NUMBER, SIZE, AND LOCATION OF RED OAK BORER, *ENAPHALODES RUFULUS* HALDEMAN, ATTACK SITES ON RED OAKS IN INDIANA

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Abstract.--The distribution and size of red oak borer (*Enaphalodes rufulus* Haldeman) attack sites were studied during 1978 and 1979 in five forest stands on the Tell City Ranger District in the Wayne-Hoosier National Forest, Indiana. Species examined included: northern red oak, *Quercus rubra* L.; black oak, *Q. velutina* Lam.; and scarlet oak, *Q. coccinea* Muenchh. Tree diameter classes ranged from 1 to 12 inches dbh. Discussion of distribution and abundance of attack sites includes the variability among stands, among trees within stands, and within the tree. Indiana red oak borer attack-site patterns are compared to patterns found in Ohio. Indiana red oak borer population levels and attack-site patterns are used to estimate borer impact on the red oak forest component. A pest management strategy for the stands under study is presented.

Additional keywords: carpenterworm, oak timber worm, pole borer, white oak borer, Columbian timber beetle, silvicultural control

INTRODUCTION

The red oak borer, *Enaphalodes rufulus* Haldeman (hereafter ROB), is a native pest of Indiana oak species including: northern red oak, *Quercus rubra* L.; black oak, *Q. velutina* Lam.; scarlet oak, *Q. coccinea* Muenchh.; and white oak, *Q. alba* L. ROB's have a 2-year life cycle with a 22-month larval period spent inside the host tree. Adults are present in the forest during late June, July, and early August. The adults are nocturnal and are seldom seen even in heavily infested stands.

Economic loss is caused when the larvae feed in subcortical and heartwood tissues. Hardwood lumber graders refer to certain defects in oak lumber as "bark pockets" and "cat faces." These defects are caused when borer larvae feed in the cambium and die. The larval feeding area is overgrown, and pockets of bark that look like a cat's face are formed. Another defect is "grub holes" and they are late-instar larval galleries made in the heartwood. The overgrowth process takes from 1 to 20 years depending on size of the defect and tree growth rate. Until the overgrowth is completed the xylem is exposed, and ROB attack sites are used by other insects and decay fungi as points of entry. After ROB damage occurs it generally is not noticed until the attacked tree is harvested and cut into primary products.

Quantitative damage estimates for oak borers are well documented: Bryan

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(1960), Donley (1974), Hay and Wootten (1955), Lockard et al. (1963), Morris (1964), and Snyder (1927). However, with skyrocketing inflation and tight profit margins for industry, impact assessments of borers on timber losses must be constantly updated. At 1979 factory grade lumber prices the losses from the ROB and other borers directly associated with defects from insect galleries amounted to about $40/M board feet. To cause such a loss borer population levels must vary from 60 to 280 attacks per merchantable tree (Donley 1974). To suffer this number of borer attacks a tree must be subjected to the pest over a period of about 60 years (Donley and Worley 1976). Trees harvested in 1980 have been under attack since about 1920.

Current borer loss estimates are based on the permanent record which past generations of the ROB and associates etched in the wood of our forest over some 30 pest generations.

MATERIALS AND METHODS

During 1978 and 1979 we visited a number of sawmills and one veneer plant to read the historical record of ROB in Indiana oak. We examined logs for surface indicators of past borer attack and factory grade lumber for the number of defects caused by such borer species. Logs and lumber came from trees cut in Bartholomew, Brown, Clark, Daviess, Decatur, Dubois, Jackson, Jefferson, Harrison, Lawrence, Martin, Perry, Putnam, Ripley, Rush, Scott, Shelby, Spencer, and Washington counties. We examined veneer and veneer logs that came from trees cut in Boone, Delaware, Grant, Hamilton, and Montgomery counties. The examinations provided data of oak borer influence on wood quality from trees cut in the most recent cutting cycle.

To study ongoing ROB damage we examined every tree of the red oak group in five management units--stands--on the Tell City Ranger District in the Wayne-Hoosier National Forest. Three stands were in Perry, one in Orange, and one in Crawford county. Stands were selected on the basis of compartment inventory data. Each stand was the oak/hickory type and between 3 and 5 acres in size. Also, the date of origin was between 1940 and 1960, and oak timber production was one of its management objectives. Ohio data were collected from four stands selected from the Athens Ranger District in the Wayne-Hoosier National Forest (Donley 1979).

We located and tagged each host oak with a dbh of at least 2.5 inches. Examination of trees larger than 6 inches dbh was made from ladders. For each tree we recorded species; and we determined stump circumference, dbh, and dob at 17 feet. On the butt logs of these trees we located each ROB attack site, and estimated dimensions of the associated defects to the nearest one-tenth inch (Donley and Terry 1977). Attack sites above 17 feet were located and counted, but not measured.

To compare ROB populations from Indiana trees with those found in other localities we expressed insect abundance as the average number of attack sites per unit of host material; for example, per M board feet of factory grade lumber (Donley 1974). Another expression of borer population level is larvae per unit of host bark surface area in each acre of forest examined; for example, the number of attacks per square foot of bark surface area was used to compare Indiana populations with Ohio populations.

Size of defects associated with a particular stage of insect development was obtained by averaging estimates of all defects associated with a given insect stadium.

Location and number of insect attack sites aids in determining economic impact, deciding for or against control, determining which trees should be removed as a silvicultural practice, and evaluating effectiveness of a control. We can determine the minimum level of borer damage for a tree or group of trees (Donley and Worley 1976) by considering current tree size and projecting a harvest date (from compartment planning documents), estimating damage from past borer attack from overgrowths and visible galleries (Morris 1964), and counting ongoing borer attacks.

RESULTS AND DISCUSSION

Mill studies

Examinations of logs and primary red oak products showed damage and degrade from the following wood borers: the red oak borer, the carpenterworms (*Prionoxystus robiniae* Peck and *P. macmurtrei* Guerin), the oak timber worm (*Arrhenodes minutus* Drury), and the pole borer (*Parandra brunnea* Fab.). Damage from these four species was also found in white oak. In addition, white oak products were degraded by the white oak borer (*Goes tigrinus* DeGeer) and the Columbian timber beetle (*Corthylus columbianus* Hopk.)

A comparison of ROB defects in primary oak products for Indiana and Ohio is given in figure 1. In general, defects are slightly more common in Indiana than Ohio oak. In factory grade lumber such an infestation level will give an economic loss that is slightly higher than the previously mentioned $40/M board feet calculated from earlier studies (Donley 1974). It is too late for Indiana's timber managers to do anything about the borer etchings in oak timber ready for harvest in 1980.

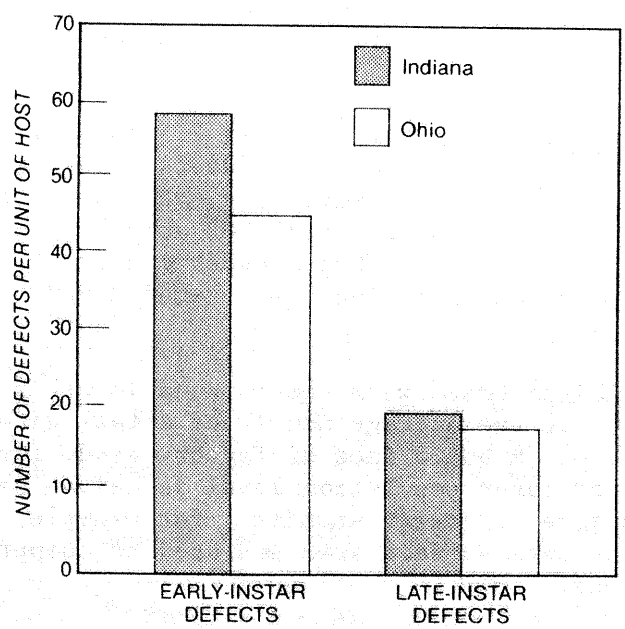


Figure 1.--Indiana and Ohio ROB infestation levels in primary products.

Forest studies

Stocking data from five stands were pooled to show the proportion of host oaks to nonhost trees (fig. 2). In the management units trees supported larvae of two ROB generations. Some attack sites discovered in the winter of 1978-1979 were by larvae from eggs laid by borer adults in the summer of 1978, and other attack sites were by larvae from eggs laid by adult beetles in the summer of 1977. Thus, we found two distinct size classes of external defects caused by ongoing larvae on the same trees at the same time. Larvae that are 14 to 20 months old are larger than 4 to 8-month-old larvae and produce larger defects.

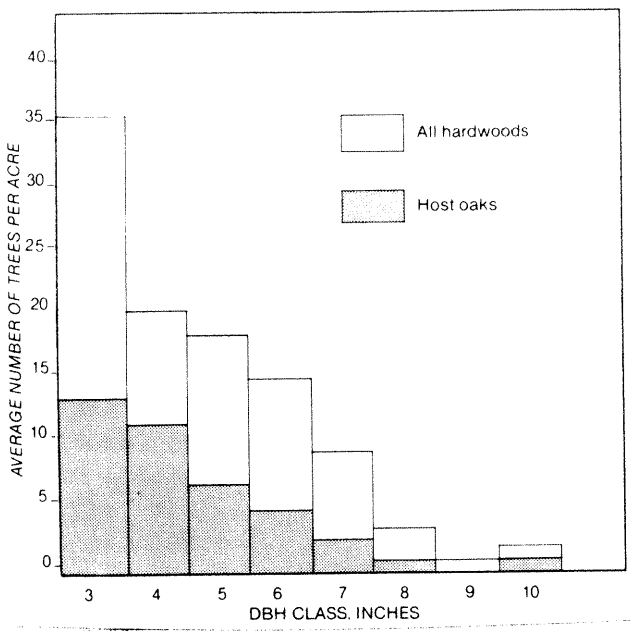
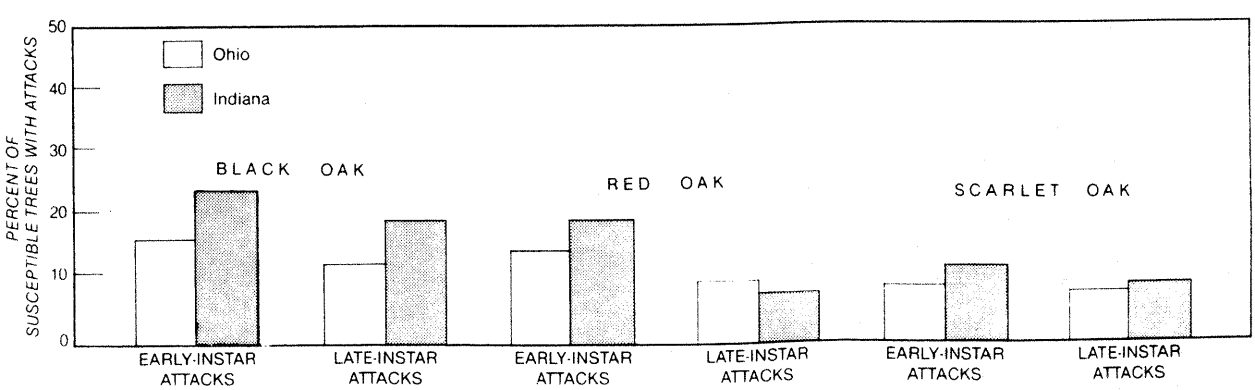


Figure 2.--Frequency distribution of potential ROB host oaks in Indiana plots.

Figure 3.--ROB infestation levels for Indiana and Ohio oak species.



Dimensions of an early-instar larval attack site averaged 2.2 inches long (measured parallel to the long axis of the bole), 1.3 inches wide (measured at right angles to the long axis of the bole), and 0.4 inch deep (measured at the point of deepest penetration). Similar dimensions for the late-instar larval attack site were 11.1 inches long, 4.8 inches wide, and 3.2 inches deep. Each attack site has the potential to produce a defect on the grading face of a factory grade board equal to the dimensions stated.

Comparison of ROB populations among host tree species in Indiana and Ohio showed that black oak is attacked most while scarlet oak is attacked least, and the attacks on red oak are in the middle of this range (fig. 3).

To summarize the location of attack sites on trees of different size classes and host tree species I used average attack heights and range of attack heights (figs. 4, 5, and 6). The location of attack sites is important in relating the proportional part of a ROB infestation found in the easy-to-examine basal portion of a stand containing trees of different size classes. The average number of host trees per acre in a size class varied from 0 for 10 inch dbh red oaks to 92 for 3 inch dbh black oaks. We estimate borer occurrence in a stand to: (1) decide on treatment, (2) determine the most effective method of silvicultural control, and (3) evaluate the effectiveness of any borer control.

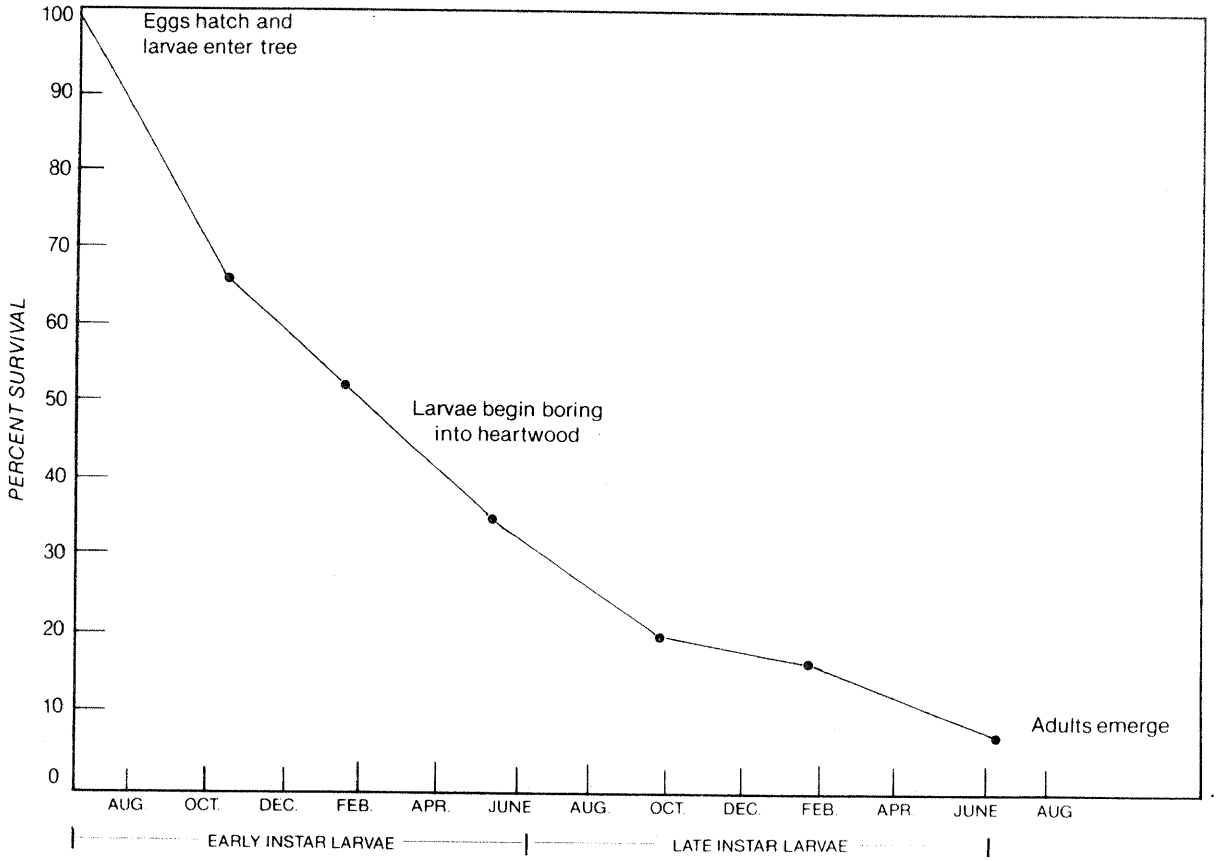
Within a given ROB generation natural mortality reduces, over time, the number of borer survivors in a unit of habitat. If a stand is examined when ongoing borers are 5 months old, more trees will be supporting attacks than if the same stand is examined when the borers are 18 months old. Thus, as a silvicultural control practice, the number of trees selected for removal on the basis of ongoing borer numbers can be expected to change over time within a given pest generation. A ROB survival curve for our combined five stands is given in figure 7.

Pest management strategy

We examine the basal 8-foot sections of all red, black, and scarlet oaks in a stand at a given point in time for ongoing borer attacks. Then from figures 4 to 6, on an individual-tree basis, considering both tree species and size class, we determine how many attacks that particular tree is likely to support and remove trees that are going to produce more than one adult borer.

Using the present data on ROB distribution in the five stands we find that a 50 percent reduction in borer damage could have been achieved with the sacrifice of only about 5 percent of the host oak basal area. The number of trees in this amount of basal area varied among stands but was never more than 11 nor less than 3 trees per acre. In one 4.6-acre stand examined when the borers were 17 months old we could have achieved a 50 percent reduction of ROB by removing 18 trees--2 percent of the stand basal area.

Figure 7.--Survivorship of a ROB cohort in Indiana oaks.



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