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USE OF A MONITORING SYSTEM TO EVALUATE PESTICIDE EFFICACY AND RESIDUAL ACTIVITY AGAINST TWO PINE ROOT WEEVILS, *HYLOBIUS PALES* AND *PACHYLOBIUS PICIVORUS* (COLEOPTERA: CURCULIONIDAE), IN CHRISTMAS TREE FARMS

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ABSTRACT

Hylobius pales, the pales weevil, and *Pachylobius picivorus*, the pitch-eating weevil, comprise part of a weevil complex which affects plantation pine production in the Lake States. Common control practices on Christmas tree farms include calendar applications of persistent insecticides. The resulting environmental risks could be minimized by repeating applications only when needed. A sampling method using ethanol-and turpentine-baited pitfall traps was used here to assess the efficacy and monitor persistence of chemical sprays. Trap catch in lindane-treated field plots and untreated controls were compared over two years. Unsprayed controls had significantly higher weevil populations than treated plots. Spray efficacy continued for three years following application. Weevil population growth in relation to insecticide efficacy and degradation is discussed.

The pales weevil, *Hylobius pales* (Herbst), and pitch-eating weevil, *Pachylobius picivorus* (Germar) are important pests of pines in the eastern United States. Larvae of both species develop in highly stressed hosts or recently cut stumps. Adult feeding on branches and twigs can disfigure mature trees and cause heavy seedling mortality (Kearby1965, Davis & Lund 1966, Wilson 1968).

With the increasing production of plantation pines in the Lake States, the importance of these two species and the pine root collar weevil, *Hylobius radicis* Buchanan, is increasing (Hunt & Raffa 1989, Rieske 1990, Rieske & Raffa in press). The even-aged plantations used for Christmas trees, timber, and pulp provide ideal habitat. Insecticide usage on Christmas trees in particular is often high (Benyus 1983).

A major problem in managing these weevil species is that infestations may not be detected until damage is irreversible. Subterranean larval development and nocturnal adult activity make direct detection difficult. Common practice dictates preplant dipping of seedlings to prevent feeding injury, or stump applications of lindane to prevent brood development (Benyus 1983, Lynch 1984). Lindane poses severe environmental problems (Newton & Knight 1981), however, and is banned from all commercial uses in Wisconsin except against pine root weevils in Christmas trees. This exception is allowed because other insecticides do not provide the desired long-term control.

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A method of detecting and monitoring pine root weevils prior to yield losses and quality grade reduction, could potentially reduce insecticide usage to situations where damage was imminent. Ethanol and turpentine baited pitfall traps are effective in capturing these weevils (Raffa & Hunt 1988, Hunt & Raffa 1989). The objective of this study was to use this trapping system for monitoring resurgence of weevil populations following insecticide treatments.

MATERIALS & METHODS

The study was conducted in the summers of 1988 and 1989, in Waushara and Portage counties, in the "central sands" region of Wisconsin. Plots were established in the spring of 1988 in 4-1/2 and 5-1/2 year old Scots pine, *Pinus sylvestris*, Christmas tree farms. The trees were planted in rows 1.8 m apart, and with 1.8 m between trees in a given row, with the exception of one site, where this spacing was 1.68 m. Plots were established on six farms which exhibited a range of foliar discoloration indicative of root weevil infestation.

The pitfall traps used were modified from those developed by Tilles et al. (1986a,b), and consisted of 17 cm sections of 10 cm diameter plastic PVC drainpipe. Eleven cm from one end, eight 7 mm diameter holes were drilled about the perimeter. The trap interior was coated with liquid teflon Fluon to prevent weevil escape. The traps were capped at each end and inserted into the ground so that the holes were flush with ground level. Two 2 mm holes were drilled in the bottom to allow for drainage. The exposed 6 cm of the trap was painted flat black (New York Bronze Powder Co. Inc., Elizabeth, NJ) to simulate a tree trunk image.

Baits were dispensed from two 2 ml glass vials (0.5 dram, 12 mm x 35 mm) and were suspended by thin aluminum wire to a stiff 14 guage wire that passed through two 2 mm holes in the trap wall. The vials were suspended 4 cm below ground level. Baits consisted of 95% ethanol (Worum Chemical Co., St. Paul, MN) and turpentine (Mautz Paint Co., Madison, WI). The turpentine consisted of 46% alpha-pinene, 42% beta-pinene, 2% beta-phellandrene, 1% limonene, 0.88% camphene, 0.77% myrcene, and less than 1% unknown compounds, as determined by gas liquid chromatography using the method of Raffa & Steffeck (1988). The volatilization rates from the 2 ml vials at 23° C were 200 mg/ 24 h of ethanol and 40 mg/ 24 h of turpentine.

Each treatment consisted of 6 traps/ 432 m^2, equivalent to the 1 trap/ 72 m^2 used by Hunt & Raffa (1989). Within each treatment, traps were arranged 7 m apart on two transects within the interior of the plot. Two treatments were compared for total trap catch: (1) Standard insecticide application, and (2) control. Standard insecticide treatment consisted of a liquid formulation of lindane applied at a rate of 0.95 l of active ingredient per acre. The lindane was mixed with water at the rate of 0.95 l lindane: 473 l water. 0.48 l of mixture was applied to the collar region of each tree in June, 1987.

There were 15 replicates for the insecticide treatment and 30 replicates of the unsprayed control, located on farms with a wide array of symptoms indicative of pine root weevil damage.

Traps were monitored on 6 to 10 day intervals throughout the 1988 and 1989 growing seasons. At each monitoring interval, the weevils were removed and the baits replenished. Weevils were identified to species and their gender determined using available keys (Warner 1966, Wilson et al. 1966, Franklin & Taylor 1970).

Data were analyzed from each year and from both years combined by the General Linear Model and Duncan's Multiple Range Test (SAS 1982). A square root + 0.5 transformation normalized the data prior to analysis.

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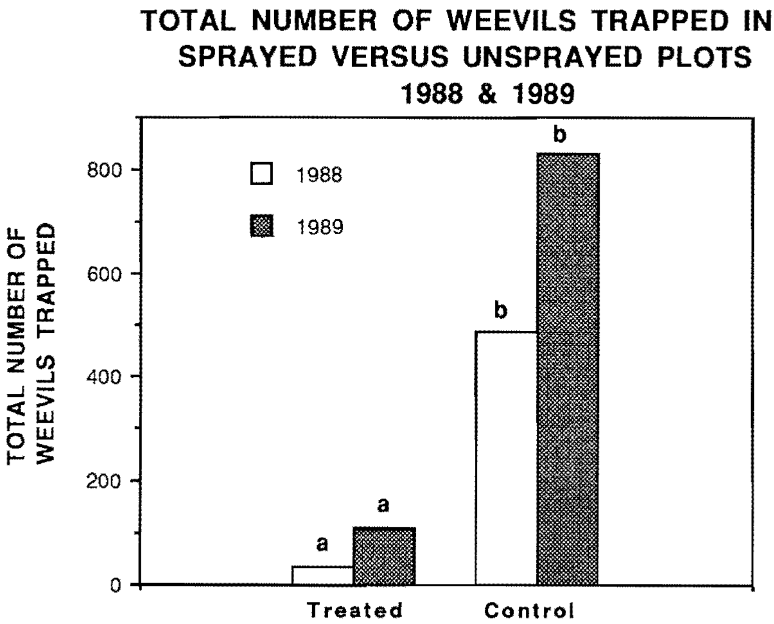

Figure 1. Comparison of *Hylobius pales* and *Pachylobius picivorus* pitfall trap catches in lindane versus untreated control plots, 1988 and 1989. $P < 0.05$. Means within years followed by the same letter are not significantly different, Duncan's Multiple Range Test.

RESULTS

There was a 58% increase in the number of insects trapped from 1988 to 1989 (Fig. 1). In both years, *P. picivorus* comprised 59% of the total trap catch; *H. pales* comprised 40%. *Hylobius radicis* comprised less than 1% of the total in both 1988 and 1989, even though this species is attracted to the ethanol-turpentine bait (Hunt & Raffa 1989). The 1988 drought appears to have impacted root collar weevil more severely than either pales or pitch-eating weevil populations (Rieske 1990). Because so few *H. radicis* were trapped, this species was not included in the analysis.

The insecticide application had a strong effect on trap catch. Plots with standard insecticide spray caught significantly fewer weevils of both species than the unsprayed controls ($P < 0.009$, Table 1) in both 1988 and 1989. Differences between treatments were similar for both genders. However, the proportion of total insects trapped in sprayed plots increased from 6.7% in 1988 to 11% in 1989. This includes a 1.56x increase in *H. pales*, and a 1.63x increase in *P. picivorus*.

No significant difference emerged in the total trap catch between farms in either year. There was no significant treatment/farm interaction in either year individually or pooled ($P > 0.05$).

Table 1.—Mean number (+/-s.d.) of *H. pales* and *P. picivorus* trapped per replicate under standard insecticide spray and unsprayed controls. (P < 0.05, Means within columns within years followed by the same letter are not significantly different, Duncan's Multiple Range Test).

Treatment	N	*H. pales*	*P. picivorus*	TOTAL
		1988		
Standard spray	15	2.04 (1.28) a	1.75 (1.71) a	2.93 (2.19) a
Unsprayed control	30	6.45 (5.06) b	10.17 (7.03) b	16.42 (9.72) b
		1989		
Standard spray	15	4.26 (4.12) a	3.81 (1.92) a	6.70 (5.59) a
Unsprayed control	30	10.99 (8.83) b	16.34 (4.19) b	27.33 (9.43) b
		1988 & 1989		
Standard spray	30	3.03 (1.97) a	2.66 (3.36) a	4.82 (4.82) a
Unsprayed control	60	8.57 (5.03) b	13.10 (8.53) b	21.57(10.87) b

DISCUSSION

The strong treatment effect among all locations in both 1988 and 1989 confirms the efficacy of lindane and the potential of baited traps in monitoring residual control. While total weevil catch increased by 58% in 1989, weevil catch in sprayed plots increased three-fold. This suggests that traditional chemical applications are an effective means of controlling the pine root weevil complex for up to three growing seasons after application (Fig. 1). The population resurgence in treated plots suggests that residual activity begins to break down in its second season.

This trapping method may allow growers to monitor weevil populations following sprays, so that repeat applications are applied only where necessary. By assuring growers that weevil population resurgence can be detected before grade reduction or yield loss occurs, this method may also allow use of less persistent insecticides. This approach could also be used against other species such as *H. radicis*, *Hylobius rhizophagus* Millers, Benjamin, and Warner, and *Hylobius abietis* L., against which ethanol/ turpentine combinations are known attractants (Tilles et al. 1986a, 1986b, Hunt & Raffa 1989).

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