but no insecticides were applied to the field. The summer of 1988 was unusually hot and dry, which may have resulted in increased weevil mortality or dispersal into the adjacent woodlot.

A single application of acephate three weeks after the first adults emerged from the soil had no effect on the subsequent larval infestation suggesting that overwintered adults and those that emerged early did not contribute significantly to maintaining the population. These results are consistent with those reported by Garth and Shanks (1978) who found that infestation of strawberry plants under field conditions resulted from eggs deposited in late-July and August. Eggs deposited during June and most of July did not result in infested plants. Thus, it may be possible to delay the first insecticide application until mid or late July. By that time, most of the adults that contribute significantly to the infestation will have emerged, and a single application of an insecticide with short residual activity may be effective. Such compounds would be advantageous in reducing the impact of insecticides on the natural enemies of mealy bugs and scale insects that also infest yews. In addition, pyrethroids may not be as effective on other plant species as they are on yews, because Shanks and Chamberlain (1988) found that these insecticides were more effective on weevils fed on yew than on strawberry foliage.

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