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USE OF ETHANOL-AND TURPENTINE-BAITED FLIGHT TRAPS TO MONITOR *PISSODES* WEEVILS (COLEOPTERA: CURCULIONIDAE) IN CHRISTMAS TREE PLANTATIONS

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ABSTRACT

Pissodes nemorensis and *Pissodes strobi* are major pests of pine production in eastern North America. Ethanol-and-turpentine baited traps were used here to monitor weevil populations in a Scotch pine Christmas tree plantation in Wisconsin. Baited pitfall traps were ineffective in trapping either weevil species. However, baited flight traps at 0.8 and 1.6 m above ground effectively captured flying weevils of both species, 70% of which were *P. nemorensis*. Females of both species were more attracted than males to the ethanol/turpentine baits. Significantly more female *P. nemorensis* and total *P. nemorensis* were trapped at a height of 0.8 m than 1.6 m. There was no significant difference in male *P. nemorensis* response to the different heights, nor was there a significant difference in response to trap height by *P. strobi.*

The white pine weevil, *Pissodes strobi* (Peck), and the eastern pine weevil, *Pissodes nemorensis* Germar, are significant pests of conifer reproduction (Drooz 1985). *Pissodes strobi* feeding, oviposition, and larval development occur in the terminal leaders of host pine (*Pinus*) and spruce (*Picea*) trees. Damage appears as flagged terminal branches with a characteristic shepherd's crook, most commonly on young, vigorous trees (Benyus 1983). *Pissodes strobi* is widely distributed throughout North America. In eastern North America, eastern white pine, *Pinus strobus* L., and Norway spruce, *Picea abies* L., are most severely attacked (Drooz 1985).

Pissodes nemorensis requires stressed host plants to complete development. It preferentially attacks the basal stem region and lower lateral branches of stressed trees, and frequently breeds in stumps and logs (Bliss & Kearby 1969, Drooz 1985). Seedlings in Christmas tree planatations and intensively managed timber stands are particularly susceptible to attack. *Pissodes nemorensis* commonly occurs throughout eastern North America, with favored host plants being red pine, *Pinus resinosa*, and Scotch pine, *Pinus sylvestris*.

Although *P. strobi* is the more aggressive of the two species, adult feeding and larval development of both species can cause considerable host disfigurement and occasional mortality. The dispersal abilities of both species are well documented (Finnegan 1958, Overhulser & Gara 1975). *Pissodes strobi* emerge from overwintering sites when temperatures reach 6° C (Sullivan 1959), and flight activity occurs at temperatures from 16°C to 29°C (MacAloney 1932, Silver 1968).

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Ethanol and turpentine are recognized as important host volatiles attracting many forest-dwelling insects; these compounds have been successfully employed to bait traps for pine-infesting coleopterans (Moeck 1970, Fatzinger 1985, Raffa & Hunt 1988, Rieske 1990, Rieske & Raffa 1990).

Insecticides, intensive cultural practices, and sanitation are used to manage these weevil populations in pine plantations. A simple method for detecting and monitoring these weevils prior to yield losses and grade reduction could reduce insecticide usage, and alleviate the need for labor intensive examination of potentially infested trees.

The objectives of this study were to assess the feasibility of employing ethanol and turpentine baited traps to monitor *Pissodes* populations, and characterize flight patterns of these weevils in infested Christmas tree plantations.

MATERIALS AND METHODS

The study was conducted in the summer of 1989 in Waushara county in central Wisconsin. The field site was established on a Scotch pine Christmas tree plantation on sandy soil, with a tree spacing of 1.7 m.

To monitor *Pissodes* flight activity, baited flight traps equivalent to those developed for *Hylobius* spp. (Rieske 1990, Rieske & Raffa 1990) were used, and consisted of inverted 4 l (1 gal.) plastic milk containers with three sides cut away. The fourth side served as a mounting and strike surface for in-flying insects. A 200 ml polyethylene jar was attached at the bottom of each trap and served as a holding jar for trapped insects. The holding jar was unbaited, and the interior was coated with liquid Teflon to prevent weevil escape. Two 2 mm holes were drilled in the bottom to allow for drainage.

Baits were dispensed separately from two 2 ml glass vials (0.5 dram, 12 × 35 mm), suspended by thin aluminum wire and attached to the strike surface. Baits consisted of 95% ethanol and undiluted turpentine. The turpentine (Mautz Paint Company, Madison, Wisconsin) was analyzed by gas chromatography using the method of Raffa & Steffeck (1988), and was found to consist of 46% alpha-pinene, 42% beta-pinene, 2% beta-phellandrene, 1% limonene, 0.88% camphene, 0.77% myrcene, and $<1\%$ unknown compounds. Volatilization rates under laboratory conditions (22° C) were 200 mg/day for ethanol and 40 mg/day for turpentine, for a 1:1 volume. Baits were replenished weekly throughout the monitoring period.

Two flight traps were attached to wooden stakes (5 × 5 × 180 cm), with the height of the trap tops at 0.8 and 1.6 m. The heights were chosen to coincide with the grass and tree canopy heights (0.2–0.5 and 1.7 m, respectively). The direction of the strike surface was randomly assigned to one of the four cardinal directions. Barriers consisting of 20 × 20 cm corrugated plastic, coated with liquid Teflon, were attached approximately 0.5 m above ground level to prevent trap access by walking insects.

The flight traps were arranged in nine blocks of six stakes, each stake with two traps, for a total of 108 traps. Each block occupied a 432 m^2 area (21.6 × 20 m), and a 432 m^2 buffer zone containing no traps was placed between each block. Blocks were oriented in a north-south direction, forming a transect through a gradient of trees infested with *Hylobius* weevils. Although the *Hylobius* infestation level approached 90% of all trees, little *Pissodes* damage was evident at this site (Rieske 1990). The topography of the site was such that some blocks were located on hill tops, whereas others were on slopes.

Adjacent to the flight traps, 54 corresponding ethanol and turpentine baited pitfall traps were placed, separated by a 30-m wide buffer strip containing no traps. The pitfall traps used were modified from those developed by Raffa & Hunt (1988), and were arranged similarly to the flight traps; they also transected a gradient of *Hylobius*-damaged trees.

Both flight traps and pitfall traps were monitored on 6 to 10 day intervals from mid-April to the end of August. Weevils were removed and the baits replenished at each monitoring interval. Weevils were identified to species using the discriminant analysis technique developed by Godwin et al. (1982), and sexed according to the technique of Harman & Kulman (1966).

A chi-square contingency table was used to determine if *Pissodes* trap catch differed between heights. Trap catch based on trap height was compared with Student's T-test; each sex of each species was analyzed individually.

Daily temperature was monitored at a weather station approximately 19 km from the study site (National Oceanic & Atmospheric Administration 1989). *Pissodes* activity was related to cumulative degree days, based on thresholds for *P. strobi* of 6° C for emergence from overwintering sites (Sullivan 1959, Wallace & Sullivan 1985), and 16° C for diurnal flight (Silver 1968), beginning 1 March.

RESULTS

Flight activity was first detected in late April, after cumulative degree days reached 104.1 (6° C emergence threshold). The maximum number of weevils were trapped in late May, and no *Pissodes* flight activity was detected after July 1 (Fig. 1). Table 1 lists accumulated degree days for each week in which flight activity was detected. Flight activity increased with increasing temperatures, and continued until maximum temperatures exceeded the upper flight threshold of 29° C (Table 1 and Fig. 1). 70% of the weevils trapped were *P. nemorensis*, 30% were *P. strobi* ($N = 69$). Very few (< 10) *Pissodes* weevils were trapped in the pitfall traps.

Both species preferred the 0.8 m height to the 1.6 m height ($P < 0.005$, $X^2 = 66.6$, $df = 1$); 90% of the total weevils trapped were captured at the lower height. Trap height was significant ($P < 0.05$) for female and total *P. nemorensis* (Table 2, $T = 2.56$ and 2.48, respectively).

The observed sex ratio for both species was female biased. For *P. nemorensis* the ratio of females to males was 1.7, which differed significantly ($P < 0.05$) from the expected 1:1 ratio across both heights ($X^2 = 40.5$, $df = 1$). Although the observed ratio of female to male P. strobi was 1.6, too few *P. strobi* were captured for a chi square analysis.

DISCUSSION

Traps baited with ethanol and turpentine proved effective for monitoring *Pissodes* flight activity in Christmas tree plantations. The species composition found at this site was not surprising. Stressed and weakened trees, as well as fresh stumps, supply ideal breeding substrate for *P. nemorensis* (Benyus 1983). These conditions were provided by the severe drought of 1988, high tree mortality due to *Hylobius* weevils, and intensive management practices that supplied an adequate resource base.

The larger catch in the lower traps suggests that these weevils fly below the tree canopy, and perhaps orient to the understory vegetation. The absence of appreciable numbers of *Pissodes* in the ethanol-and-turpentine baited pitfall traps suggests that these species orient to hosts during flight rather than

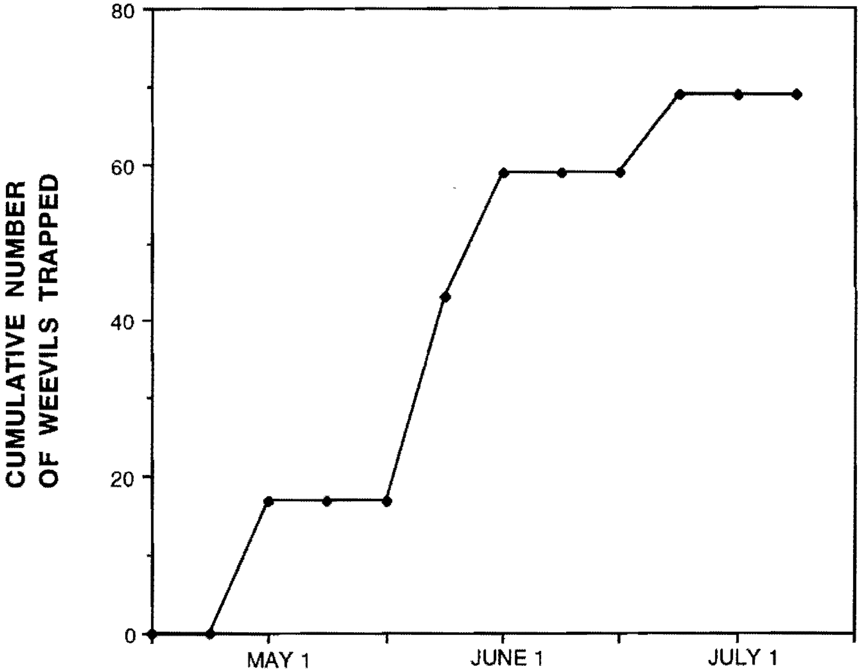

Figure 1. Seasonal pattern of *Pissodes nemorensis* and *P. strobi* captured in ethanol-and-turpentine baited flight traps in a Wisconsin Christmas tree plantation, 1989. Traps were monitored from mid-April through the end of August.

Table 1. Weekly accumulated degree days beginning 1 March (flight threshold temperature = 16° C), and days exceeding the 29° C maximum for *Pissodes* flight activity, over the period in which *Pissodes* flight activity was detected.

Time interval	DD (°C)	Cumulative DD (°C)	Days over 29° C[1]
May 1–7	0	0	0
8–14	0.2	0.2	0
15–21	23.4	23.6	0
22–28	30.3	53.9	0
May 29–June 4	22.7	76.6	0
June 5–11	27.1	103.7	0
12–18	15.3	119.0	0
19–25	81.4	200.4	5
26–July 2	56.9	257.3	2

[1]Maximum daily temperature

while walking, and/or they respond to these volatiles primarily during periods of migration and dispersal.

Although all the weevils were caught during mid-spring to early summer, newly emerged *P. strobi* are known to be present and active in late summer to

Table 2. Total number of *Pissodes nemorensis* and *P. strobi* captured in ethanol and turpentine baited flight traps at 0.8 and 1.6 m above ground in a Wisconsin Scotch pine Christmas tree plantation, April 15 to August 31, 1989. Test statistic (T) and probability (p) for differences between trap height.

		Trap height (m)		
Species	Sex	0.8	1.6	T(p)
P. nemorensis	Male	18	0	2.19 (0.08)
	Female	27	3	2.56 (0.05)**
	Total	45	3	2.48 (0.05)**
P. strobi	Male	6	2	0.79 (0.46)
	Female	11	2	1.75 (0.13)
	Total	17	4	1.56 (0.17)
Total insects		62	7	2.22 (0.07)

**,$P<0.05$, T test.

early fall (Wallace & Sullivan 1985). Thus, adults emerging from overwintering sites in spring may be more responsive to host volatiles than recently developed, sexually immature adults, as has been observed with some *Hylobius* weevils (Rieske & Raffa 1990, Nordenhem & Eidmann 1991).

The nearly 2:1 ratio of females to males of both *Pissodes* species in this study suggests that orientation to host material may be more important for female weevils. Although the brood sex ratio of *Pissodes* is reported to be 1:1, previous studies with attractants have resulted in female-biased trap catches (Godwin & Odell 1967, Phillips et al. 1984). The male produced aggregation pheromone attracting both sexes of both species is reportedly produced only during periods when females are reproductively mature (Booth et al.1983, Phillips et al. 1984). The possibility that trapped males emitted pheromone, and thereby contributed to the female biased ratio found here, cannot be excluded.

Current control methods for *Pissodes* weevils call for annual inspection for adult feeding scars and larval damage, calendar applications of insecticides, and intensive cultural practices (Benyus 1983). The ability to detect and monitor potential infestations will further help in the development of management techniques that allow Christmas tree growers to apply treatments based on defined action thresholds, rather than as insurance.

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