Status and Management of Pales Weevil in the Eastern United States

Scott M. Salom

Assistant professor, Virginia Polytechnic Institute and State University, Department of Entomology, Blacksburg, Virginia

The pales weevil—Hylobius pales *(Herbst) is a subcortical feeding insect with a large geographic range and wide host-species range amongst conifers. It is a regeneration pest of forest and Christmas tree plantation, and nurseries, feeding on stems of seedlings and branch tips of saplings. It breeds in freshly killed stumps and slash. Across the geographic range of pales weevil, different conifer management objectives and constraints result in varying pest impacts and application of different pest management strategies. A questionnaire was sent to 32 states where pales weevil was believed to occur. Responses indicated that pales weevil is an important Christmas tree pest in the north central states, a pest of pine seedlings and Christmas trees in the northeastern states, and principally a pest of pine seedlings in the southern states. Pest management tactics used in the north central states focus on stump treatments (removal or application of insecticides). In the northeastern states, tactics include stump and seedling insecticide treatments and delayed planting of seedlings in recently harvested sites. In the South, the most popular tactic is to delay planting of seedlings. All these tactics are considered effective, yet they are also costly and those that include insecticides are not favored by land managers. Overall, there is a fair amount of dissatisfaction by foresters and landowners with currently available tactics. The need for development of more effective and less hazardous pest management tactics is discussed.* Tree Planters' Notes 48(1/2): 4-11; 1997.

The pales *weevil—Hylobius pales* (Herbst) (Coleoptera: Curculionidae)—has long been considered a pest of seedlings and sapling stage coniferous trees in central and eastern North America (Carter 1916; Peirson 1921). A complete review of the systematics, distribution, biology, and recommended pest management practices for this insect has been presented by Lynch (1984).

Pales weevil is found throughout the eastern and central United States (figure 1), as well as southeastern Canada (Lynch 1984). In general, adult weevils are attracted by the resinous volatiles produced by dead and dying trees (Fox and Hill 1973; Hertel 1970; Peirson 1921; Thomas and Hertel 1969). They then feed and oviposit in the roots, dying stumps, or boles of fallen trees, where broods develop until the onset of winter (Anderson 1980; Doggett and others 1977). Subsequently, overwintering adults emerge the following spring, or brood adults emerge the following spring and summer, and feed on tender bark and cambial tissue of seedling stems and roots, and sapling branch tips (figure 2).

Figure *1—The states in which pales weevil is known to occur are shaded.*

Pales weevil has also been implicated as the principal vector of *Leptographium procerum* (Kendr.) to eastern white pine *(Pinus strobus* L.) and Scots pine (P. *sylvestris* L). in Virginia (Lewis and Alexander 1986; Nevill and Alexander 1992a, b). Overlapping generations occur throughout the geographic range of pales weevil with the duration of the life cycle being about 1 year in southern Canada (Finnegan 1959) and northern United States (Peirson 1921) and less than 1 year in the southern

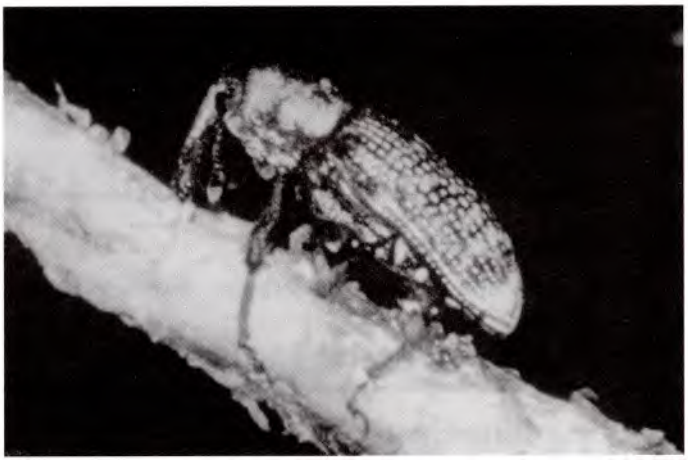

Figure *2—Adult pales weevil feeding on hark tissue of twig (photograph courtesy of Stephen Cade).*

United States (Beal and McClintick 1943; Doggett and others 1977; Speers 1974).

The abundance of pales weevil is generally dependent on host availability. Because the weevils can feed on live tissue and breed in recently killed or dead material, they can be present in different conifer management settings. This may partially explain why pales weevil is capable of becoming a pest of nursery and plantation seedlings, and Christmas trees. Another reason for its success may be that pales weevil has been reported to feed on 11 coniferous genera including 29 tree species (Lynch 1984).

Currently, the following pest management tactics are available for reducing the impact of pales weevil:

1. Determining site hazard from host species composition and site preparation activities
2. Harvesting the site before mid-summer
3. Delaying the planting of new seedlings for 1 or 2 years after harvest
4. Treating seedlings with insecticide either before or after planting (Nord and others 1982)
5. Treating stumps with insecticides (Nielsen and Balderston 1975; Thomas 1971)
6. Removing stumps of recently harvested trees (Benjamin 1963)
7. Not harvesting the bottom whorl of branches, thus keeping stumps alive (Corneil and Wilson 1984a)

Following some preliminary inquiries, I found that the perceived impact of pales weevil on conifer seedlings and Christmas tree production varied from state to state, as did the application of pest management tactics (Salom 1992). Therefore, the objectives of this paper are to more completely characterize the following information throughout the geographic range of pales weevil:

- The impact of the pest on forest, nursery, and Christmas tree management
- The pest management tactics used to combat the problem
- The research needs as expressed by state forest health officers

State forest health officers were targeted because they keep abreast of forest pest activity and are often called upon to make recommendations or develop programs for residents of their state.

Methods

I developed a questionnaire to be completed by state forest entomologists or forest health officers for all states in which pales weevil has been documented to occur (figure 1) (Lynch 1984). There were 9 questions in the questionnaire. The first 2 questions served to identify the respondent. A third question asked if pales weevil has ever been a pest of conifers in that state. If the answer was no, they were instructed not to answer any more questions. If the answer was yes, they completed the questionnaire. The remaining questions focused on situations in which pales weevil is a pest in their state. Respondents were then asked to rate the severity of pales weevil as a pest in their state. Severity classifications ranged from minor to serious relative to other pest problems within the state. The pest status of pales weevil was not based on economic data because such records are scarce. The respondents were then asked to list the host species most impacted from 1 (most impacted), 2 (second most impacted), and so on. The next question asked what management tactics are recommended. Again, respondents were asked to rank their recommendations with 1 (most frequent), 2 (second most frequent), and so on. Even though a tactic may be recommended, it may not be ideal. Therefore, the next question asked if state officials and users were satisfied with the currently used tactics. Lastly, respondents were asked to state their opinions on research needs for improving management of pales weevil.

The questionnaires were sent out to 1 state official in each of 32 states. In a few cases, more than 1 individual responded to the questionnaire, and the answers from within a state were then combined into a single response. Although some of the respondents may not have had intimate knowledge of pales weevil activity in their state, they were requested to obtain information from the person in the state best able to answer the questions or alternatively pass the questionnaire on to them. Because I considered it unlikely for each state to have more than a few individuals who could answer detailed questions about pales weevil, I focused on the most knowledgeable person in the state.

Results and Discussion

Responses were obtained from all 32 states. According to the respondents, pales weevil has never been a pest in Massachusetts and Connecticut. Therefore, the rest of the summary will not include information from these states. However, it should be noted that an important early paper on pales weevil by Peirson (1921) was based on studies carried out in Harvard Forest in Petersham, Massachusetts.

Pest status. Pales weevil was reported to cause serious damage to branches of Christmas trees in Wisconsin, Illinois, Pennsylvania, and New Jersey, and to a lesser extent in Indiana (figure 3a). Several of the

midwestern states and Maine reported moderate branch damage. Serious damage to Christmas trees seedlings was reported in Illinois, New York, New Jersey, and Maine (figure 3b). In addition, 11 other states rated this problem as moderate. Pales weevil was reported to be a serious seedling pest of forest plantations in almost all of the southern states plus Maryland (a border state) and New York (figure 3c). Although the southern states have long reported this problem, it was unexpected to have Maryland and New York included in this group. Pales weevil was generally reported as a minor pest in nurseries (figure 4), although New Jersey did report serious damage to branches of nursery trees (figure 4b).

The contrast in impacts between the southern and north central states is not unexpected. Although North Carolina and Virginia have become strong Christmas-tree-producing states, the main objective of foresters for growing conifers in the South is still pulpwood and sawtimber production. Even though several of the north central states are at the top of the Christmas tree production list (National Christmas Tree Association, unpublished report), the southern states surpass the northeastern and north central states combined in volume of conifer growing stock (2:1), volume of sawtimber (4:1), harvesting of growing stock (6:1), and harvesting of sawtimber (9:1) (Anonymous 1982).

Figure 3—*Pest status of pales weevil in the eastern United States: for branches on Christmas trees (A), seedlings in Christmas tree plantations (B), and seedlings in forest plantations (C).*

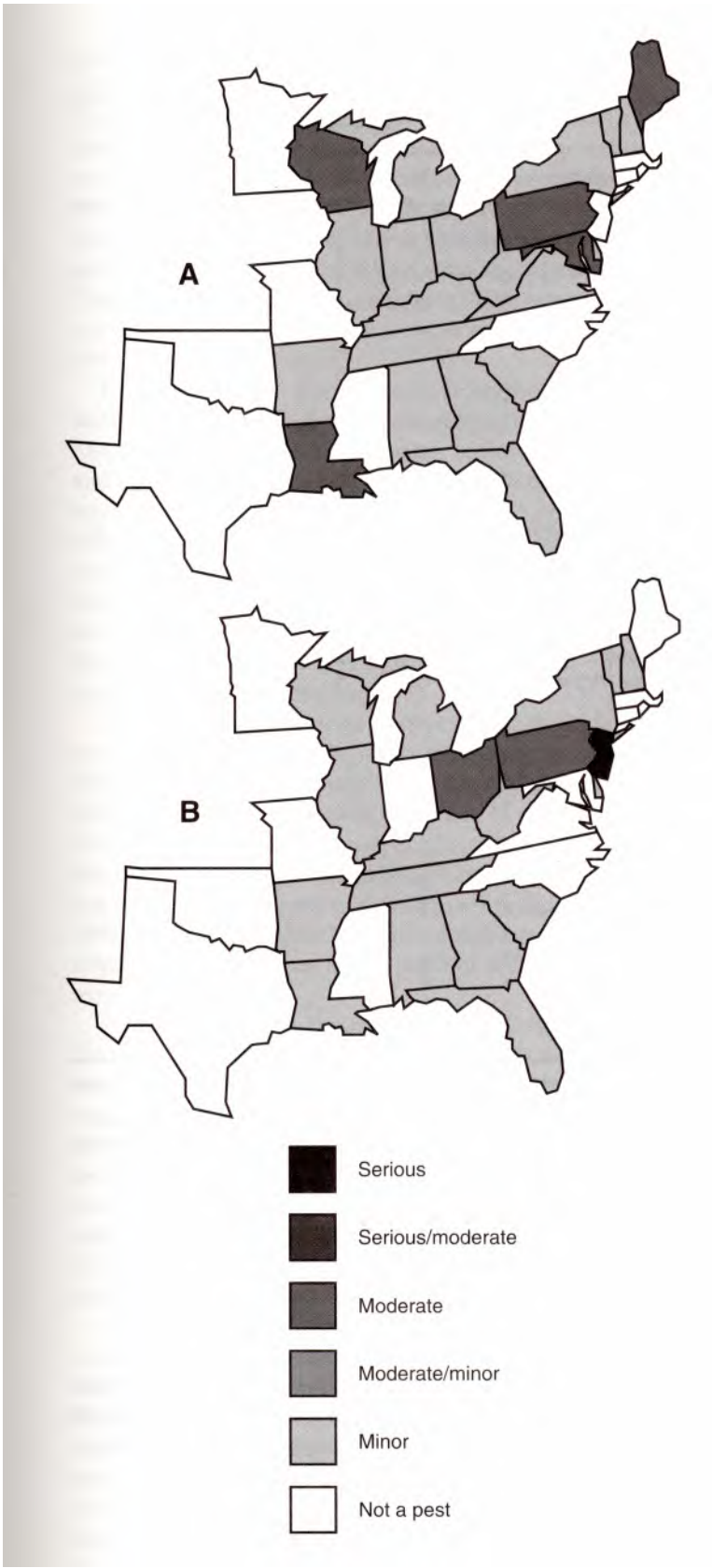

Figure 4—*Pest status of pales weevil in the eastern United States: for seedlings in nurseries (A) and branches on nursery trees (B).*

Host species. Among the surveyed states, the species of tree most frequently attacked by pales weevil is determined in part by both the geographic location and the relative importance and objectives of forest and Christmas tree managers. In the north central states of Indiana, Michigan, Minnesota, and Wisconsin, Scots pine is the most frequently attacked tree species, followed closely by eastern white and then red pine *(P. resinosa* Ait.) (table 1). Additional pine species were reported to be attacked in the northeastern states, yet both eastern white pine and Scots pines were the most highly ranked. In the South, loblolly pine *(P. taeda* L.) is reported to be the most attacked species. The second most attacked appears to be shortleaf pine *(P. echinata* Mill.). Despite being located north of Virginia, both Maryland and Delaware reported similar host species impacted as reported by most of the southern states. All species reported in this survey have been previously listed as susceptible hosts by Lynch (1984) and sources therein.

Pest management tactics, In the north central states, the treatments recommended most frequently for minimizing pales weevil damage are some form of stump treatments (table 2). Respondents were split between favoring insecticidal treatment of stumps or stump removal/slash management. Both approaches focus on reducing breeding material for pales weevil. The respondent from Wisconsin emphasized delayed planting over stump treatment, yet still ranked stump treatment with insecticides second.

Respondents in states that recommend stump removal and sanitation (table 2) are pleased with the results. In contrast, respondents in all states treating stumps with insecticides are interested in finding more "environmentally friendly" and less costly treatments. Although delaying planting 1 or 2 years is effective, it is unpopular with many growers. Even the respondent from Wisconsin, who ranked this tactic #1, is interested in finding an alternative approach.

In the northeastern states, recommendations varied (table 2). Respondents from New Jersey, Pennsylvania, Rhode Island, and West Virginia ranked insecticide treatment of stumps highest, whereas those from Maine, Maryland, and New York recommended delayed planting of seedlings the highest. Respondents from New Jersey and West Virginia gave a fairly high ranking (#2) to cutting stumps down to ground level and covering them with soil. Several of the respondents recommended treating seedlings with insecticides, yet only the Delaware respondent gave that tactic its highest rating (tied with stump removal and slash management).

Some of the respondents found treating stumps with insecticide acceptable, yet others would like an alternative to lindane, the most widely used insecticide for

Table 1— *Ranking of conifer species most affected by pales weevil (1 = most affected), as reported by surveyed states; all species are pines unless otherwise indicated*

	Tree species ranking		
State	1	2	3
Alabama	loblolly	longleaf	slash
Arkansas	loblolly	shortleaf	slash
Delaware	loblolly	Virginia	eastern white
Florida	slash	loblolly	
Georgia	loblolly	slash	shortleaf
Indiana	Scots	eastern white	red
Illinois	eastern white	Scots	Fraser fir
Kentucky	Scots	eastern white	loblolly
Louisiana	loblolly	shortleaf	slash
Maine	eastern white	balsam fir	
Maryland	loblolly		
Michigan	Scots	red & Jack	
Minnesota	Scots	red	
Mississippi	loblolly	shortleaf	longleaf
Missouri	Scots	eastern white	
New Hampshire	eastern white		
New Jersey	eastern white	Douglas-fir	spruce species
New York	red	Scots & eastern white	
North Carolina	loblolly	eastern white	longleaf
Ohio	eastern white	Scots	balsam fir
Oklahoma	loblolly	shortleaf	Virginia & Scots
Pennsylvania	eastern white	Scots	Douglas-fir
Rhode Island	eastern white	Scots	Fraser fir
South Carolina	loblolly	Virginia	eastern white
Tennessee	loblolly	eastern white	Virginia
Texas	loblolly	shortleaf	
Vermont	Scots	eastern white	
Virginia	loblolly	eastern white	Virginia
West Virginia	Scots	eastern white	
Wisconsin	Scots	red	eastern white

Table 2—*Pest management tactics recommended and used for managing pales weevil in the United States*

	Rank of control tactics*					
Region & state	A	B	C	D	E	F
North Central						
Illinois			1	2		
Indiana	2		1	3		
Michigan	3	2	1			
Minnesota				1		
Missouri				1		
Ohio			2	1		
Wisconsin	1		2			
Northeast						
Delaware		1.5		1.5		
Maine	1		2.5	2.5		
Maryland	1	2				
New Hampshire						1
New Jersey			1	3	2	
New York	1	2				
Pennsylvania			1			
Rhode Island		2	1			
Vermont			2	1		
West Virginia		3	1		2	
South						
Alabama	1					
Arkansas	1					
Florida	1	2				
Georgia	1	2				
Kentucky		1				
Louisiana	1					
Mississippi	1	2				
North Carolina	2	1				
Oklahoma	1					
South Carolina	1	2				
Tennessee	1	3	2			
Texas	2					1
Virginia	2	1	3			

1 = most commonly used or recommended tactic, 2 = next most common tactic, and 3 = least common tactic; No ranking indicates tactic not even considered.

Treatment A = Delay planting 6 months to 2 years; treatment B = treat seedlings or trees with insecticides; treatment C = treat stumps with insecticides; treatment D = remove stumps, slash and /or sanitation; treatment E = cover stumps down to soil; treatment F = none.

stump spraying. Treatment of seedlings with insecticides is not a popular option with workers, as they would rather not work with hazardous materials. Covering stumps with soil is a satisfactory treatment for 2 states, New Jersey and West Virginia, but I am not aware of a published report recommending this treatment. Satisfaction with stump removal/sanitation was mixed. Some respondents stated that this tactic works, yet one respondent described sanitation as too time consuming.

In the South, all but 1 state respondent ranked delayed planting of seedlings as either the first or second most recommended treatment (table 2). This was followed by treating seedlings with insecticides. Stump treatments were rarely recommended, except in Virginia and Tennessee, which have significant Christmas tree industries. However, North Carolina and Georgia, both with strong Christmas tree industries, do not recommend stump treatments. In Texas, where pales weevil is rarely a problem, the primary recommendation is to do nothing.

Delayed planting after harvesting was considered effective by all respondents in the South. However, some do not consider this approach economical, even though the delay is from 6 months to 1 year, rather than the 1 to 2 years needed in the northern states. Insecticide treatments of seedlings were also considered effective, yet satisfaction was also mixed for this tactic for the same reasons as stated above.

The differences in treatment recommendations between the southern and north central states may be largely a reflection of their different management objectives. With the emphasis in the north central states on Christmas tree production, intensive management of

plantations allows for stump treatments. Yearly harvesting and shearing practices associated with Christmas trees provide a consistent source of host volatiles and breeding material for the weevils. This makes delayed planting of seedlings less desirable and probably less effective. However in the South, where emphasis is on production of pulpwood and sawtimber, harvesting is generally intermittent on a temporal and spatial scale. Therefore, lack of continuously available breeding material makes delayed planting a more appealing and effective tactic.

Research needs, Respondents from the north central states indicated varied needs for research, including life history studies, better monitoring, biological control, and identification of pheromones. It is likely that recent research efforts and publications may not be reaching everyone equally. Much needed information on pales weevil life history (Hoffman and others 1997; Raffa and Hunt 1989; Rieske and Raffa 1990a;) and techniques for monitoring the pest (Raffa and Hunt 1988; Rieske and Raffa 1990b, 1991, 1993) is now available. Less effort has gone into the latter two areas.

Indiana reported a need to investigate the role of subcortical feeding insects in vectoring *Leptographium procerum* to trees that ultimately succumb to procerum root disease. Nevill and Alexander (1992a, b, c, d) studied this topic extensively. However, the actual timing of inoculation of the tree within the Christmas tree rotation has not been conclusively determined (Salom and Gray 1993) unpublished data). Respondents from the less impacted north central states did not feel any improvements were needed.

Respondents from the northeastern states focused on the need to develop either safer chemicals or non-chemical control tactics. One suggestion from the Maine respondent was to find a way to kill stumps. The respondent suggested that herbicide treatments might be less toxic and might solve the problem of available breeding material. Rennels and Fox (1969, 1970), however, reported little success in applying fuel oil, pentachlorophenol, or 2,4,5-T to stumps in an effort to inhibit pales weevil breeding.

In the South, the most pressing need is for the development of a method to predict weevil damage. Respondents from 6 of 12 southern states ranked this need the highest. This is not surprising. Nord and others (1982) stated that the biggest problem in managing for pales weevil is the inability to correlate number of weevils at a site with potential damage to seedlings. Sampling for field populations of pales weevil is based on three fundamental aspects of their biology:

- Adults are most active underground and are rarely active aboveground during sunny days (Corneil and Wilson 1984b)
- Adults are attracted to volatiles produced by dying conifers
- Populations are highly aggregated (Rieske and Raffa 1993)

Sampling for pales weevil is difficult and requires labor-intensive techniques, ranging from digging pits and filling them with insecticide-laced pine material (Doggett and others 1977) to using PVC drainpipe pitfall traps baited with ethanol and turpentine (Raffa and Hunt 1988). Studies have been conducted to predict weevil activity, mainly as damage to seedlings (Lawrence 1975) or pre-harvest Christmas trees (Rieske and Raffa 1993). Lawrence (1975) was unable to correlate weevil trap catches with weevil feeding on seedlings, but Rieske and Raffa (1993) did find a correlation between the number of females trapped and weevil activity in following years. However, it is unknown whether their data can be used as a reliable predictor of pales weevil activity. This may be partially due to the inherent problems associated with measuring damage to trees resulting from the complex of weevils present in the Wisconsin Christmas tree system. In Sweden, Nordlander (1987) had better success correlating trap catches of the closely related European pine weevil *(H. abietis* L.) to seedling damage.

Conclusions

There are several management options available for use against pales weevil. The differences in treatment recommendations for many of the states are partially a function of management objectives and constraints. It is apparent that recommended tactics can be effective, yet many landowners do not follow them, possibly a result of high cost or time allocation. The reasons why tactics were not often followed was not investigated in this survey.

An obvious weakness in the effective use of management tactics is an inability to correlate weevil density with damage. Such a tool would provide a relatively easy way to hazard-rate sites. Effective trapping techniques are critical for monitoring weevil densities. Such techniques became easier in the United States with the adoption of the PVC pitfall traps baited with ethanol and turpentine (Raffa and Hunt 1988). However, these traps are not effective in catching pales weevil in Virginia unless recently killed or cut host material is a component of the bouquet (Fettig 1996).

In this survey, insecticidal treatments were the least desirable, yet most often recommended tactic. The

development of less hazardous and equally effective compounds was seen as a priority by most respondents. In Virginia, a nursery application of permethrin to protect outplanted seedlings has been effective without some of the negative aspects associated with use of phosmet (preplanting) and chlorpyrifos (postplanting) insecticides (Tigner 1995). Active research efforts are being made into the possible treatment of seedling stems with non-toxic, biologically based anti-feedants (Salom and others 1994, 1996) or wax (Nordlander 1995). Although this research shows some promise, more work is needed.

Progress has been made over the years in minimizing the impact of pales weevil on conifer tree production in the eastern United States. Although many of the states reported that improved pest management tactics are needed for better acceptance by growers and land managers, most are satisfied with the level of control they are able to achieve with the tactics available. We all hope that continued research will lead to even better and less hazardous control tactics for pales weevil.

Address correspondence to: Dr. Scott Salom, Virginia Tech, Department of Entomology, Blacksburg, VA 24061; **e-mail:** salom@vt.edu

Acknowledgments

Adapted from a presentation made to Working Party 7.03.03 (Insects Affecting Reforestation) at the IUFRO 20th World Congress in Tampere, Finland, August 6-12,1995. This paper would not have been possible without the help of the state forest entomologists and health specialists who responded to the questionnaire in a timely fashion. Tim Tigner was most helpful in reviewing earlier versions of the questionnaire and manuscript. I am also grateful to Jodi Gray, James Johnson, Frank Sapio, and Chris Fettig, who reviewed earlier versions of the manuscript.

Literature Cited

Anderson GW. 1980. Pine reproduction weevils (Coleoptera: Curculionidae) infesting Christmas trees plantations in southwest Virginia. Blacksburg, VA: Virginia Polytechnic Institute and State University. M.S. thesis. 65 p.

Anonymous. 1982. An analysis of the timber situation in the United States, 1952 2030. Rep. 23. Washington, DC: USDA Forest Service. 499 p.

Beal JA, McClintick KB. 1943. The pales weevil in southern pine. Journal of Economic Entomology 36: 792-794.

Benjamin DM. 1963. Control of weevils associated with replanted Scotch pine Christmas tree plantations following final harvest. Wisconsin Christmas Tree Producers Association New Bulletin 34: 1-2.

Carter EE. 1916. *Hylobius pales* as a factor in the reproduction of conifers in New England. Proceedings of the Society of American Foresters 11: 297-307.

Corneil JA, Wilson LF. 1984a. Live branches on pine stumps deter weevil breeding in Michigan (Coleoptera: Curculionidae). Great Lakes Entomologist 17: 229-231.

Corneil JA, Wilson LF. 1984b. Some light and temperature effects on the behavior of the adult pales weevil, *Hylobius pales* (Coleoptera: Curculionidae). Great Lakes Entomologist 17: 225-228.

Doggett CA, Grady CR, Green HJ, Kunselman MB, Layman H, Taylor S. 1977. Seedling debarking weevils in North Carolina. North Carolina Forest Service Forestry Note 31.

Fettig CJ. 1996. Development and evaluation of trapping studies for *Hylobius pales* (Herbst) and *Pissodes nemorensis* Germar (Coleoptera: Curculionidae) in Virginia Christmas tree plantations. Blacksburg: Virginia Polytechnic Institute and State University. M.S. Thesis. 82 p.

Finnegan RJ. 1959. The pales weevil, *Hylobius pales* (Hbst.), in southern Ontario. Canadian Entomologist 91: 664-670.

Fox RC, Hill TM. 1973. The relative attraction of burned and cutover pine areas to the pine seedling weevils *Hylobius pales* and *Pachylobius picivorus.* Annals of the Entomological Society of America 66: 52-54.

Hertel GD. 1970. Response of the pales weevil to loblolly pine seedlings and cut stems. Journal of Economic Entomology 63: 995-997.

Hoffman GD, Hunt DWA, Salom SM, Raffa KF. 1997. Reproductive readiness and niche differences affect responses of conifer root weevils (Coleoptera: Curculionidae) to simulated host odors. Environmental Entomology 26: 91-100.

Lawrence LK. 1975. Relationship between number of pales weevils trapped and subsequent seedling mortality. North Carolina Forest Service Forestry Note 23.

Lewis KA, Alexander SA. 1986. Insects associated with the transmission of *Verticicladiella procera.* Canadian Journal of Forest Research 16: 1330-1333.

Lynch AM. 1984. The pales weevil, *Hylobius pales* (Herbst): a synthesis of the literature. Journal of the Georgia Entomology Society 19: 1-34.

Nevill RJ, Alexander SA. 1992a. Distribution of *Hylobius pales* and *Pissodes nemorensis* (Coleoptera: Curculionidae) within Christmas tree plantations with procerum root disease. Environmental Entomology 21: 1077-1085.

Nevill RJ, Alexander SA. 1992b. Transmission of *Leptographium procerum* to eastern white pine by *Hylobius pales* and *Pissodes nemorensis* (Coleoptera: Curculionidae). Plant Disease 76: 307-310.

Nevill RJ, Alexander SA. 1992c. Pathogenicity of three fungal associates of *Hylobius pales* and *Pissodes nemorensis* (Coleoptera: Curculionidae) to eastern white pine. Canadian Journal of Forest Research 22: 1438-1440.

Nevill RJ, Alexander SA. 1992d. Root- and stem-colonizing insects recovered from eastern white pines with procerum rot disease. Canadian Journal of Forest Research 22: 1712-1716.

Nielsen DG, Balderston CP. 1975. Evaluation of insecticides for preventing reproduction of pales and northern pine weevils in pine stumps. Journal of Economic Entomology 68: 205-206.

Nord JC, Ghent JH, Thomas HA, Doggett CA. 1982. Control of pales and pitch-eating weevils in the South. For. Rep. SA-FR-21. Atlanta: USDA Forest Service.

Nordlander G. 1987. A method for trapping *Hylobius abietis* (L.) with a standardized bait and its potential for forecasting seedling damage. Scandinavian Journal of Forest Research 2: 199-213.

Nordlander G. 1995. Host finding in *Hylobius abietis* possibilities of control. Proceedings, IUFRO 10th World Congress, 1995 August 6-12; Tampere, Finland. (Abstr.): 77.

Peirson HB. 1921. The life history and control of the pales weevil *(Hylobius pales).* For. Bull. 3. Petersham, MA: Harvard Forest. 33 p.

Raffa KF, Hunt DWA. 1988. Use of baited pitfall traps for monitoring pales weevil, *Hylobius pales* (Coleoptera: Curculionidae). Great Lakes Entomologist 21: 123-125.

Raffa KF, Hunt DWA. 1989. Microsite and interspecific interactions affecting emergence of root-infesting pine weevils (Coleoptera: Curculionidae) in Wisconsin. Annals of the Entomological Society of America 82: 438-445.

Rennels RG, Fox HW. 1969. Chemical control of the pales weevil in an Illinois Christmas tree plantation. Journal of Forestry 67: 310-311.

Rennels RG, Fox HW. 1970. The pales weevil a serious pest in Illinois Christmas tree plantations. American Christmas Tree Journal 14: 17-18.

Rieske LK, Raffa KF. 1990a. Dispersal patterns and mark-and-recapture estimates of two pine weevil species, *Hylobius pales* and *Pachylobius picivorus* (Coleoptera: Curculionidae), in Christmas tree plantations. Environmental Entomologist 19: 1829-1836.

Rieske LK, Raffa KF. 1990b. Use of a monitoring system to evaluate pesticide efficacy and residual activity against two pine root weevils, *Hylobius pales* and *Pachylobius picivorus.* Great Lakes Entomologist 23: 189-193.

Rieske LK, Raffa KF. 1991. Effects of varying ethanol and turpentine levels on attraction of pine root weevil species, *Hylobius pales* and *Pachylobius picivorus* (Coleoptera: Curculionidae). Environmental Entomology 20: 48-52.

Rieske LK, Raffa KF. 1993. Potential use of baited pitfall traps in monitoring pine root weevil species, *Hylobius pales, Pachylobius picivorus,* and *Hylobius radicis* (Coleoptera: Curculionidae) populations and infestation levels. Journal of Economic Entomology 86: 475-485.

Salom SM. 1992. Pales weevil: a diverse pest requiring flexibility and innovation in management strategies [abstr.]. In: Allen DC, Abrahamson LP, eds. Proceedings, North American Forest Insect Work Conference. Gen. Tech. Rep. PNW-GTR-294. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 119.

Salom SM, Gray JA. 1993. Unpublished data.

Salom SM, Carlson JA, Ang BN, Grosman DM, Day ER. 1994. Laboratory evaluation of biologically-based compounds as antifeedants for the pales weevil, *Hylobius pales* (Herbst) (Coleoptera: Curculionidae). Journal of Entomological Science 29: 407-419.

Salom SM, Gray JA, Alford AR, Mulesky M, Fettig CJ, Woods SA. 1996. Evaluation of natural products as antifeedants for the pales weevil (Coleoptera: Curculionidae) and as fungitoxins for *Leptographium procerum*. Journal of Entomological Science 31: 453-465.

Speers CF. 1974. Pales and pitcheating weevils; development in relation to time pines are cut in the Southeast. Res. Note SE-207. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station.

Thomas HA. 1971. Integrated control of weevils attacking coniferous reproduction. Journal of Forestry 69: 806-808.

Thomas HA, Hertel GD. 1969. Response of pales weevil to natural and synthetic host attractants. Journal of Economic Entomology 62: 383-386.

Tigner TC. 1995. Personal communication. City: Virginia Department of Forestry