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SEASONAL OCCURRENCE OF PINE ROOT COLLAR WEEVIL, *HYLOBIUS RADICIS* (COLEOPTERA: CURCULIONIDAE), IN RED PINE STANDS UNDERGOING DECLINE

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ABSTRACT

A trapping scheme was devised for sampling the pine root collar weevil, *Hylobius radicis*, in mature red pine plantations in Wisconsin. Adult weevils were trapped throughout the 1986 field season, and the method appears sensitive enough to discern temporal and spatial trends. The number of weevils caught was higher in stands symptomatic of the general condition currently labelled Red Pine Decline and Mortality. In some stands there was a strong tendency for trap catches to be particularly high near certain trees. Seasonal trends and sex ratios were compared with published reports of *H. radicis* activity in Michigan.

Plantations of red pine, *Pinus resinosa*, in southern and central Wisconsin are currently experiencing a very common and damaging, but ill-defined condition simply labeled "Red Pine Decline and Mortality." The condition is typified by a group of dead trees at the center, around which are several rows of trees that appear to have stunted growth during the last few growing seasons. A circle of these stunted trees dies every year thus causing the pocket to enlarge. The trees are generally 20–45 years old. A variety of microorganisms and insects can be cultured or reared from the killed trees, thus precluding any immediate identification of one organism as a sole cause of death. In addition, these plantations may occupy unfavorable sites, and so physiological stress cannot be eliminated as a source of the decline.

The killed trees are invariably infested with pine engravers, *Ips pini* (Say) and/or *Ips grandicollis* (Eichhoff), with the accompanying blue stain caused by *Ceratocystis* associates. The stunted trees are frequently infested with the red turpentine beetle, *Dendroctonus valens* (LeConte), and *Leptographium* associates. However, we frequently find larvae and/or completed brood galleries of the pine root collar weevil, *Hylobius radicis* Buchanan, in these trees as well. Because *Ips* and *D. valens* have much shorter development times (Schenk 1961) than *H. radicis* (Millers 1965), the life stages present can be used to infer the sequence of attack. These preliminary observations caused us to suspect that root collar weevils may infest trees initially, and stress their hosts to the degree that bark beetles can then colonize them. Attack by *Ips* beetles is fatal to the tree within 1 or 2 years.

During this study we conducted trappings of root collar weevil adults throughout the 1986 season. Our objective was to monitor the activities of weevils in red pine plantations in various levels of decline.

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Table 1. Location and site description of red pine plantations sampled for *H. radicis* adults.

Stand	Location		Year Planted	DBH (cm)	Site Index	Basal Area	Type and degree of tree mortality
	County	Description					
Arena 1	Iowa	T8N, R4E, Sec. 23	1945	20.7	64	130	Adjacent to large pocket.
Arena 2	Iowa	T8N, R4E, Sec. 23	1952	16.8	54	120	None.
Spring Green	Sauk	T8N, R4E, Sec. 18	1945	21.7	63	150	Adjacent to large pocket.
Bakken's Pond	Sauk	T8N, R3E, Sec. 8	1961	13.3	75	195	One small pocket.
Webster	Burnett	T40N, R15W, Sec. 24	1969	16.3	47	30	Individual trees dying in one year—no pockets; no decline.

MATERIALS AND METHODS

Five red pine plantations were selected for study. Three of these were undergoing decline in the typical pocket pattern and had experienced significant mortality over the last three years. One (Webster) was undergoing scattered mortality of individual trees. One (Arena 2) showed no evidence of decline. The general site information is given in Table 1.

We modified a trap originally described by Maki (1969). Aluminum door screen supported with 14-gauge steel wire formed a sloping skirt around the lower stem of the tree. The upper end of the skirt was formed into an inverted funnel which fed through the inverted lid of a 12 oz. jar. The upper edge of the skirt was nailed to the tree with a shingle nail; the lower end was held in place by stapling the two wires to the tree where they crossed. A small pine twig was placed in the jar to arrest the beetles that entered. The jar was supported by tying it to the tree with cotton cord. As adult weevils ascended the tree during nocturnal feeding (Millers 1965, Wilson 1968a, 1968b, Wilson and Millers 1983), they walked into the jars and became trapped.

Within each stand, a 100-tree plot sampling universe was selected. Twenty trees were randomly selected within each plot for trapping.

Beetles were sampled from mid-May to early October, 1986. All of the stands in Iowa and Sauk counties (Table 1) were sampled on the same dates. The Webster plantation was examined separately. Weevil species and sex were determined using the methods of Warner (1966) and Wilson et al. (1966), respectively.

The number of weevils trapped was analyzed by two-way ANOVA (Steel and Torrie 1960) for sources of variation due to sampling date and plot location. The Webster plot was not included in this two-way ANOVA because of the different sampling dates. Within plots, a one-way ANOVA (Steel and Torrie 1960) was conducted for sampling date, and a one-way ANOVA was conducted for tree number. Means were compared by Duncan's Multiple Range Test (Steel and Torrie 1960). The numbers of males and females trapped in all plots were compared by paired-t analysis (Steel and Torrie 1960).

RESULTS

The total trap catches are shown in Table 2. The Webster, Spring Green, Arena 1, and Bakken's Pond stands were most highly infested.

There were very pronounced differences in weevil densities among the various stands ($F = 6.38$; $P < 0.001$). There was a weaker effect due to time of sampling ($F = 1.86$; $P < 0.06$). In general, weevil numbers were greater earlier in the season (Figure 1). The Bakken's Pond ($F = 2.55$; $P < 0.002$), Webster ($F = 2.06$; $P < 0.04$), Arena 1 ($F = 1.76$; $P < 0.045$), and Spring Green ($F = 1.57$; $P < 0.087$) stands showed a strong relationship between weevil numbers and seasonal occurrence. The only stand that showed no relationship between sampling date and beetle numbers was the Arena 2 stand, which also contained the fewest weevils.

Weevil populations were five times higher in the stands that had been undergoing decline and mortality than in the non-declining Arena 2 stand (Figure 1). We did not include the data from the Webster plot in this calculation because of the difference in the pattern of mortality described above. If these data had been included, however, the difference would be even more pronounced (Table 2). The weevil catches occurred in the same rank order as the severity of stand decline (Table 1).

The within-stand spatial distribution of weevils depends on their population density. Weevil populations were highly clustered about certain trees in stands where their densities were moderate (Spring Green $F = 3.27$; $P < 0.001$; Arena 1 $F = 1.67$ $P < 0.041$) but a more uniform distribution occurs at the lower (Arena 2 $F = 0.72$; ns) and higher (Bakken's Pond $F = 1.09$; ns, Webster $F = 0.76$; ns) densities. In the Spring Green stand, 27% of the weevils were captured at one tree. At both Spring Green and Arena 1, half of the weevils were trapped at only 3 of the 20 trap trees. Weevil distributions were random in the other stands.

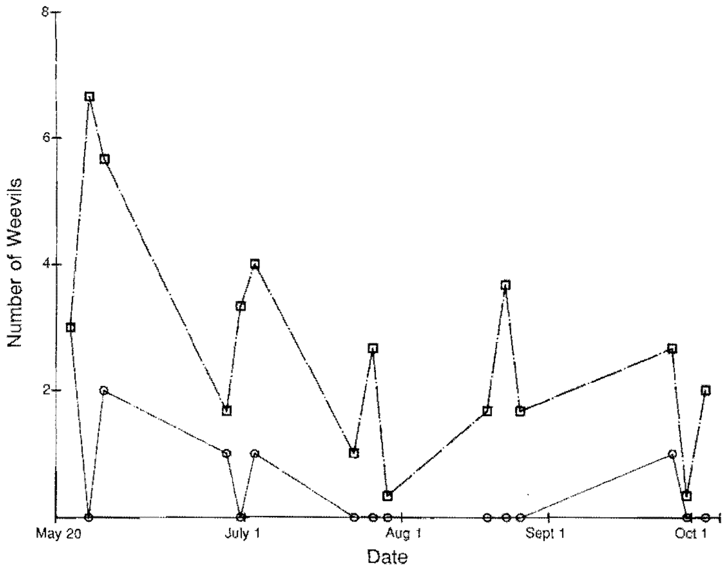

Fig. 1. Number of *H. radicis* adults trapped in stands containing (Square) and not containing (Circle) clusters of dead and dying trees characteristic of Red Pine Decline and Mortality.

Table 2. Number of *H. radicis* adults trapped in red pine plantations in Wisconsin. Means followed by the same letter are significantly different at $P < 0.05$.

	Stand				
	Arena 1	Arena 2	Spring Green	Bakken's Pond	Webster
Total	35	8	58	28	87
Mean	2.33AB	0.53C	3 .87A	1.87BC	—

The sex ratio of trapped beetles was 1.5 male: 1.0 female. However a paired-t test indicates that we cannot reject the assumption of a 1:1 ratio with any degree of confidence ($t = 1.18$, $df = 3$, $P = 0.32$).

DISCUSSION

This is the first attempt to quantify *H. radicis* populations in Wisconsin. This method is sensitive enough to discern seasonal and spatial trends in adult weevil numbers. The peak period of root collar weevil activity in south-central Wisconsin is earlier than that reported in the northern lower peninsula of Michigan (Wilson 1975). Wilson (1975) observed peak adult activity in mid-June, whereas we observed peak activity in late May (Table 3). Peak trap catch in northwestern Wisconsin, however, occurred on 3 July (Figure 2). Thus there appears to be a strong latitudinal gradient in weevil emergence, although there are surely differences due to yearly variation as well.

The period of adult activity was also longer in our region, as Wilson (1975) did not observe any weevils after 15 September. The median date of weevil capture was 30 June

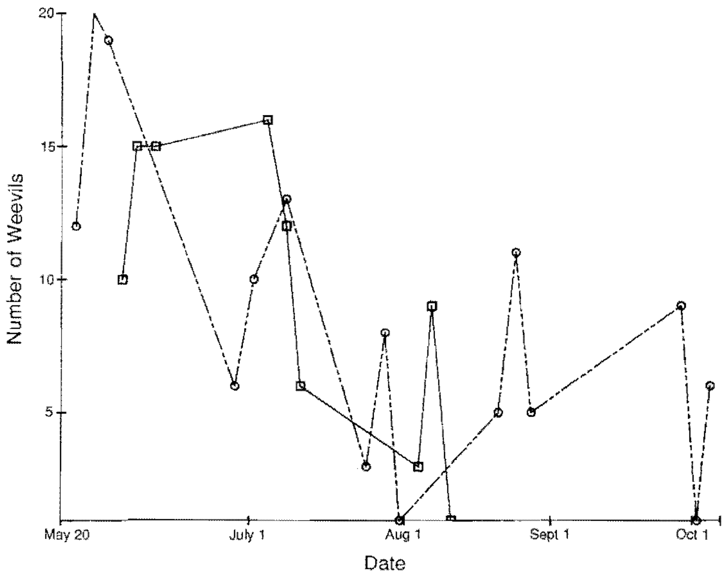

Fig. 2. Seasonal occurrence of *H. radicis* adults in south-central (Circle) and northwestern (Square) Wisconsin red pine plantations.

in south-central Wisconsin, compared to 18 June in northern Michigan (Wilson 1975). The median date of weevil capture was 2 July in northwestern Wisconsin.

The seasonal distribution data (Figure 2) show two major peaks in *H. radicis* adult numbers in south-central Wisconsin. Weevils were significantly less abundant from late July to mid-August than in the preceeding or following periods (Table 3). These peaks probably correspond to the emergence of overwintering adults in the spring, and the development of new adults in late summer to early fall (Millers 1965). There also appear to be two peaks in northwestern Wisconsin (Figure 2), but we do not have sufficient data for statistical analysis.

Our observed sex ratio of 1:1 agrees with earlier reports by Millers (1965) and Wilson (1975), although there is some indication that a larger sample size would have revealed a higher percentage of males caught during nocturnal feeding.

The disproportionately high occurrence of *H. radicis* in plantations characteristic of Red Pine Decline and Mortality suggests that they are involved in this pathology. This view is supported by our field observations. We have examined 79 trees in Red Pine Decline Pockets in and near the Bakken's Pond stand. Twelve of the 13 living trees infested with *D. valens* had previously been attacked by *H. radicis*. Only 28 of the 66 trees not attacked by *D. valens* had signs of previous *H. radicis* infestation ($X^2 = 10.8$; $p < 0.001$).

Root collar weevils have primarily been considered a pest of young pine plantations, but these results suggest they may be a serious threat to more mature trees as well. We cannot discern at this time whether *H. radicis* is an important agent in the onset of the Red Pine Decline symptoms, or whether these weevils simply orient to trees that are sufficiently stressed to allow colonization by a number of insects and microorganisms. We are currently investigating their potential role as vectors of *Leptographium* and predisposing agents to *Ips* and *D. valens*.

Table 3. Means separation (Duncan's Multiple Range Test) of *H. radicis* adults caught in south-central Wisconsin red pine plantations during 1986. Means followed by the same letter are not significantly different at $p < 0.05$.

Time	Mean
May 23	3.00 ABC
May 27	5.00 A
May 30	4.75 AB
June 26	1.50 ABC
June 30	2.50 ABC
July 3	3.25 ABC
July 24	0.75 C
July 28	2.00 ABC
July 31	0.25 C
August 21	1.25 BC
August 25	2.75 ABC
August 28	1.25 BC
September 29	2.25 ABC
October 2	0.25 C
October 6	1.50 ABC

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