Attraction of *Hylobius radicis* and *Pachylobius picivorus* (Coleoptera: Curculionidae) to Ethanol and Turpentine in Pitfall Traps

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ABSTRACT

Pitfall traps were used in field tests to evaluate the relative attractiveness of red pine, *Pinus resinosa* Aiton, volatiles, turpentine, ethanol, and combinations thereof to adult *Hylobius radicis* Buchanan and *Pachylobius picivorus* (Germar). Traps baited with a combination of ethanol and turpentine caught significantly more of both species of weevils than any other bait tested. Only overwintered *H. radicis* were attracted to the baits. The sex ratio for weevils captured in all traps was 9:1 females/males for *H. radicis* and 1:7:1 for *P. picivorus*. A significant relationship was observed between numbers of *H. radicis* captured in pitfall traps placed in plots of Scotch pine, *Pinus sylvestris* L., and percentage incidence of foliar symptoms.

KEY WORDS

Insecta, root weevils, attractants, pitfall traps

It was our goal to study the chemical attraction of *H. radicis* and contrast this with the secondary insect *P. picivorus*. A field test was conducted during the summer of 1987 to determine whether host volatiles, ethanol, and terpenes were attractive to adult *H. radicis* and to compare these responses with those of *P. picivorus*. We also have attempted to develop a sampling method for *H. radicis* and to determine whether numbers of weevils trapped can be related to host damage in pine plantations.

Materials and Methods

The traps used were a modified version of the pitfall trap described by Tilles et al. (1986a,b). Sections of PVC plastic drainpipe (20 cm long, 10 cm inside diameter) were drilled with eight holes (6 mm diameter) spaced equally around the circumference of the pipe, 16 cm from one end. The pipes were then inserted into holes in the soil formed with a post hole digger to a depth of 16 cm so that the holes in the sides of the pipe were just above ground level. The pipes were capped at both ends with removable plastic lids; the lower lid was drilled with two holes (0.28 cm diameter) to allow water drainage. A thin layer of Fluon was applied to the inner surface of the walls of the traps to prevent the escape of weevils which had entered the traps through the holes. A wire passing through two holes (2 mm) in the walls of the trap at ground level served as a support for baits. The above-ground portion of the trap was painted with a flat black spray enamel (New York Bronze Powder Company, Elizabeth, N.J.) to provide a tree trunk silhouette for possible visual orientation by the weevils.
The traps were placed in a Scotch pine Christmas tree plantation (4.5 yr old) in Waushara County, Wis. Many of the trees had yellow or red foliage typical of *H. radicis* infestations, as well as pitch-soaked soil adjacent to the base, extensive girdling of the collar region, and large numbers of larvae. Five plots were chosen within the plantation so that they represented a wide range of weevil infestation, with 0.3–8.3% of the trees within a plot exhibiting foliar symptoms on 6 May 1987. The distribution of trees exhibiting foliar symptoms within each of the five plots did not appear to be related to the edges of the plots or the edges of the plantation.

The trees had been planted in rows with 1.7 m between trees in a row and 1.7 m between adjacent rows. The traps were placed along the rows midway between every second tree, resulting in a spacing of traps approximately 3.4 by 3.4 m. A minimum of 30 m served as a buffer between the edge of a plot and the edge of the adjacent plot or the edge of the plantation.

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The baits consisted of: freshly cut red pine stems 7–8 cm long and 1–2 cm in diameter, 95% ethanol, turpentine (Sunnyside Corporation, Wheeling, Ill.), stems + ethanol, stems + turpentine, ethanol + turpentine, and unbaited control. The traps were arranged in a randomized block design, with seven treatments per block and eight blocks in each of the five plots, resulting in 56 traps per plot. The turpentine and 95% ethanol each were released separately from open 2-ml glass vials (12 by 35 mm), such that the release rates were approximately 200 mg and 40 mg/24 h, respectively, at 22°C. 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 (0.55%), myrcene (0.65%), and unknown (0.65%), as determined by gas liquid chromatography using the method of Raffa & Steffeck (1988). The vials of turpentine and 95% ethanol, as well as the pine stems, were suspended from a support wire such that they were not accessible to weevils in the traps.

Weevils were collected from the traps, and the baits were replenished at approximately weekly intervals from 19 May to 7 September 1987. All weevils were identified in the laboratory using the keys developed by Kissingler (1964) and Warner (1966), and gender was determined by the methods of Wilson et al. (1966) for *H. radicis* and Franklin & Taylor (1970) for *P. picivorus*.

Numbers of weevils of each species captured in pitfall traps with various baits were analyzed using analysis of variance (ANOVA) and Duncan’s multiple range test. The Statistical Analysis System (SAS Institute 1982) model used was: Trapped Insects = Plot, Block, Bait, Plot·Bait, Plot·Block, Block·Bait; each sex of each species was analyzed separately. Variances in numbers of weevils caught with different treatments were proportional to their means, so a square root (\(Y + 0.5\)) transformation was used to normalize the data before performing analysis of variance. The relationship between the number of weevils captured in each plot and the percentage of trees exhibiting foliar symptoms in each plot was analyzed using linear regression. Regression analysis also was used to relate pitfall trap catch to distance from an edge of the experimental plots. This analysis was performed in an attempt to provide an explanation for the between-block, within-plot variation that we observed. The deviation of trapped male and female *H. radicis* and *P. picivorus* from a 50:50 ratio was computed by \(x^2\) analysis. Statistical Analysis System (SAS Institute 1982) programs were used for all analyses.

**Results and Discussion**

The combination of turpentine and 95% ethanol is highly attractive to female *H. radicis* and both sexes of *P. picivorus* (Table 1). Low numbers of weevils also were captured in traps baited with ethanol + stem, stem + turpentine, or ethanol alone, but these catches were not significantly different from the blank control traps. The complete absence of any attraction of *H. radicis* or *P. picivorus* of either sex to the blank control traps indicates that the traps did not provide an attractive tree trunk silhouette for visual orientation by the weevils in the absence of volatiles.

The interaction of Plot·Bait was significant for female *H. radicis* (F = 2.27, P < 0.0001), female *P. picivorus* (F = 2.27, P < 0.0001), and male *P. picivorus* (F = 3.72, P < 0.0001), whereas the interaction of Block·Bait was significant for female *H. radicis* (F = 2.27, P < 0.0001). There were no significant interactions at P = 0.05 because of Plot·Bait for male *H. radicis* (F = 1.45, P < 0.09), Block·Bait for female *H. radicis* (F = 1.00, P < 0.49), male *H. radicis* (F = 1.24, P < 0.18), and male *P. picivorus* (F = 1.29, P < 0.14), or for Plot·Block for female *H. radicis* (F = 0.88, P < 0.64), male *H. radicis* (F = 1.33, P < 0.14), female *P. picivorus* (F = 1.04, P < 0.42), and male *P. picivorus* (F = 0.94, P < 0.56).

The seasonal distribution data show a peak in *H. radicis* trap catch during the last week of May and the first week of June and a peak for *P. picivorus* during the second week of July (Fig. 1). The peak for *H. radicis* is in agreement with the spring peak previously reported for this species in central Wisconsin (Raffa & Hall 1988). This peak probably corresponds to the emergence of overwintered adults (Millers 1965). However, the peak in newly emerged adult *H. radicis* activity (Millers 1965), which was reported to occur in late summer to early fall in central Wisconsin (Raffa & Hall 1988), was not observed using pitfall traps. When the dust was removed from around the bases of Scotch pine trees in our study site in late August and early September, numerous *H. radicis* adults were found. Also, screen traps similar in design to those used...
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Table 1. Mean number (± SE) of H. radicis and P. picivorus adults caught per trap from 19 May to 7 September 1987 in pitfall traps baited with various compounds

<table>
<thead>
<tr>
<th>Treatment</th>
<th>H. radicis</th>
<th>P. picivorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol/turpentine</td>
<td>1.73 ± 0.32a</td>
<td>1.53 ± 0.39a</td>
</tr>
<tr>
<td>Ethanol/stem</td>
<td>0.25 ± 0.08b</td>
<td>0.28 ± 0.11b</td>
</tr>
<tr>
<td>Ethanol</td>
<td>0.05 ± 0.03b</td>
<td>0.18 ± 0.06b</td>
</tr>
<tr>
<td>Stem/turpentine</td>
<td>0.03 ± 0.03b</td>
<td>0.13 ± 0.06b</td>
</tr>
<tr>
<td>Stem</td>
<td>0b</td>
<td>0b</td>
</tr>
<tr>
<td>Turpentine</td>
<td>0b</td>
<td>0b</td>
</tr>
<tr>
<td>Blank</td>
<td>0b</td>
<td>0b</td>
</tr>
</tbody>
</table>

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

We had anticipated that H. radicis, which breeds in the root collar area of living pine trees (Wilson & Millers 1983), would be attracted primarily to host volatiles and not ethanol. Thus, we were surprised to find such a strong synergism between ethanol and turpentine in attracting H. radicis to pitfall traps, whereas turpentine or cut stems alone did not attract this species. The synergism between ethanol and host terpenes in attracting P. picivorus (Table 1, Fatzinger 1985), H. pales (Fatzinger et al. 1983, Raffa & Hunt 1989), and H. abietis (Tilles et al. 1986a) is more easily interpreted because these species breed in the stumps and roots of trees that have been killed, injured, or harvested; thus ethanol could be used as a signal indicating host deterioration. Likewise, Moeck (1970) found ethanol to attract secondary but not primary bark beetles. However, although ethanol is apparently always present in the trunks and roots of trees (Crawford & Baines 1977), microbial growth probably would result in substantially more ethanol production in dead or weakened trees than in healthy trees. Further research is required to determine whether healthy pine trees give off sufficient quantities of ethanol to be used in host orientation by H. radicis, or whether the increased levels of ethanol given off by stressed pines (Kimmerer & Kozlowski 1982) are of significance.

While P. picivorus is known to be a serious pest of young pine plantations in the southeastern United States (Nord et al. 1982), very little is known about the importance of this insect in the Northeast. In our plots, which were chosen on the basis of a high level of foliar and root collar damage typical of H. radicis, P. picivorus were captured as frequently as H. radicis in pitfall traps. This does not necessarily indicate that P. picivorus were present at higher population levels than H. radicis in the area of our plots, because H. radicis are thought to move between host trees primarily by walking (Wilson & Millers 1983), whereas P. picivorus, which are thought to be good flyers (Nord et al. 1982), were likely to be drawn into the traps from longer distances.

Further evidence of the possible importance of P. picivorus in pine plantations in the northeastern
United States is provided from a small number of larvae which were collected from the root collars of Scotch pines adjacent to our experimental plots and reared to adults on an artificial medium. One-half of these adults were identified as *P. piceivorus*, but the other half were *H. radicis*. We suspect that *P. piceivorus*, and *H. pales*, captured in our traps in much smaller numbers, together with *H. radicis*, may cause tree mortality in many pine plantations. *H. radicis*, which attacks living pines, could initiate the attack on a stand of trees, and *P. piceivorus* or *H. pales* or both would subsequently be attracted by the host deterioration caused by *H. radicis* feeding and could then establish a mixed infestation. This would pose a severe threat to young neighboring stands, where feeding by adult *P. piceivorus* or *H. pales* or both could cause high seedling mortality.

When total numbers of *H. radicis* captured in the pitfall traps in each block were pooled for the five plots, trap catch per block was significantly associated with distance of the blocks from the northern edge of the plot (r = 0.85, P < 0.05; y = 0.64x + 20, where y = number captured, x = distance in meters from the southern edge). This may indicate that weevils from the area surrounding each plot (which was free of traps) moved into the plots primarily from the southern edge and that they tended to be captured in the first attractive trap they encountered. Although we do not have any meteorological data for our experimental site, we hypothesize that there may have been a prevailing wind from the north during the last week of May and the first week of June, and that *H. radicis* were orienting upwind to an attractive plume of ethanol and terpentine. There was no significant relationship between total numbers of *P. piceivorus* captured in pitfall traps in the five sets of eight blocks and the distance of the blocks from the southern edge of the plots.

Numbers of *H. radicis* captured in pitfall traps placed in plots showing varying degrees of weevil damage were significantly related to percentage incidence of foliar symptoms as recorded on 6 May in the spring before the experiment was conducted (r = 0.87, P < 0.05; y = 3.4x + 3.2, where y = number captured, x = percentage of trees with symptoms). Nordlander (1987) also showed a positive correlation between numbers of *H. abietis* caught in pitfall traps and incidence of damage of Scotch pine seedlings. There was no significant relationship in our study between numbers of *P. piceivorus* captured in pitfall traps and foliar symptoms. These data for *H. radicis* suggest that pitfall traps baited with ethanol and terpentine may be useful as a monitoring tool for these weevils. Currently, the first symptoms of root weevil infestation in pine plantations occur too late to save the trees. As a result, growers of high-value plantations such as Christmas trees must rely on preventive insecticide sprays with highly persistent materials, primarily lindane. By using this pitfall trapping system, we may be able to detect when serious infestations are imminent. This would reduce unnecessary use of insecticides and perhaps allow for effective protection using less toxic and persistent materials.

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