CONTROL OF THE SHOT-HOLE BORER¹

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The shot-hole borer is a small, brown beetle that attacks orchards and may kill small twigs, entire limbs, or even whole trees. These beetles can be found throughout the summer, crawling rapidly over the bark of weakened trees,

brown to black; and the legs are lighter brown than the body.

The females cut circular holes in the bark, generally³ in the centers of lenticels (fig. 1). The lenticels are raised and roughened areas of

Fig. 1.--Entrance holes made by females constructing egg tunnels. These holes represent sufficient brood to give rise to the condition in figure 2, when the next generation of beetles emerge. This view shows the bark enlarged two times. (From Ext. Cir. 64.)

particularly through the warmer part of the day. They can be recognized by the following characters: the body is roughly cylindrical in shape; the length is about 1/10 inch; the color is dark

the bark, which contain soft, spongy tissue, adapted to the exchange of gases. Such areas afford the beetles better footing and are less resistant than smooth bark. From these holes, tunnels are constructed through the bark to the beginning of the wood. Here the females generally work up or down the length of the limb and continue to make their tunnels through the inner bark and cambium. Generally these tunnels

¹This leaflet supersedes Extension Circular 64, *The Shot Hole Borer*, by Leslie M. Smith (1932), which is out of print.

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are cut slightly into the wood, so that when the bark and the frass, or undigested food deposited by the larvae, are removed from a heavily infested limb, the adult burrows are indicated by shallow grooves in the wood. As soon as the females have constructed a short length of tunnel, they begin to lay eggs along the sides. The white, spherical eggs are enclosed only in a thin membranous shell. To protect them the females shred bark and wood, cementing it along the sides of the burrow until the eggs are completely imbedded. A completed tunnel is 1 inch to 1-1/4 inches long. In the work of excavation each female is generally accompanied by a male, often seen standing on the bark near the mouth of the burrow. When the burrow is completed and the eggs are all laid, the female backs to the opening of the burrow and dies there with the posterior end of her body projecting. She thus blocks the opening and prevents the entrance of parasites and predators, which might kill the eggs or young larvae.

The eggs hatch within a few days after being laid. The young, or larvae, are at first almost too small to be seen with the unaided eye. Feeding on the cambium and inner bark, they advance through it, generally at right angles to the egg tunnel. They grow rapidly; and the burrow constructed by their feeding becomes larger as they advance. Unlike the egg tunnels, the larval burrows are packed full of frass. They are small at the beginning and widen rapidly, whereas the egg tunnels are of uniform bore. In outline the burrows or tunnels of a single, isolated female and her progeny somewhat resemble a centipede; the primary burrow represents the body, and the secondary burrows represent the legs. Such a formation is practically never seen isolated; when the beetles are numerous enough to assure economic importance, the primary burrows are close together, and the larval burrows are completely intertwined. In heavy infestations the entire inner bark is reduced to powder. Young feeding larvae are pinkish because the ingested bark is visible through their skins. The full-grown larvae are white, with small brown heads sunken into the enlarged anterior part of their bodies. They are legless, and their bodies are generally curved. The fully matured larvae generally burrow toward the center of the limb and penetrate about 1/16 inch into the wood. They then turn up or down the limb and construct a cell in which to pupate (transform to the adult stage). The short burrow leading to the pupal cavity is tightly packed with chewed wood. Some larvae of the summer broods pupate in the bark, but all of the overwintering generation pupate in the wood. The length of the larval period is imperfectly known; in summer it is probably a little more than one month.

In the pupal cells, the larvae molt and transform to pupae--white, motionless bodies that indistinctly show the form of the adult. After some time the pupae molt and change to adult beetles, which are white at first, but which

soon turn brown, and then black. The adults remain in the pupal cells for a few days, then cut their way through the bark (fig. 2) and begin the cycle again.

Fig. 2.--Adult beetles and exit holes in bark of French prune, shown enlarged two times. (From Ext. Cir. 64.)

Seasonal History

The shot-hole borers pass the winter as larvae living and feeding, to some extent, in the inner bark. Some of these overwintering larvae pupate in the wood during the winter. The remainder pupate very early in the spring. The first beetles emerge from orchard wood about March 15. The last adults from overwintering larvae emerge before the middle of May. By this date, most of the adults from the overwintering brood have laid eggs, and the eggs have hatched, so that the first spring generation is represented, on May 15, mainly by large larvae. No pupae are found at this time. By the middle of June, in the observations here reported, the development of the first generation was estimated as follows: larvae 40 per cent, pupae 50 per cent, and new adults 10 per cent. Since April 15 represents the peak of emergence for the overwintering brood, the complete cycle, from overwintering adults to emergence of the greatest number of adults of the first spring generation, is roughly two months. By the middle of July the broods overlap: eggs, larvae, pupae, and adults are all present in numbers. The beetles continue to breed through the summer and fall. A few adults still construct egg tunnels and deposit eggs early in November. Eggs and young larvae are very common at this time; only a few larvae have constructed pupal chambers in the wood, and none have pupated. With a generation completed every two months and a breeding season extending from the latter part of March to the latter part of October, three complete generations and a partial fourth are possible.

Injury to Trees

Injury to trees by the shot-hole borer results from the feeding of both adults and larvae. Injury by the mature beetles falls into two fairly distinct groups: twig injury and limb injury. In producing twig injury the adults bore shallow holes in the new wood at the bases of the buds. They work in such places for only a short time, and evidently seek them only if suitable larger limbs are not available. In laboratory tests, when terminal growth and suitable limbs were both present, the beetles entered the limbs and rarely attacked the twigs. Such punctures, made at the bases of the buds and fruit spurs, exude considerable gum (fig. 3). This gumming increases throughout the summer; in severe cases, nearly all the terminals on the tree may be gummed by fall. Eggs are rarely laid in twig growth that is less than 1/2 inch in diameter.

Limb injury by the adults is due to tunneling through the inner bark and the cambium. Entrance holes are frequently cut into limbs and trunks where the sap flow is still strong. The beetles abandon these holes, and gum exudes freely. Occasional trees, particularly young trees that lack water, become studded all over the trunk, limbs, and twigs with masses of gum. In favorable situations--that is, in the limbs and trunk of weak trees, where the sap flow is much re-

Fig. 3.--Twigs of French prunes showing gumming as a result of punctures made by the shot-hole borer at the bases of buds and spurs. (From Ext. Cir. 64.)

duced--the beetles continue their tunnels and lay their eggs. They rarely girdle the limb, however, since they nearly always turn up or down it.

The larvae often girdle the limb; they tend to travel at right angles from the vertical, primary burrow, and hence work around the limb. Probably, however, a branch too weak to produce gum to repel the adults, and therefore suitable for egg deposition, could not survive even in the absence of beetle injury.

In the Santa Clara Valley the shot-hole borer attacks chiefly prunes and cherries. In the Sacramento and San Joaquin valleys, peaches, prunes, apricots, and almonds are often attacked. Essig³ gives the following host list: almond, apple, apricot, cherry, chokecherry, elm, hawthorn, Juneberry, loquat, mountain ask, nectarine, peach, pear, plum, prune, and quince.

Control

In control the most important consideration is that the shot-hole borer cannot live in healthy, vigorous trees. One factor largely responsible for an epidemic is lack of soil moisture. Trees may be suffering so slightly from drought that no ill effect is visible, and yet be weakened and attract the beetles. The pests single out such a tree even if it shows no outward sign of sickness. According to abundant field evidence, it is on trees of low vitality that the beetles injure the bases of the buds on the year-old wood. The following year, when these trees have been further weakened by bleeding through numerous punctures, the beetles are able to attack the larger limbs.

It is therefore extremely important to keep the trees strong and vigorous. The chief aid to the tree, in withstanding the borer, is water. In the center of one of the most heavily infested areas, several orchards have been almost completely protected by heavy irrigation, whereas near-by trees suffering from lack of water were seriously injured by this insect.

Other practices that increase the vigor of the trees, such as reducing the tops, cutting back, and fertilizing, should be followed when the beetle is established in the vicinity.

Next in importance to keeping the trees vigorous is orchard sanitation. Many growers have already witnessed severe injury to trees growing near woodpiles. Dead and dying wood removed from the orchard in late fall or in winter contains the overwintering larvae. If such wood is cut up and piled for home use, the beetles will emerge from it without difficulty the following spring. In dispersing from such a center of infestation, the adults stop and feed on the terminal growth of trees in the immediate vicinity; they may, in

³Essig, E. O. Insects of Western North America. p. 511. Macmillan Co., New York, N.Y. 1926.

a single season severely injure or even completely kill these trees. Eventually, most of the beetles fly onward to more distant trees, so that distribution is fairly uniform and the injury does not show a definite connection with the woodpile. The grower should therefore not underestimate the danger from this source; he should burn all infested wood before the end of February.

If there is a large woodpile, representing considerable value as household fuel, the grower may wish to treat it in some way to kill the overwintering larvae. This treatment is usually difficult: many of the beetles are in pupal cells in the wood, with the entrance sealed. In tests, the brood has been killed by fumigating the wood for 24 hours with carbon disulfide, used at the rate of 25 pounds per 1,000 cubic feet. A thorough spraying from all sides with stove distillate will likewise kill all over-

wintering beetles. Infested wood cut and piled during the winter may harbor adult beetles until, by the early part of June, all of the overwintering brood have emerged. Such wood is never reinfested; that is, no eggs are laid in it. Being no longer a menace, it may be kept indefinitely.

Wood from healthy, noninfested trees, which may be removed for various reasons during the winter, may retain enough sap to be acceptable to the beetles the following spring and may serve as food for the first spring brood.

Dead trees and limbs left in the orchard also present a serious menace; they may carry the beetles through the winter, precisely as does the cut wood. Severe twig injury is commonly found on trees adjacent to a dead tree. All such material, therefore, should be removed and burned before the end of February.