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ORIENTATION OF *HYLOBIUS PALES* AND *PACHYLOBIUS PICIVORUS* (COLEOPTERA: CURCULIONIDAE) TO VISUAL CUES

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ABSTRACT

Pitfall traps with above-ground silhouettes of various colors and diameters were used in field tests to evaluate the role of vision in host orientation by adult pales weevils, *Hylobius pales*, and pitch-eating weevils, *Pachylobius picivorus*. White traps (11 cm outer diameter) baited with ethanol and turpentine caught significantly more weevils than similarly baited black or green traps (11 cm outer diameter). Trap diameter (range of 6–22 cm outer diameter) did not affect trap catch. Pitfall traps can be used to monitor root weevil populations in young pine plantations and Christmas tree farms, where they are major pests. These results demonstrate that visual and chemical cues can be integrated to improve trap efficiency.

The pales weevil, *Hylobius pales* (Herbst), and the pitch-eating weevil, *Pachylobius picivorus* (Germar), are important pests of a variety of pine species in eastern North America. The adults of both species feed on the inner bark of young pine stems, and can cause widespread mortality in recently planted pine plantations (Nord et al. 1982). Adult feeding on stems and branches can also disfigure young trees (Drooz 1985). Along with the pine root collar weevil, *Hylobius radicis* Buchanan, these root weevils comprise the most important pest group affecting Christmas trees in Wisconsin. Infestations are difficult to detect, so growers rely on routine applications of persistent insecticides, primarily Lindane.

Recent research has focused on the development of a simple trap-based monitoring technique for forecasting weevil damage (Hunt and Raffa 1989, Rieske and Raffa 1990). The objective is to replace calendar applications with threshold-triggered treatments to reduce insecticide use, and allow for conversion to less persistent materials. Monitoring efficiency is increased through the use of cues that weevils use to orient to host trees. A variety of host odors appear to be involved in host location by adult weevils. Host monoterpenes are attractive to *H. pales* (Thomas and Hertel 1969, 1979), and *P. picivorus* (Fatzinger 1985). The combination of ethanol and terpenes is also attractive to both species, and factors such as ratios of the components and season can greatly affect attraction (Fatzinger et al. 1987, Raffa and Hunt 1988, Hunt and Raffa 1989, Rieske and Raffa 1991). In contrast, relatively little is known about the possible role of visual cues in host orientation. It was our goal to determine whether visual cues influence orientation by *H. pales* and *P. picivorus* to attractant-baited traps.

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MATERIALS AND METHODS

The traps used were a modified version of the pitfall trap described by Tilles et al. (1986a, b) and modified by Hunt and Raffa (1989). Sections of PVC drainpipe, 76 cm long, were drilled with eight 6 mm diameter holes spaced equally around the circumference of the pipe, 31 cm from one end. The pipes were inserted into the ground to a depth of 31 cm so that the holes in the pipe were at ground level, and the remaining 46 cm provided a silhouette. The pipes were capped at both ends with removable plastic lids, with two 0.3 cm diameter holes in the lower lid to allow water drainage. Liquid Teflon was applied to the inner surfaces of the traps to prevent the escape of weevils. A wire passing through two 2 mm holes in the walls of the trap at ground level served as a support for baits.

To examine the effect of trap color, the above ground portion of 11 cm outer diameter traps was painted black, white or green using a flat spray enamel (New York Bronze Powder Co. Inc., Elizabeth, NJ). To examine the effect of diameter, black PVC of 22 or 6 cm outer diameter were compared. These sizes were used so that the weevils could choose between traps of greater and lesser diameter than the trees present in the plantation. The traps were placed in a 4 yr old Scotch pine Christmas tree plantation in Waushara County, WI. The plantation was known to be infested with *H. pales* and *P. picivorus*. The trees had been planted at 1.7 m between trees and rows. The traps were placed between the rows, every third row, midway between every third tree. This resulted in approximately a 5.1 x 5.1 m spacing of groups of traps. The traps were arranged in 20 pairs for the diameter experiment and at the points of 20 equilateral triangles for the color experiment, with 0.6 m between traps in a group. The position of each color or diameter of trap was assigned randomly within each triplet or pair, respectively.

The baits consisted of vials of turpentine (Sunnyside Corp., Wheeling, IL) and 95% ethanol. The turpentine and 95% ethanol were each released separately from open 12 x 35 mm glass vials, such that the release rates were approximately 40 mg and 400 mg/24 h, respectively, at 22° C. Vials within each type of trap exhibited different rates of evaporation, probably due to temperature differences within the trap which were characteristic of each color and diameter of PVC tube. In order to standardize the release rates a variable number of vials was used for each color and diameter of trap. The turpentine consisted mostly of monoterpenes, of which the relative proportions were: alpha-pinene (52.45%), beta-pinene (41.35%), beta-phellandrene (2.00%), limonene (1.05%), camphene (0.85%), myrcene (0.65%), and unknown (0.65%), as determined by gas liquid chromatography using the method of Raffa and Steffeck (1988). Weevils were collected from the traps and the baits replenished at approximately weekly intervals from May to Sept., 1987. All weevils were examined in the laboratory for species identity using the keys developed by Kissinger (1964) and Warner (1966), and sex was determined by the methods of Wilson et al. (1966).

Numbers of weevils of each species captured in pitfall traps were analyzed using analysis of variance and Duncan's multiple range test. Statistical Analysis System programs were used for all analyses (SAS Institute 1982).

RESULTS AND DISCUSSION

Adult *H. pales* and *P. picivorus* of both sexes were captured in significantly larger numbers in baited pitfall traps that were painted white than in similarly baited pitfall traps painted black or green (Table 1). This seemed surprising because black or green traps more closely approximate the color of the host trunk and foliage, respectively. However, *H. pales* and *P. picivorus* breed primarily in the stumps and roots of pines that have recently been harvested or were killed by bark beetles, fire, or some other agent (Nord et al. 1982), so these insects may not be very responsive to

Table 1.—Mean number (±SE) of *Hylobius pales* and *Pachylobius picivorus* adults caught per trap from 19 May to 7 Sept. 1987, in 11 cm diameter pitfall traps of various colors in Wisconsin. N = 20 traps for each color[a].

	H. pales		*P. picivorus*	
Trap color	Females	Males	Females	Males
White	17.3±3.2a	1.8±0.7a	15.3±3.9a	9.8±2.3a
Black	2.5±0.8b	0.5±0.3b	2.8±1.1b	1.8±0.8b
Green	0.5±0.03b	0 b	0 b	0 b
Total captured	406	46	362	232

[a]Means within columns followed by the same letter are not significantly different ($P = 0.05$; Duncan's multiple range test [SAS Institute 1982]).

Table 2.—Mean number (±SE) of *Hylobius pales* and *Pachylobius picivorus* adults caught per trap from 19 May to 7 Sept. 1987, in black pitfall traps of different diameters (large = 22 cm; small = 6 cm) in Wisconsin. N = 20 traps for each diameter[a].

	H. pales		*P. picivorus*	
Trap diameter	Females	Males	Females	Males
Large	3.2±1.0a	0.7±0.4a	3.1±0.9a	1.7±0.7a
Small	2.9±0.8a	0.8±0.4a	3.0±0.8a	1.5±0.5a
Total captured	122	30	122	64

[a]Means within columns followed by the same letter are not significantly different ($P = 0.05$; Duncan's multiple range test [SAS Institute 1982]).

host color. Also, both of these species feed nocturnally, so white traps may simply provide greater contrast at night.

Our data on the effects of color on trap catch contradicts the results of Fatzinger (1985), who reported that in Florida more *H. pales* and *P. picivorus* were caught in black flight-barrier traps than in white traps. This discrepancy may be due to differences in the behavior of flying and walking weevils, or may reflect differences in Wisconsin and Florida populations.

Trap diameter did not affect catch for either *H. pales* or *P. picivorus* (Table 2). Orientation to an odor source may be a more effective method than diameter-related preference for locating stumps and roots, since a silhouette may be absent or of variable dimensions above suitable host material. For these weevils tree condition may determine host suitability more than age or size. Similarly, Nordlander et al. (1986) reported that *Hylobius abietis* oriented to underground odor sources in the absence of visual cues. The large proportion of female weevils caught in traps baited with ethanol combined with turpentine is in agreement with Hunt and Raffa (1989), and suggests that these compounds are used as chemical cues primarily by females.

Weevil orientation to baited traps of various colors in this study suggests that visual cues play a role in host orientation by root weevils. However, neither *P. picivorus* nor *H. radicis* are attracted to black pitfall traps in the absence of turpentine and ethanol baits (Hunt and Raffa 1989), suggesting that visual orientation can augment olfactory orientation but not replace it. Because *H. radicis* breed in the root collar area of standing pine trees (Schaffner and McIntyre 1944), as opposed to the stumps and roots used by *H. pales* and *P. picivorus*, visual cues such as color or diameter may be even more important in *H. radicis*.

Previous studies of host orientation in pine root weevils have used black pitfall traps (Raffa and Hunt 1988, Hunt and Raffa 1989). Our results suggest that more weevils would have been captured if these studies had used a more attractive or more visible color such as white. Since the number of certain species of root weevils captured in pitfall traps appears to be correlated with tree damage in pine plantations (Nordlander 1987, Hunt and Raffa 1989) the use of white traps could increase trapping efficiency, and thereby provide for a more sensitive and accurate monitoring tool.

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