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Forest Insect and Disease Leaflet 163

Red Oak Borer

The red oak borer, *Enaphalodes rufulus* (Haldeman) (Coleoptera: Cerambycidae), is a woodboring beetle that develops in living oaks. Red oak borers are large insects, and the larvae feed on phloem, sapwood, and heartwood. They create extensive feeding tunnels that can reduce lumber quality (fig. 1) because most damage occurs in the bottom 16 feet (ft) (5 meters [m]) of the trunk.

Canopy dieback (fig. 2) becomes more extreme as larval densities build in trees. Callus tissue grows around larval feeding galleries in more vigorous trees and deforms the wood (fig. 3).

Figure 1. Structural damage and degrade in lumber quality caused by red oak borer larval feeding. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

Figure 2. Substantial crown dieback in a northern red oak heavily infested with red oak borer. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

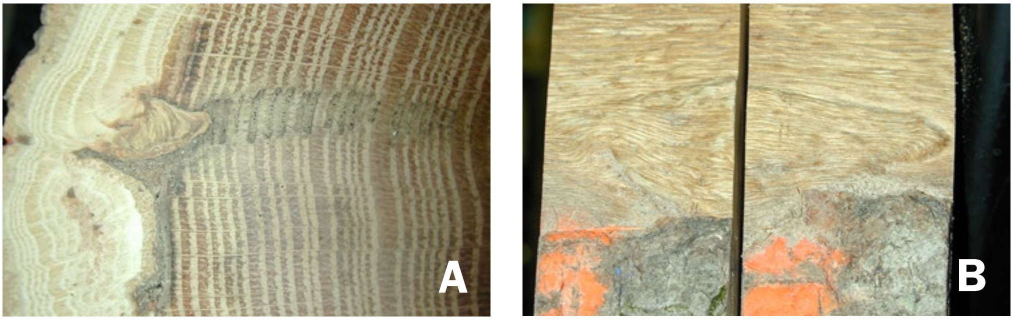

Figure 3. Callus tissue deforms the wood as it grows over red oak borer larval galleries. (A) Sanded surface of cross section; (B) external view, with bark peeled away, of two cross sections intersected by a larval gallery. Photos by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

Larval feeding also disrupts the phloem, cambium, and xylem, which causes stress and can lead to tree death. The red oak borer has not historically been an outbreak pest and typically acts only as a secondary mortality agent that kills oaks already stressed by other factors. Small, slow-growing, overtopped trees, or trees substantially weakened by other factors, may die once colonized by a low density of red oak borers. High larval densities may be enough to unilaterally kill a healthier, codominant tree. Though red oak borer outbreaks are not known to coincide with major tree die-offs, a notable exception occurred in Arkansas, Missouri, and Oklahoma (1995 to 2005) concurrent with widespread oak decline, causing landscape-scale mortality of dominant, overstory oaks. Population densities at the peak of that outbreak were more than 100 beetles per tree, which was far greater than previous reports from Kentucky, West Virginia, Pennsylvania, Indiana, and Ohio in the 1970s and 1980s. Other stressors in the 2000s oak decline that weakened trees, predisposing them to red oak borer, were aging, overcrowded forest conditions, recurrent drought, and widespread incidence of *Armillaria* root disease.

Distribution and Hosts

Red oak borer is native to the Eastern United States. Although no intensive surveys have been made, its range likely matches that of eastern oaks (*Quercus* spp.), especially its three preferred hosts: northern red oak *(Q. rubra),* black oak *(Q. velutina),* and scarlet oak *(Q. coccinea)* (fig. 4).

Southern red oak *(Q. falcata),* blackjack oak *(Q. marilandica),* willow oak *(Q. phellos),* Nuttall's oak *(Q. texana),* and white oak *(Q. alba)* are less preferred hosts. Red oak borer prefers red oaks over white oaks and rarely attacks nonoak species.

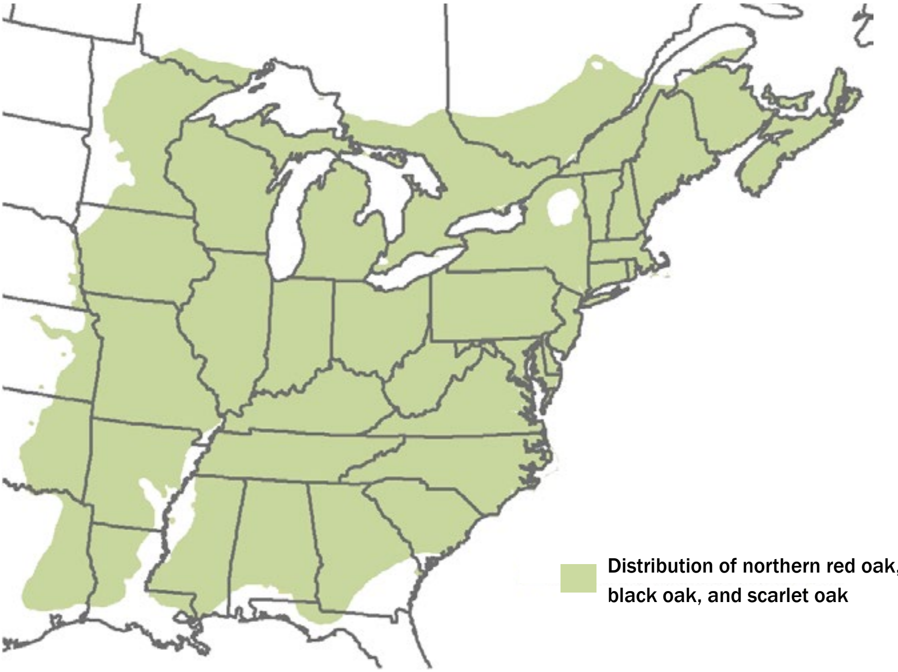

Figure 4. Combined distribution of *Q. rubra, Q. velutina, Q. coccinea,* and probable native range of red oak borer. Map by Quinn Chavez, USDA Forest Service, Northern Research Station, St. Paul, MN.

Identification

Attacks by the red oak borer are distinct and appear as crescent-shaped holes on the bark surface (fig. 5) with an approximate length of 0.1 inches (in) (3 millimeters [mm]). Eggs are cream-colored, oblong, and 0.1 in (2 to 3 mm) long (fig. 6A). Larvae are cream-colored, with a dark head capsule and mandibles, amber-colored spiracles, and small, jointed legs on the thorax (figs. 6B, C). Larvae are characteristic of members of the subfamily Cerambycinae. First-instar larvae are similar in size to borer holes and eggs; late instars are 1.5 to 2 in (4 to 5 centimeters [cm]) long.

The number of larval instars appears to be variable, as found with some other woodboring cerambycids. Pupae are tan-colored and exarate, with appendages externally visible (fig. 6D). Adults are 0.8 to 1.2 in (2 to 3 cm) long, a muted mix of tan, brown, and red in color, with antennae approximately body length (females) or twice the body length (males) (fig. 6E). Adult females are somewhat larger than males.

Round holes in the bark on the trunk indicate adult beetles have exited the tree (fig. 7). The feeding galleries of late-instar red oak borer are teardrop-shaped and very distinct in size (fig. 8).

Figure 5. Crescent-shaped attack hole in the bark, approximately 0.1 inches (3 millimeters) long, made by a first-instar larva. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

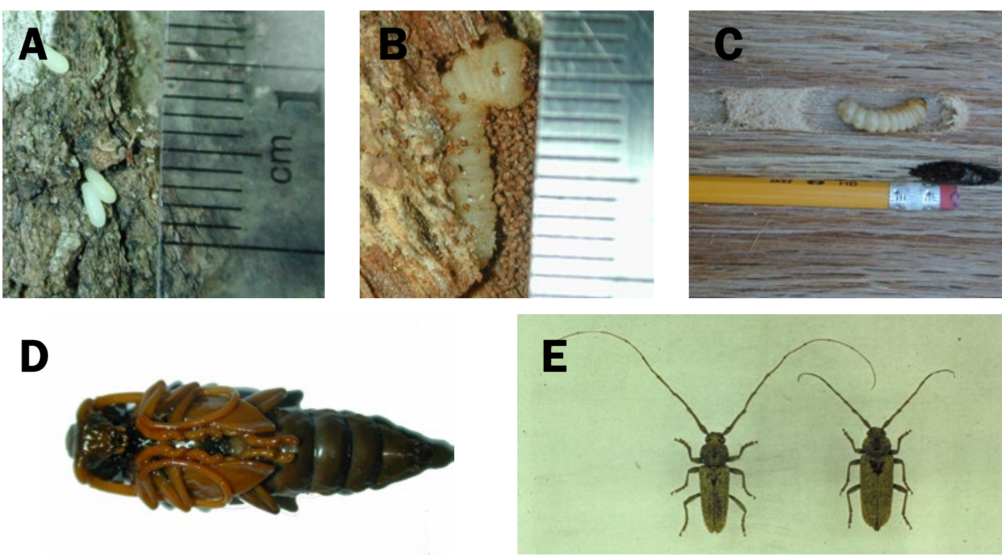

Figure 6. Red oak borer (A) eggs; (B) first-year larva; (C) second-year larva; (D) pupa; and (E) adult male (left) and female (right). Photos (A to D) by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR; photo (E) by J.D. Solomon, USDA Forest Service, Southern Forest Experiment Station, Stoneville, MI.

Figure 7. Round exit hole in bark created by an adult red oak borer. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

Figure 8. Distinctive teardrop shape of late-instar red oak borer feeding gallery, with vertical tunnel visible at the top. Frass and bark have been cleared away to highlight shape and size of gallery. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

Life History

Red oak borers typically have a 2-year generation time. Adults emerge synchronously in the summer of odd-numbered years only (fig. 9).

Adults are short-lived (1 to 3 weeks), do not feed, and are nocturnal in flight. They are apparently not attracted to host odors nor long-range pheromones, but are attracted to ultraviolet (UV) light. Females lay approximately 120 eggs singly or in small groups in bark cracks or under lichens. Eggs hatch in about 2 weeks and larvae bore crescent-shaped holes directly through the bark (see fig. 5) and create irregular-shaped feeding galleries full of dark, fine frass in the phloem. Red oak borers spend most of their lives as larvae, feeding in phloem, cambium, and xylem. During their first summer and fall (odd years), larvae continue to excavate within the phloem and remain inactive in their galleries over the winter (fig. 10).

In late spring (even years), larvae begin to feed again, enlarging the gallery into a teardrop shape (see fig. 8), and tunneling first obliquely and then vertically 6 to 10 in (15 to 25 cm) through the sapwood and sometimes heartwood (fig. 11). Coarse, woody frass is pushed out from the gallery of late instars and may appear as a sawdust pile at the base of the tree (fig. 12). Larvae remain inactive in the tunnel during their second winter in the tree. In the spring, they pupate behind a frass-packed plug at the top of the xylem tunnel. Adults emerge from trees in midsummer of odd years (see fig. 7).

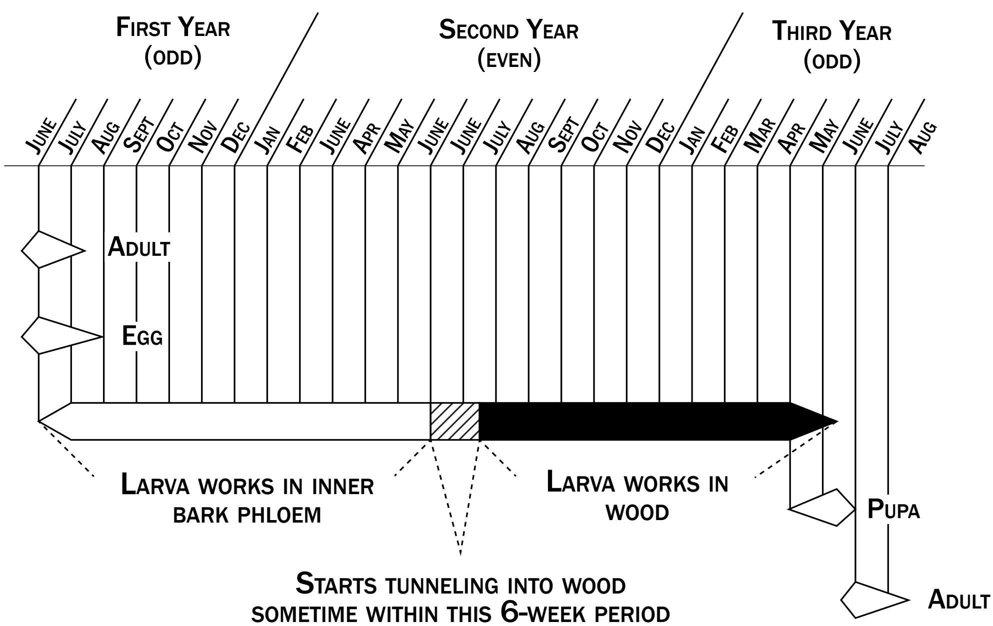

Figure 9. Red oak borer life cycle diagram. Adapted from the original Forest Insect and Disease Leaflet: Red Oak Borer by D.E. Donley and R.E. Acciavatti, 1980.

Figure 10. First-year larva creating a phloem feeding gallery. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

In stands with extensive damage, trees may be colonized by several successive generations of red oak borers. These oaks are referred to as brood trees and are typically slow growing and pole-sized (4 to 12 in [10 to 30 cm] in diameter). Brood trees can be identified by their numerous attack and emergence holes and by the crown thinning associated with years of successive red oak borer colonization.

Figure 11. Tunnel into the xylem (sapwood and heartwood) excavated by a second-year lava. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

Natural Enemies and Mortality Factors

A variety of natural enemies and mortality factors have been noted, though none of them singly or in combination have been reported as effective in regulating outbreak populations of red oak borer.

Carpenter ants (*Camponotus* spp.) carry off and feed on red oak borer eggs. Woodpeckers feed on second-year larvae and cause variable, sometimes substantial, amounts of mortality. Cannibalism occurs at high larval densities. Intraguild associates such as carpenterworms (Cossidae) and click beetle (Elateridae) larvae also prey on red oak borer larvae. The fungal pathogen *Beauveria bassiana* has been found in red oak borer-infested trees, but did not cause significant larval mortality. Most larval mortality occurs during the second year of feeding.

Mechanisms of tree resistance have only been partially explored, and with limited success. Tree resistance through tolerance of larval feeding appears to be important. Callus tissue encapsulates small larvae and vigorous growth can reestablish damaged vascular tissue.

Management

Because red oak borer is generally a secondary pest of stressed red oaks, efforts to develop integrated pest management strategies have been limited. Red oak borer damage can occur concurrent with oak decline, which is caused by a complex of factors related to stressful growing conditions (e.g., an overcrowded, aging, single age class of oaks planted outside its natural range) and is exacerbated by drought, defoliation, or both. Therefore, standard silvicultural practices that promote tree health will reduce damage and mortality caused by red oak borer and exacerbated by oak decline. Particularly useful practices are: (1) scheduled thinning of stands to maintain vigorous trees; (2) matching species to sites for which they are well adapted; and (3) monitoring oak stands that have reached their rotation age, with removal of oaks with signs of stress or insect damage. Oaks growing under dry conditions (e.g., south-facing slopes, ridge tops) may have a higher incidence of red oak borers, so management actions could be focused in these areas.

Treatment or removal of brood trees can reduce population growth. However, since red oak borer has a 2-year generation time and populations grow slowly, lightly infested trees are rarely killed or even visibly damaged by low-to-moderate red oak borer population levels. Therefore, lightly infested trees should be monitored and removed if population increases and potential tree death become evident.

Because of its lack of apparent long-range pheromones and/or attraction to host odors, no effective detection tools have been developed for red oak borer. Visual monitoring for signs of active attacks or canopy dieback from the ground or via detection flights or satellite imagery may alert managers to increasing red oak borer populations.

Figure 12. Pile of frass at the base of a tree indicative of second-year larvae. Photo by F.M. Stephen, Forest Entomology Lab, University of Arkansas, Fayetteville, AR.

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