emerge. If they happen to be in roofing, then rain leaks can result. Otherwise, little serious destruction occurs. Most of these beetles will emerge during the first year to 18 months of a house's existence. There are a few rare exceptions to this rule that might result in emergence many years after construction.

ROUND-HEADED BORERS THAT WILL REINFEST

"The old house borer [*Hylotrupes bajulus* (L)] probably ranks next to termites in importance as a pest of buildings in the eastern United States." That introductory sentence of an article on this species (St. George, 1957), published more than three decades ago, probably is still true so far as the coastal states are concerned. This quotation does not refer to actual damage inflicted on wood in houses, but to the frequency with which it is encountered. As its name implies, the old house borer attacks well-seasoned coniferous wood found in old buildings, but also attacks relatively unseasoned pine and other coniferous construction material. It does not attack hardwoods.

■ CHARACTERISTICS

The adult beetle is 5/8 to 1 inch (16-25 mm) long, slightly flattened, brownish-black in color, with many gray hairs on its head and the fore part of the body. The hairs are easily rubbed off. The pronotum (segment just behind the head) has a shiny ridge down the middle and a shiny raised knob on each side, giving it the appearance of a face with a pair of eyes. The wing covers sometimes bear four patches of gray that form two indistinct cross bands or spots (Fig. 3-10A).

The larva is a typical round-headed borer up to 1-1/4 inch (31 mm) long (Fig. 3-10B). There are three black eyespots (ocelli) in a row on each side of the small head (Fig. 3-10C). The eyespots can be seen with a hand lens, and will separate this species from others of similar appearance. The other species found boring in softwoods have no more than one eyespot (ocellus) on each side.

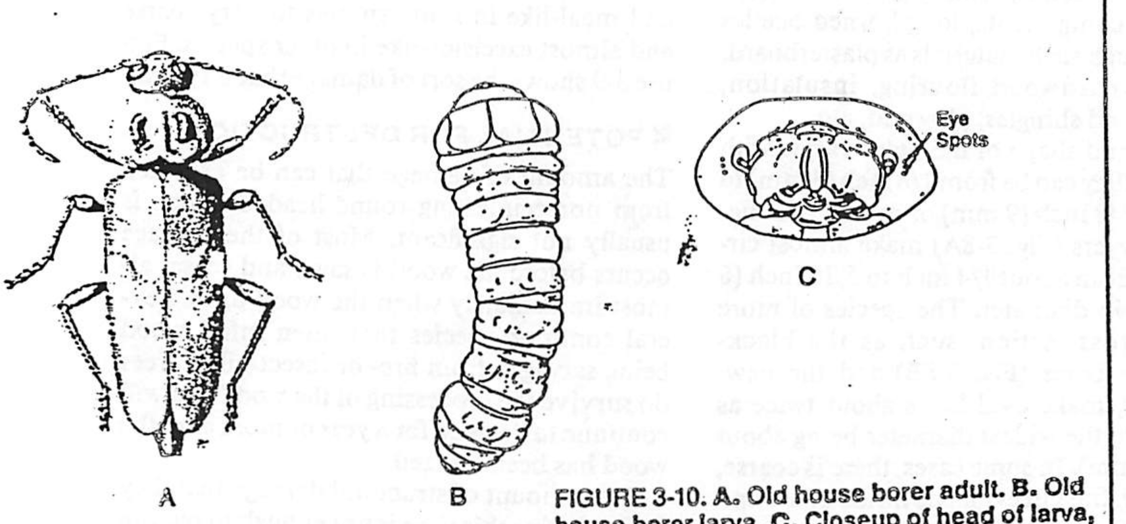

FIGURE 3-10. A. Old house borer adult. B. Old house borer larva. C. Closeup of head of larva, showing eye spots. Courtesy N.C. State University.

DISTRIBUTION AND ECONOMIC IMPORTANCE

Thought to have originated in North Africa, the species has spread to many parts of Europe, South Africa, New Zealand, Australia, South America, China, and the eastern half of the United States. An August mean temperature of about 73 degrees Fahrenheit (23 degrees Celsius) is an important factor favoring the development of the old house borer, and might be a useful criterion in predicting the future distribution of the beetle in North America (Anonymous, 1967).

The heaviest infestations occur in the states on the Atlantic seaboard, particularly the mid-Atlantic states. Since the old house borer is easily transported in infested articles, there is no reason to believe that it could not become established in the western part of the country. Its climatic requirements are such that it is not likely to become a pest in the tropics. It is strictly a pest of structures and, although it is found in barns, fence posts, and rustic buildings, it has not yet been found in logs or stumps.

It is very difficult to establish the economic importance of the old house borer. Although it is very common, particularly in new construction on the East Coast, the amount of actual damage that it does in houses is limited in most cases. It is not uncommon to find that only a few boards are infested in an entire house. The old house borer is also commonly found in untreated pine logs used in constructing log houses. Sometimes, many logs are thus infested. There is much evidence to indicate that in heated, well-ventilated, occupied dwellings the chance of reinfestation beyond the first generation is rare. Unfortunately, this is not widely recognized, and a great deal of unnecessary treatment, particularly by fumigation, is performed.

BIOLOGY AND HABITS

The eggs are laid in cracks and crevices in wood. Stacks of lumber are ideal sites. A female can lay 150 to 200 eggs, but 40 to 50 is probably nearer the average. The larvae hatch in about 2 weeks. They may crawl over the surface of the wood until they find a suitable point of entry. The young larvae feed near the surface for the first part of their lives, but penetrate deeper into the sapwood as they grow. The wood has the highest protein content near the bark. A minimum of 0.2 percent protein is required for development of old house borer larvae; the higher the level, the faster they develop.

The deeper portions of wood have little protein, and the older the wood becomes, the lower the protein content. Consequently, the greatest damage is in the outermost sapwood of new wood. Heartwood is not attacked. Pine generally has a higher protein content than spruce and fir, and so is more often attacked. The length of the larval period may be as short as 2 to 3 years in the southern part of its range but is very commonly 3 to 5 years. In areas north of Washington, D.C., the larvae usually require 2 to 3 years longer to develop. In very dry wood, such as in attics, it may take 12 to 15 years for one generation.

The larvae can digest the wood cell walls (primarily cellulose) as well as the cell contents (mostly starches, sugars, and proteins). Unlike the anobiid beetles and termites, they do not require the help of yeasts or protozoans in their guts. Wood that has been decayed by some species of fungi will be attacked by old house borer larvae (Becker, 1968). This does not apply to all species of fungi, and the larvae do not require fungal attack on wood before they will infest it.

The moisture content of the wood plays an important role in the speed of development. At moisture contents below 10 percent, the larvae develop very slowly, and it is doubtful that newly hatched larvae can survive. They develop most rapidly at moisture contents in the range of 15 to 25 percent.

Pupation occurs near the surface of the wood in spring. Adults sometimes remain in the wood for extended periods before they emerge. Their flight season extends from April to October in the South and from June to September in the North. The greatest adult activity is in June and July in most areas. The adults are strong fliers and are capable of spreading infestations from one building to another.

■ SIGNS OF INFESTATION

Infestation is all but impossible to detect in its early stages. The larvae are small and develop rather slowly for the first year. Since there are no external signs of infestation, infested wood is often used in construction.

As the infestation progresses, the larvae can be heard boring in the wood. They make a rhythmic ticking or rasping sound, much like the sound of a mouse gnawing. They seldom break through the surface, even though the interior of the wood may be severly damaged.

In severe infestations the frass, which is packed loosely in the tunnels, occupies a greater volume than the wood from which it was produced. When it is in tunnels near the surface of the wood, the thin surface layer may bulge out, giving the wood a blistered look. These "blistered" areas are best discovered by shining a light parallel to the surface.

When enough time has passed for the adults to have emerged (3 to 5 years in the South, 5 to 7 years in the North), there may be small piles of frass beneath or on top of infested wood. The frass is composed of very fine powder and tiny, elongate, blunt-ended pellets that often split lengthwise when dry. The exit holes made by the adults are oval 1/4 to 3/8 inch (6 - 10 mm) maximum diameter. They are not easily seen on dark or discolored wood. The holes may be made through a number of building components, including hardboard, plywood, siding, trim, plasterboard, hardwood flooring, etc., when adults emerge.

The adult beetles may be found in spider webs and on surfaces near light sources such as window sills and at ventilation openings in attics or crawl spaces. Live adults are rarely numerous enough to be seen by an inspector.

If the wood surface is probed with a sharp instrument, internal damage can be exposed. The larvae may be found when they are in the later stages of development and have reached a size which is more than 1/2 inch (12 mm) long.

■ CHARACTERISTICS OF DAMAGED WOOD

Damage is most often found in wood framing in crawl spaces, basements, and storage areas in the southern portion of the beetles' range. In northern areas, it is more commonly found in attic framing. The sapwood may be completely reduced to powdery frass, with the outer veneer of wood left paper thin by the larvae. The galleries are loosely filled with the frass, which falls freely from the wood when the surface is pried away. The surfaces of most galleries have

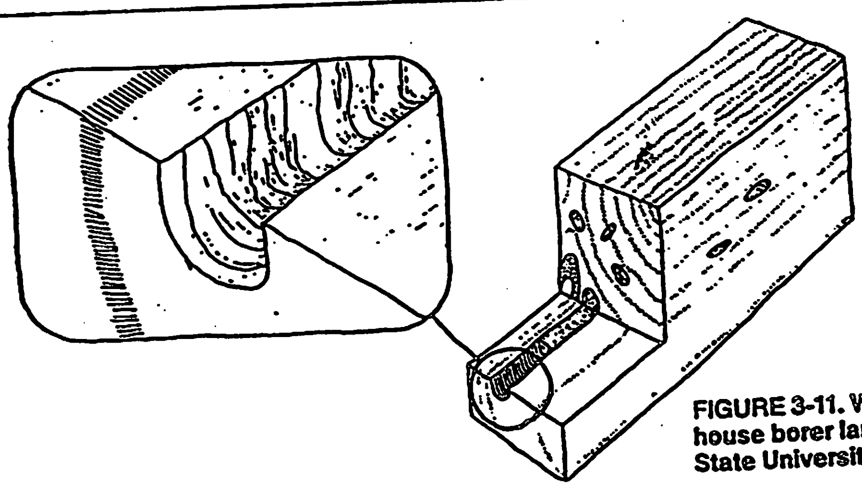

FIGURE 3-11. Wood damaged by old house borer larvae. Courtesy N.C. State University.

a very distinctive feature. They have a rippled pattern like sand over which water has washed (Fig. 3-11). Most other wood borers do not make such marks on gallery surfaces. Any marks that resemble those of the old house borer are much more coarse, and any frass that occurs is not of the same type as that produced by old house borer larvae. The galleries are oval in cross-section and may be up to 3/8 inch (9 mm) in their broadest dimension.

■ POTENTIAL FOR DESTRUCTION

The amount of damage that old house borers can cause in a structure varies with many factors.

If the building is centrally heated, has no moisture problems resulting from poor drainage or ventilation, and does not stay closed up and unoccupied for long periods, there probably is very little chance that an infestation will get any worse than it was when first discovered. As indicated previously, it is most common for only a few boards in a house to be infested. The larvae may live for many years in the dry wood.

The periodic emergence of adults through plaster, flooring, or siding may cause concern. Other than the nuisance which they create by the gnawing sounds of the larvae and the few holes made by the adults, old house borers are often no real economic concern. An exception to this occurs when the adults emerge through outdoor surfaces of logs in pine log houses. This may allow entrance of rain water that leads in some cases to serious decay problems.

In portions of houses that may have a high enough humidity to allow reinfestation of the beetles after the first and subsequent generations, serious damage can result. Since virtually all sapwood of infested boards may be disintegrated, the extent of structural damage caused depends upon the proportion of sapwood to heartwood. In small-dimensioned timbers where the amount of sapwood is extensive, structural collapse may occur in time. This sort of serious damage is most likely to occur in unheated storage areas, recreational structures which are intermittently occupied and rarely heated for long periods, or in occupied structures where structural members have relatively high moisture content because of moisture problems, and/or heating inadequate to dry out the framing timbers.

FLAT OAK BORER

The flat oak borers are much less common and of much less economic importance than the old house borers. Since they can infest dry wood in houses, however, it is important that they be recognized.

The adults are small, elongate, flattened, dull yellowish, shiny beetles about 1/3 to 2/5 inch (8 to 10 mm) long (Fig. 3-12). The larvae are typical round-headed borers that reach a length of about 1/2 inch (12 mm). They have very tiny legs and a smooth white triangular arch on the underside of the first segment of the thorax. The larvae excavate long, meandering tunnels in dry oak and hickory. The tunnels, which may be in heartwood or sapwood, are about 1/8 inch (3 mm) in diameter and are tightly packed with fine, granular frass. The larvae may continue to feed in the wood until it is riddled.

The species occurs in the entire eastern United States from New York to Florida to Texas. They often attack stored lumber and

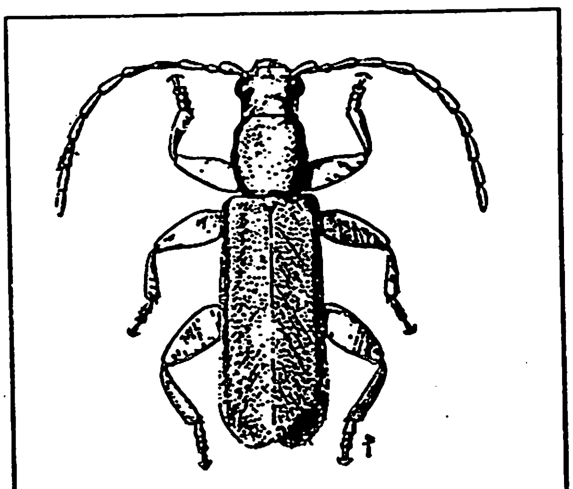

FIGURE 3-12. Adult of flat oak borer. Adapted from USDA.

have caused serious damage in several places, especially in the Gulf States.

The adults are active in mid to late summer, laying eggs in crevices of exposed wood. There normally is one generation per year in green logs under natural conditions. In dry wood, several years may be required to complete one generation.

The significant thing to keep in mind is that flat oak borers attack the heartwood of oak, as well as the sapwood. Their frass is granular and not fine like flour as is the frass of the lyctids. Although some anobiids will attack oak heartwood, their frass contains distinct pellets which will distinguish them from either of the other two types of beetles.

FLAT-HEADED BORERS

The flat-headed borers belong to the family Buprestidae. This is a very common type of wood-borer, more than 150 species and varieties having been recorded east of the Mississippi River alone.

The larvae of all species are borers in trees. Some mine leaves, twigs, branches and roots. Most of them excavate winding tunnels in inner bark, and some of the more important species tunnel through sound and decaying sapwood and heartwood. These wood-boring species are highly destructive to newly cut logs and can seriously reduce the logs' value as lumber. Attack in dry wood is not common.

■ FAMILY CHARACTERISTICS

The adults vary in length: those encountered in seasoned wood from about 1/4 inch (6 mm) up to 1-1/3 inches (33 mm) or more. They are boat-shaped and somewhat flattened (Fig. 3-13). Many are beautifully marked or metallic colored. For this reason, adults often are referred to as "metallic wood borers." The wing covers usually are ridged or roughened. Those that are found in softwoods in structures are usually dark-colored but have a metallic sheen, partic-

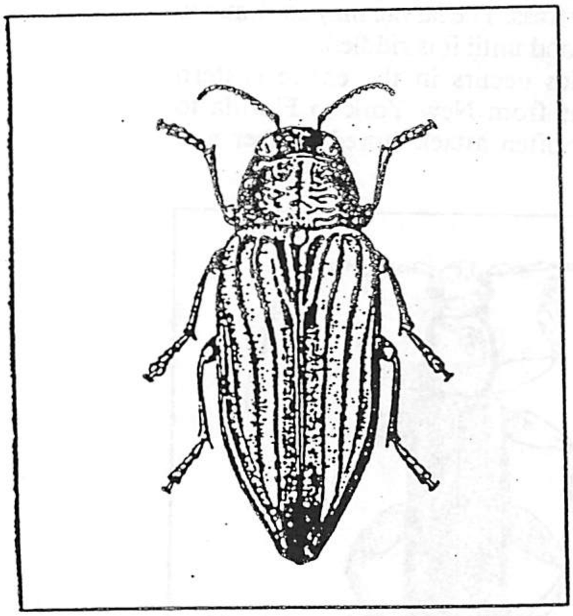

FIGURE 3-13. Adult of the golden buprestid, a typical flat-headed borer. From Forest Insects by R. W. Doane et al. Copyright 1936 by McGraw-Hill Book Company. Used with permission of McGraw-Hill Book Company.

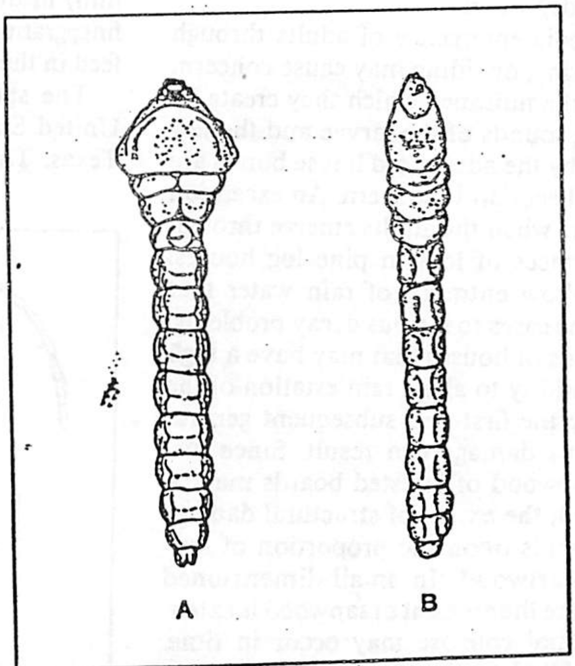

FIGURE 3-14. The larva of the golden buprestid, a typical flat-headed borer A. Top view. B. Side view. Adapted from USDA.

ularly on the underside.

The larvae are distinguished by the well developed, flattened plates on the upper and lower surfaces of the prothorax (first segment behind the head). They are whitish to yellowish, have no legs, and their abdominal segments are much smaller than those of the thorax (Fig. 3-14). The flattened area behind the head has led to the common name "flat-headed borers," though the head itself is small and retracted into the prothorax. When full grown, they may reach a length of 1 to 2 inches (25 to 50 mm), depending on the species.

■ DISTRIBUTION AND ECONOMIC IMPORTANCE

Species of this family are found in all the contiguous states and in the tropics. There are, however, only a few species that are of concern in structures. Even fewer species are active after wood has become seasoned, and they rarely emerge within buildings. Wood that has been previously damaged by the larvae is used as structural timbers, however, and the flat-headed borer must be recognized for that reason.

This is especially true when the lumber has been sawn from trees salvaged after forest fires, windstorms, or bark beetle infestations.

One species common in the eastern half of the United States is *Buprestis lineata* (F.). This species has been found frequently in untreated pine logs used in log homes.

■ GENERAL BIOLOGY AND HABITS OF THE FAMILY

Bark- and wood-boring buprestids deposit their eggs in crevices in the bark or wood or under the bark at the edges of wounds. Weakened, injured, dead or dying trees are usually attacked. The young larvae that hatch from the eggs bore first under the bark and then into the sapwood or heartwood or both. Most require 1 to 2 years to complete their development.

When *Buprestis lineata* has infested logs used in a log house, they may continue to develop and emerge up to five or six years after

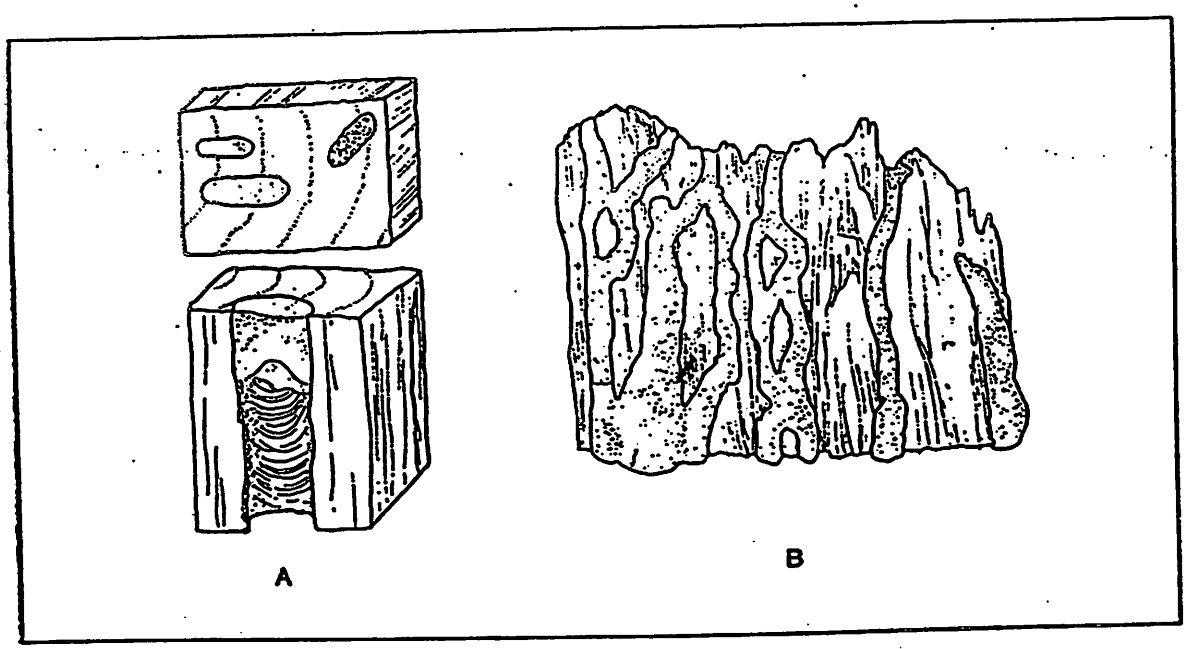

FIGURE 3-15. A. Flat-headed borer damage in wood. B. Flat headed borer tunnels under bark. From Certification Manual for Structural Pesticide Applicators edited by Kellog West, Center for Continuing Education, California State Polytechnic University, 1975. Used with permission.

the house was constructed (unpublished research by author). The larvae construct an elongate pupal cell near the surface of the wood. The adults cut their way out upon completion of development. There may be adults present at any time during warm weather. Upon emerging, they feed, mate, lay their eggs and are dead by the end of the season.

■ SIGNS OF INFESTATION

Wood that has been damaged by flat-headed borers is most often sawed after the damage has occurred. For this reason, the galleries are cut at oblique angles, and their cross-sections are distorted. The exact characteristics of such damaged wood will be discussed in the next section.

Exit holes made by the adults in the surface of the wood are sometimes present. They are elongate-oval, much like the exit holes made by some of the flattened long-horned beetles, such as the old house borer.

When bark edges have been left on structural timbers, the flat-headed borers will continue to develop until the wood becomes too dry. The borers can be heard chewing under the bark in houses that are only a few months old. When their activity has ceased, only the frass which they produce is found, tightly packed under the bark.

■ CHARACTERISTCS OF DAMAGED WOOD

Wood damaged by flat-headed borers has winding tunnels that are extremely flat, three to four or more times as wide as high (Fig. 3-15A). The tunnels are very tightly packed with layers of sawdust-like borings and pellets, and their walls are scarred with fine, transverse lines. The frass is somewhat like that of some round-headed borers, but the galleries are much more flattened. The tunnels of round-headed borers are no more than two to three times broader than high, and the frass is less tightly packed.

The galleries under bark edges left on structural timbers are serpentine and wander over the surface of the outer sapwood (Fig. 3-15B). They are packed with a mixture of light, wood-colored frass and brown, bark-colored frass. Western red cedar shakes and shingles sometimes have holes or tunnels made by the western cedar borer. The damage occurs before the manufacture of the shakes and shingles and will not increase.

■ POTENTIAL FOR DESTRUCTION

There is no danger of serious damage to structural timbers from the flat-headed borers. They usually have completed their development before the wood is sawed, and their damage is evaluated at the time the wood is graded. Those that might remain active in the wood rarely cause any significant additional damage. The exit holes cut by the adults may allow water to enter through siding or trim that is penetrated. Although their damage to untreated logs in pine log houses is not serious, *B. lineata* do allow the entrance of rain water into their tunnels through exit holes and this has led to some serious decay problems. Occasionally, the adults emerge through roofing materials and cause leaks. They also can emerge on the inside of houses through hardwood floors, plasterboard, etc. Since very few adults emerge, the potential for this type of damage is very low.

GOLDEN BUPRESTID

One species of flat-headed borer of relatively minor economic importance should be discussed in more detail. The adults are among the most beautiful beetles encountered in structures. Therefore, they attract much attention when found. Also, these beetles are of special interest because of their extremely long life cycles in structural timbers. The golden buprestid species occurs in the Rocky Mountain and Pacific Coast states.

The adult golden buprestids are about 3/4 inch (20 mm) long and metallic green or blue-green in color (Fig. 3-13). When full grown, the whitish larva is about 1-1/2 inch (35 mm) long. Across the wide, flattened thorax, it is about 3/8 inch (9 mm; Fig. 3-14).

Adult beetles lay eggs on trees that still bear bark. They are attracted to pitchy wood, and often lay eggs on fire scars. They sometimes lay eggs in cracks of freshly sawed lumber. Douglas fir is the preferred host tree, but golden buprestids have also been found in several species of pine, spruce and fir, and occasionally have been found in western red cedar.

Upon hatching from the eggs, the larvae bore into the wood, excavating a winding tunnel that increases in size as the larva grows. The tunnels are typically oval, up to 3/8 inch (10 mm) in width and tightly packed with powdery frass.

Under natural conditions, the length of the larval stage is from 2 to 4 years. When the larvae are incorporated into wood products, the period is considerably lengthened. There are authenticated reports of adults emerging from wood up to 50 years after it was initially infested (NPCA, 1964; Smith, 1962). When the larval development is completed, the golden buprestids construct an oval pupal cell near the surface of the wood and the adults emerge, usually during the spring and summer outdoors, but during fall and winter indoors.

The exit hole is oval and approximately 3/16 to 1/4 inch (5 to 6 mm) across. These exit holes are usually the first evidence of the presence of the beetles, their galleries are so small in freshly sawn, unseasoned wood that they are not detectable, even when exposed on the surface. Beetles emerging from wood in structures fly away and do no further damage to the wood from which they come.

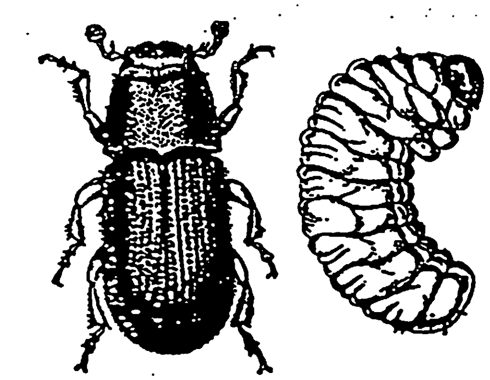

FIGURE 3-16. A. A typical adult bark beetle. B. Bark beetle larva. From Forest Insects by R. W. Doane et al. Copyright 1936 by McGraw-Hill Book Company. Used with permission of McGraw Hill Book Company.

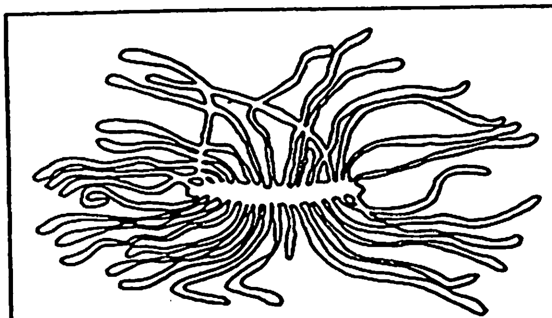
FIGURE 3-17. An example of bark beetle egg and larval galleries that are found between bark and wood. From Certification Training Manual for Structural Pesticide Applicators edited by R. Kaae and E. D. Young, Kellog West, Center for Continuing Education, California State Polytechnic University, 1975. Used with permission.

BARK BEETLES

The bark beetles, belonging to the family Scolytidae, are small, cylindrical, robust beetles. They are usually brown, reddish-brown, or black. Most of them found in association with structural timbers are no more than 1/8 inch (3 mm) long. The head is partially or completely concealed from above (Fig. 3-16A).

Although the bark beetles are among the most serious forest pests, they are of very minor importance in seasoned wood. They do not actually cause any damage to the wood, but are sometimes found in houses and in association with structural timbers. For this reason, it is important that they and their damage be recognized as of no economic importance. There are species in all parts of the country.

The eggs are laid by the female in a gallery constructed in the cambium (layer of growing cells between bark and wood). There are species that attack hardwood and softwood trees. The larvae (Fig. 3-16B) tunnel away from the egg gallery. The galleries increase in size and become tightly packed with frass (Fig. 3-17). Only the surface of the wood is slightly etched with their tunnels, and the larvae cause no structural damage. Because of their characteristic damage, they often are referred to as "engraver beetles."

When larval development is complete, bark beetles pupate at the ends of the tunnels. The adults emerge from the pupal stage and tunnel straight out through the bark. The surface of the bark is sometimes riddled with round exit holes 1/16 to 1/8 inch (1.5 inch to 3 mm) in diameter. Bark beetles cannot live in seasoned wood, so there is no reinfestation.

In nature, there may be several generations per year. When wood infested with bark beetles is sawed into lumber, the beetles left under bark edges on the lumber may survive for a year or more. As the wood dries out, some of the gritty frass produced by the beetles may sift down. The adults often emerge from fireplace logs left indoors, as well as from bark edges on lumber, but they are a nuisance only, since they will not infest seasoned wood.

AMBROSIA BEETLES

There are two different families of beetles that include species known as ambrosia beetles. They have been given this common name because of their specialized food. Ambrosia was the food of the classical gods, and these beetles grow for food a fungus known as "ambrosia" on the surface of their galleries. They do not consume the wood, and they throw out all of the frass.

They maintain open space in the galleries for themselves and their larvae to move back and forth freely during feeding on the fungus. Some members of the family Scolytidae have this mode of feeding. There is another family, Platypodidae (the flat-footed ambrosia beetles), that also shares in this habit. The adults and larvae are not seen in structures, since they abandon wood which has dried below the fiber saturation point (30 percent moisture content). Their damage is often seen in hardwood and softwood and should be recognized. Species of ambrosia beetles are found in all parts of the world.

The adult beetles bore straight into the wood of unseasoned logs for several inches and throw out all of the frass. Once inside the sapwood, the tunnel may branch and follow the curvature of one or more annual rings, or it may be unbranched and relatively straight, depending on the species. There also may be short side tunnels of the same diameter that follow the grain and in which larvae feed and later pupate. The ambrosia beetles emerge as adults through the original entry hole. The damage usually is not sufficient to cause structural weakening of the wood. Several generations may continue to extend the galleries as long as the wood remains moist enough to sustain the fungus growth. Some species extend galleries into the heartwood. Freshly cut lumber may be attacked while it is stacked and before it has dried.

As the tunnels are constructed, the walls are

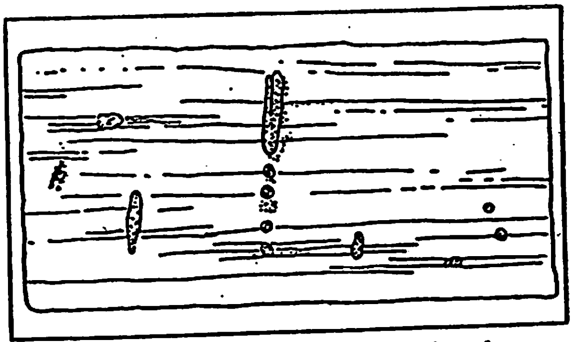

FIGURE 3-18. Wood damaged by ambrosia beetles. From Certification Training Manual for Structural Pesticide Applicators edited by R. Kaae and E. D. Young, Kellogg West, Center for Continuing Education, California State Polytechnic Universit, 1975. Used with permission.

inoculated with the fungus by the adult beetles. The fungus stains the gallery walls black, blue, or brown. The staining often spreads through the surrounding wood and is particularly obvious in lighter-colored wood species. This staining is often a greater defect than the holes themselves. It particularly limits the use that may be made of hardwoods. The beetle attack ceases when the wood dries out, and it is perfectly safe to use the wood without fear of further deterioration.

Ambrosia beetle damage seen in wood in use is characterized by circular holes and portions of tunnels between 1/50 and 1/8 inch (0.5 and 3 mm) in diameter, the size depending on the species of beetle responsible (Fig. 3-18). The tunnels, which are free of frass, run mainly across the grain and have darkly stained walls. The stain may extend into the wood in patches or streaks. All of the tunnels made by a single species are the same size, since only the adults tunnel the wood.

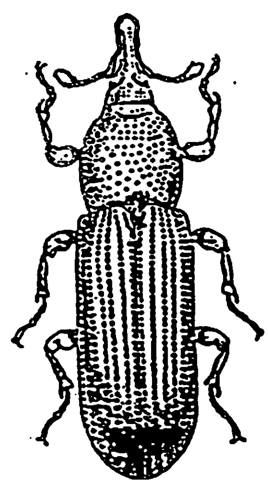

FIGURE 3-19. Wood-boring weevil adult. Some species have a shorter snout. From Forest Insects by. R. W. Doane et al. Copyright 1936 by McGraw-Hill Book Company. Used with permission of McGraw-Hill Book Company.

WOOD-BORING WEEVILS

There is one final group of wood-boring beetles that should be briefly discussed, although they are not common and do not cause significant amounts of damage. They are, however, unique in their appearance and might cause confusion if they were detected and not recognized. These are the wood-boring weevils of the family Curculionidae.

The curculionids are sometimes called "snout beetles." They may be distinguished from the other beetles by the prolongation of the head into a snout. The wood-boring species are small, black or reddish-brown, and about 1/8 to 1/5 inch (3 to 5 mm) long. The wing covers are heavily pitted (Fig. 3-19). The larvae are whitish, grublike, legless, and about 1/8 inch (3 mm) long when full grown.

Many species of wood-boring weevils attack unseasoned wood only. There are several species that will attack seasoned wood, but they are most often seen in wood that is slightly damp and partially decayed. Their damage is very similar to that caused by anobiid powder-post beetles, and both types of beetles are sometimes present in the same piece of wood. They occur in all parts of the country and have been transported, even overseas, in infested lumber.

The eggs are laid in holes excavated by the female or in cracks and crevices. The larvae enter the wood and tunnel primarily with the grain in some species. In other species the tunnels are completely random in direction. The life cycle probably takes about a year. Adults emerge through exit holes that are raggedly round, approximately 1/16 inch (1.5 mm) in diameter, or elongate, irregularly shaped holes 1/16 to 1/12 inch (1.5 to 2 mm) in diameter.

These beetles attack hardwoods, softwoods, and plywood. When damage is heavy, the interior of the wood, including sapwood and heartwood, is honeycombed. The galleries, which are up to 1/16 inch (1.5 mm) in diameter, are made by the feeding of both adults and larvae. The frass is composed of very fine powder and tiny pellets and is packed in the galleries. Though similar to the damage of anobiid beetles, the pellets in the frass are much smaller, and even the largest tunnels are smaller in diameter than those of anobiids. It is also common to find the adults feeding in the wood, which is contrary to the activity of the anobiids. Their potential for damaging the wood is probably directly related to the amount of dampness and decay which is present.

PREVENTION AND CONTROL

It is important for those concerned with the prevention or control of beetle attack in wood in houses to remain aware of the requirements for initial attack to occur. You will recall that they include: the occurrence of the beetle(s) in the particular geographic region and the possibility of a local population source close enough to initiate attack in the building; in the house, the presence of wood which is susceptible to attack by the beetle(s) in question; and environmental conditions in the wood suitable for the development of the beetle species of concern.

When wood that is already infested is shipped in and used, these natural conditions do not have to exist for beetles to be found. This emphasizes the importance of understanding the biology and habits of the beetles as well as being able to recognize them and the evidence of their attack. Before any control procedures are implemented, the identification of the beetle or its damage must be positively confirmed in order to proceed intelligently.

Some infestations may have long since become inactive because of changing conditions or because the attack occurred and ceased before the wood was even milled. Some evidence of current activity is needed before control procedures are required. The presence of the three factors which might lead to attack does, however, indicate a need to consider preventive measures where no attack has yet occurred.

PREVENTION

Most of the procedures which will prevent attack on wood before it is placed into use are the responsibility of those who harvest, mill and store the wood. Those who use wood must take precautions to reduce the chances of building in a beetle infestation.

Although careful inspection is the first step in preventing the introduction of beetles into a structure, it has severe limitations. It should, however, be a specified practice. Many times wood is placed into use before beetle infestation has progressed to the point that it can be discovered, even by careful visual inspection and probing.

The other precautionary measures that may be taken to prevent introduction of beetle-infested wood include, first, the specification that all wood be kiln-dried or air-dry before its use. This eliminates or severely restricts the development of most beetle species and also is the cheapest and most practical preventive measure. Some beetles will attack and reattack wood which is well below the air-dry level, so drying will not eliminate all concern for beetle infestation.

If there is any reason to suspect that incipient infestations may be present, or if wood components are so expensive or will be so difficult to treat or replace if infestation is discovered later, it may be feasible to require further preventive measures. Wood may be positively freed of beetle infestation by heat sterilization or by fumigation. Table 3-1 (St. George, 1973) shows the times and temperatures necessary to kill beetles in wood of different thicknesses.

These data were established for lyctid beetles, but they are more than sufficient to kill most other borers present. If bostrichid beetles are involved, use the higher temperatures, since bostrichids are harder to kill with heat than are other types (Bletchly, 1967). This schedule should not be confused with a normal drying schedule, since the temperatures involved in drying alone are not always sufficient to kill many wood-boring beetles.

Fumigation of wood before use also will render it beetle-free. The gas most commonly used is methyl bromide. The wood should be stacked loosely and covered with a gas-tight

Table 3-1. *Schedule for treating wood to check damage by powderpost beetles*

Relative humidity	Lethal temperature required		Thickness of timber		Time required to overcome lag after kiln has attained lethal temperature	Additional margin of safety	Time then held at lethal temperature	Total period of exposure after kiln has attained required conditions
Percent	°F	(°C)	Inches	(CM)	Hours	Hours	Hours	Hours
100	130	(54)	1	(2.5)	½	½	1-½	2-½
			2	(5.1)	2	½	1-½	4
			2-½	(6.3)	3-¼	½	1-½	5-¼
			3	(7.6)	4-½	½	1-½	6-½
80	125	(52)	1	(2.5)	½	½	2	3
			2	(5.1)	2	½	2	4-½
			2-½	(6.3)	3-¼	½	2	5-¾
			3	(7.6)	4-½	½	2	7
	120	(49)	1	(2.5)	½	1-½	6	8
			2	(5.1)	2	1-½	6	9-½
			2-½	(6.3)	3-¼	1-½	6	10-¾
			3	(7.6)	4-½	1-½	6	12
	115	(46)	1	(2.5)	½	7-½	30	38
			2	(5.1)	2	7-½	30	39-½
			2-½	(6.3)	3-¼	7-½	30	40-¾
			3	(7.6)	4-½	7-½	30	42-½
60	125	(52)	1	(2.5)	½	1	4	5-½
			2	(5.1)	2	1	4	7
			2-½	(6.3)	3-¼	1	4	8-¼
			3	(7.6)	4-½	1	4	9-½
	120	(49)	1	(2.5)	½	2	7	9-½
			2	(5.1)	2	2	7	11
			2-½	(6.3)	3-¼	2	7	12-¼
			3	(7.6)	4-½	2	7	13-½
	115	(46)	1	(2.5)	½	9	36	45-½
			2	(5.1)	2	9	36	47
			2-½	(6.3)	3-¼	9	36	48-¼
			3	(7.6)	4-½	9	36	49-½

tarpaulin. If such fumigation is to be performed on a regular basis, it is best to use tarpaulins made of nylon fabric coated with rubber, neoprene or plastic. These are the same type used for drywood termite fumigation. Where fumigation is not performed on a regular basis, heavy polyethylene plastic sheets may be used instead of tarpaulins. The bottom edges of the cover should be sealed with sand. The usual dosage of methyl bromide for such purposes is 3 pounds per 1000 cubic feet (1.36 kg per 28 cu m) of air space. The gas should be held under the cover for about 72 hours (St. George 1973).

In areas where structural framing members are subject to beetle attack, the use of pressure-treated wood prevents damage. It is doubtful that there are any areas in the contiguous states that have enough beetle attack to justify the extra expense for such a preventive measure. If decay fungus, drywood termite and/or subterranean termite attack potential would justify pressure-treated wood, then the prevention of beetle attack would be an added benefit.

Brushing or spraying the wood with 0.5 percent lindane before it is used will protect it from attack by beetles for 10 years or more. The lindane is applied at the rate of 1 gallon per 100 square feet (4 liters per 10 sq m) of surface, or until no more is absorbed. The current availability of lindane is limited, and its future is questionable. Recently, a borate salt compound (Bora-Care) has been registered for prevention and control of wood-boring beetles, as was described under the discussion of drywood termite prevention. The same application procedure applies here. As long as the wood does not become wet periodically so that the borate salt is leached out, it will remain toxic to beetles.

For the beetles that begin their attack under bark, the removal of any bark edges from lumber before the lumber is used in construction is a good preventive measure. Many of the roundheaded and flat-headed borers feed under bark for extended periods before they enter the wood. The bark beetles confine their attack to the inner bark, and are thus eliminated by bark removal.

Use of good building design as outlined for subterranean termite prevention also applies to beetles. Good ventilation and drainage and proper clearance between wood and soil will tend to reduce the equilibrium moisture content of wood in the structure and thus render conditions less favorable for the beetle development. The need for good clearance and ventilation is most important in the Gulf Coast areas, where high humidity and mild winter climates may allow wood framing in walls and attics, as well as crawl spaces, to retain relatively high moisture levels and support greater beetle activity.

When the building is centrally heated, the drying process after construction is speeded up and the house becomes less susceptible to beetle attack more quickly, and it usually remains so as long as the house is regularly occupied and remains heated for extended periods. Vacation or recreational structures tend to be more prone to extensive beetle attack because they often are not centrally heated or are heated only intermittently for relatively short periods. Leaving structures closed and unheated for long periods allows the moisture content of the wood to rise to higher levels than would otherwise be the case.

Proper attention to good attic ventilation is even more important in the prevention of beetles than in the prevention of termites. If attics are well ventilated, in most regions they tend to dry out below the level of moisture needed for vigorous beetle attack. This is particularly true of the roof framing and sheathing.

■ INSPECTION

All houses which include wood as a part of the structure, or of the interior or exterior trim or built-in cabinets, should be inspected at least annually for the presence of active wood-boring beetles. The incidence of beetle infestations in houses is much lower in tropical areas and in arid regions than it is in temperate climates.

There can, however, be infestations by wood-boring beetles in any part of the United States or its territories. Wood containing beetle infestation may have been incorporated into the structure, and some damage may occur, even though the infestation might eventually die out because of unfavorable environmental conditions. Local infestation of wood in use does occur in many parts of the contiguous states.

The purposes for which inspections for beetle attack are made are similar to those involved in termite inspections. They include such things as determining the condition of the wood in the house and locating any evidence of attack by wood-boring beetles. Once evidence of attack is found, the identity of the species causing the damage must be established. Only in this way is it possible to properly assess the potential for additional damage. Finally, the inspector must determine whether or not the infestation is still active and whether there is need for repair, replacement or treatment.

Most of the beetles that cannot reinfest seasoned wood show evidence of their presence within 2 or 3 years, unless they die out sooner. Infestation of wood by beetles which can survive and reinfest seasoned wood often does not become evident for several years after a house is constructed. Anobiid powderpost beetles and the old house borer may not become evident for 10 or more years if the initial infestation was limited. This is because the relatively small number of eggs laid, the high natural mortality of the larvae, and the long life cycles involved do not produce large populations very rapidly.

The external signs of their presence do not become evident until adults have emerged in enough numbers to provide easily-seen exit holes and accompanying frass. Where damage occurs, it is seldom widespread unless the property has been neglected for a number of years. Most commonly, only a very few boards are found to be infested when inspections have been performed at reasonable intervals.

Although wood-boring beetles may spoil the appearance of wood and, when neglected for long periods, may cause serious weakening of structural timbers, they develop very slowly. When an infestation is discovered during a routine inspection (rather than as a result of the sudden collapse of a wooden member), there is rarely any need for extreme haste in providing treatment.

Basic equipment and the step-by-step procedures described for termite inspection, particularly drywood termites, apply here. The reader is referred to that section of the manual for details. Certain aspects of inspecting for beetles require special attention, and they will be detailed.

In inspecting for beetles, the evidence is often less easily seen than in termite inspection. It is necessary to visually examine all exposed surfaces of wood (painted and unpainted) and to sound or probe them for evidence of internal damage. The sounding and probing is accomplished by rapping on the surface to locate hollow-sounding areas and by probing into the surface at close intervals with a sharp instrument.

Probing is usually very limited in living areas, where damage to finished surfaces might result. Particularly in its early stages, the extent of infestation by beetles is more difficult to determine than that of termites. There are no telltale shelter tubes or fecal pellets to reveal early beetle activity. Exit holes occur at the end of the first generation of beetle attack. In many cases larvae do not expel any frass to reveal their presence until there are exit holes from which the frass can sift. Minor exceptions include the bark beetles and some of the flat-headed borers which push frass from underneath bark edges left on structural timber.

When inspecting wooden siding, shakes or exterior trim, the evidence of beetle attack is unusually obscure. The signs most often discovered are the exit holes of round-headed or flat-headed borers. The adults in many cases have emerged through the exterior wood after developing in framing timbers inside the wall. The location and pattern of occurrence of the holes can often provide evidence of which framing members are involved.

Inside the house, evidence of attack may have been noticed by the occupants, and they should be interviewed for possible clues. A systematic search of all wood surfaces inside a structure that is filled with furnishings would be time consuming and probably not extremely productive, since evidence of beetle attack, other than exit holes, usually is not present. When large larvae of some of the round-headed borers, particularly old house borers, are present in framing timbers, they may be heard gnawing in the wood. Since the sounds are not produced continuously, the aid of the occupants is essential.

When lyctid beetles have attacked hardwood flooring or interior trim, it is not unusual for only a very few scattered pieces to be involved. The small size of the exit holes and the absence of frass on the surfaces again point out the need for consulting with the occupants. They are likely to have seen and removed any frass. If the attack has occurred over a long period of time, the evidence is obviously more pronounced than in houses only a few years old.

Evidence of beetle attack is much more pronounced and more easily discovered in attics, crawl spaces and unfinished basements and storage areas than on the exterior or inside the living areas. The signs are more likely to be undisturbed, and the absence of finishes on the wood leaves more wood surface that has been exposed to reinfestation.

The common practice of insulating ceilings and floors has made inspection of many parts of structural timbers impractical. As with termite inspection, removal of insulation is usually not considered feasible unless evidence warrants closer inspection because of signs above, below or adjacent to the insulation-covered areas.

Because of the similarity in some cases of damage caused by beetles that do and do not reinfest wood, the inspector would be well advised to carry small envelopes in which to collect frass and small wood samples so that they may be very closely examined with good light and magnification. If adults or larvae are found, they should be placed in small bottles or vials filled with rubbing alcohol.

Should there be any doubt as to the identity, the specimens and a description of the situation in which they were found (including the type of wood) should be submitted to a specialist for identification. In most areas this means they should be sent to the entomology department of the state university. Only in this way can positive identification of the attacking beetles be determined. Since the beetles do not cause damage very rapidly, a delay in treatment caused by this procedure will not result in any harmful consequences, and positive identification often prevents unnecessary treatment.

The fact that beetle damage is discovered is not conclusive evidence that the infestation is still active. Depending on the type of beetles involved, it may be that the infestation has died out because the environmental conditions are not adequate for the beetles to survive. Even beetles that can reinfest seasoned wood sometimes die out for various reasons.

In order to be certain that the infestation is active, there should be fresh frass which is the color of newly sawed wood and live larvae or adults in the wood. The presence of exit holes and frass alone indicates only that the beetles have been active. The adults which made the exit holes may be the last that will emerge and the wood may not be suitable for a new generation. The humidity and temperature of the air surrounding the wood are key factors in determining the likelihood of reinfestation by beetles that initiate attack in seasoned wood.

The characteristics of beetle damage found in wood in houses is summarized in Table 3-2. This table also indicates the type of wood and the portion of the wood attacked by the various kinds of beetles. This is important in determining the potential areas which might be infested by a particular species and in evaluating the likelihood of serious structural weakening.

■ CONTROL

Treatment for the control of wood-boring beetles is really necessary only when an inspection has revealed an apparently active infestation by a species that will reinfest seasoned wood. There are times, however, when treatment may be applied when it is not a necessity from the standpoint of structural damage.

Given a free choice, most homeowners do not make the decision whether or not to invest in control procedures on the basis of potential structural damage alone. For people who can afford it, the mere fact that creatures are consuming a portion of their house may be reason enough to seek immediate treatment, no matter how inconsequential the attack. This is particularly true if signs of beetle attack, such as new exit holes or gnawing in the wood, are evident in the living areas.

If the house is being placed on the market for sale, prospective buyers will usually not accept a house that is reported to be infested with wood-boring beetles, even if they are species that will not cause structural weakness and will not reinfest the seasoned wood. Sociological

Table 3-2. *Characteristics of damage caused by common wood-boring beetles in houses*

Type of borer	Wood attacked: Part and type	Wood attacked: Condition	Recognition of damage: Exit holes	Recognition of damage: Galleries (tunnels)	Recognition of damage: Frass	Reinfestation
Anobiid powderpost beetles	Sapwood of hardwoods and softwoods: rarely in heartwood	Seasoned	Circular, 1/16 to 1/8 in (1.6 to 3 mm) diameter	Circular, up to 1/8 in (3 mm) diameter; numerous; random	Fine powder with elongate pellets conspicuous; loosely packed[1]	Yes
Bostrichid powderpost beetles	Sapwood of hardwoods primarily; minor in softwoods	Seasoning and newly seasoned	Circular, 3/32 to 9/32 in (2.5 to 7 mm) diameter	Circular, 1/16 to 3/8 in (1.6 to 10 mm) diameter; numerous; random	Fine to coarse powder; tightly packed, tends to stick together	Rarely
Lyctid powderpost beetles	Sapwood of ring- and diffuse-porous hardwoods only	Newly seasoned, with high starch content	Circular, 1/32 to 1/16 in (0.8 to 1.6 mm) diameter	Circular, 1/16 in (1.6 mm) diameter; numerous; random	Fine, flour-like, loose in tunnels	Yes
Round-headed borers (general)	Sapwood of softwoods and hardwoods; some in heartwood	Unseasoned, logs and lumber	Oval to circular, 1/8 to 3/8 in (3 to 10 mm) long diameter	Oval, up to 1/2 in (13 mm) long diameter, size varies with species	Coarse to fibrous; may be mostly absent	No
Old house borer	Sapwood of softwoods, primarily pine	Seasoning to seasoned	Oval, 1/4 to 3/8 in (6 to 10 mm) long diameter	Oval, up to 3/8 in (10 mm) long diameter; numerous in outer sapwood, ripple marks on walls	Very fine powder and tiny pellets; tightly packed in tunnels	Yes
Flat oak borer	Sapwood and heartwood of hardwoods, primarily oak.	Seasoning and newly seasoned	Slightly oval; 1/16 to 1/12 in (1.6 to 2 mm)	Oval, up to 1/12 in (2 mm) long diameter	Fine granules	No
Flat-headed borers	Sapwood and heartwood of softwoods and hardwoods	Seasoning	Oval, 1/8 to 1/2 in (3 to 13 mm) long diameter	Flat oval, up to 3/8 in (10 mm) long diameter; winding	Sawdust-like, may contain light and dark portions if under bark; tightly packed	No
Bark beetles	Inner bark and surface of sapwood only	Unseasoned, under bark only	Circular, 1/16 to 3/32 in (1.6 to 2.5 mm) diameter	Circular, up to 3/32 in (2.5 mm) diameter; random	Coarse to fine powder, bark-colored, tightly packed in some tunnels	No
Ambrosia beetles	Sapwood and heartwood of hardwoods and softwoods	Unseasoned, logs and lumber	Circular, 1/50 to 1/8 in (0.5 to 3 mm) diameter	Circular, same diameter as holes; across grain, walls stained	None present	No
Wood-boring weevils	Sapwood and heartwood of hardwoods and softwoods	Slightly damp, decayed	Raggedly round or elongate, 1/16 to 1/12 in (1.6 to 2 mm) diameter	Circular, up to 1/16 in (1.6 mm) diameter	Very fine powder and very tiny pellets, tightly packed	Yes

[1]Pellets may be absent and frass tightly packed in hardwoods

and psychological factors far outweigh practical considerations in many of these cases.

The method or methods that should be used in the control of an active infestation of wood-boring beetles depends on many things. Often it is necessary to consider the possibility of damage by the treatment as well as the probability of achieving control. Each problem must be analyzed in the light of severity of infestation, possibility of reinfestation, type of wood product being attacked, the area of the structure where attack is occurring, the speed of control needed, and the cost to the property owner, as well as the sociological and psychological factors.

For aesthetic reasons, it might be important to provide immediate control to prevent any further emergence of adult beetles from infested hardwood floors, trim or cabinetry. Likewise, if a house is for sale, immediate control might be necessary to render the property marketable. Speed is not otherwise so important when the rate of development of the beetles is considered. Several months of delay in treatment after an infestation is discovered is usually of little consequence.

NONCHEMICAL CONTROL

Alteration of environmental conditions in the house might one day be the only procedure necessary to eliminate some infestations of wood-boring beetles. This is an area currently under study, and information that will be of practical value should be available within a few years.

It is a well-established fact that no wood-boring beetles found in houses develop rapidly in wood that is very dry. There are indications that the most common anobiid beetles cannot establish an infestation in wood below about 15 percent moisture content. For the old house borer, the moisture requirement for establishment is probably more than 10 percent. If the use of vapor barriers, ventilation and central heat can dry wood out and keep it dry enough, the use of other control measures may not be necessary. This method would not be a rapid means of control, and probably would not completely replace others.

At the present time, it can only be recommended that every effort be made to reduce the moisture content of the wood to be protected. If wood-boring weevils are the attacking species, they can be completely controlled by removing the cause of decay and dampness in the wood. Since they are dependent upon the dampness for their survival, they will be indirectly controlled.

REPLACEMENT OF INFESTED WOOD

Before any chemical control procedures are considered, thought should be given to the feasibility of simply removing and replacing the infested wood. Under certain circumstances, this is more effective and economical than other methods. It would, of course, not be practical except in limited infestations.

Also, the members to be replaced would have to be reasonably accessible or the cost of labor in gaining access to them, and then repairing the damage incurred in the process, would be prohibitive. Wood in contact with the pieces removed should be carefully inspected to insure that it has not also become infested and, if not removed, would remain as a source of future damage.

REPLACEMENT OF STRUCTURALLY WEAKENED WOOD

Any wood in the building which has been damaged sufficiently for it to be structurally weakened should be replaced or reinforced. This is the case whether chemical control procedures for the infestation will be employed or not. If the weakened wood, or that with which it is in contact, is actively infested with beetles, it should be replaced or reinforced with pressure-treated wood, or the replacement wood should be treated by surface application of a residual insecticide as discussed under preventive measures.

RESIDUAL INSECTICIDES

There are a number of insecticides registered for the control of wood-boring beetles in houses. They range from an inorganic borate salt solution (Bora-Care), a stomach poison, to several synthetic organic compounds which kill on contact.

These include lindane, chlorpyrifos (Dursban), and cypermethrin (Demon). Their label directions vary as to the amounts that may be applied, the methods of application, and the sites that may be treated. The specific conditions involved with each infestation should be the guide in choosing the material to use.

Most infestations of wood-boring beetles in houses are not widespread and inaccessible. For that reason, the treatment most commonly used has been the surface application of residual insecticides to infested wood. When infestation is widespread in attics, crawl spaces and other unfinished areas, all exposed wood members are treated. This is the preferred method of control when there is no requirement that control be immediate. It sometimes takes from several months to a year or more for an infestation treated in this manner to be completely controlled, since it is not possible in most cases to get complete penetration of the insecticide into all of the infested wood.

The larvae in unsaturated areas tend to avoid the treated outer layer of wood until they complete their development, pupate, and attempt to emerge as adults. When the contact insecticides are used, most adults, in attempting to cut through the treated wood layer, are killed. If there are surfaces that are insufficiently treated or untreated because of inaccessibility, some adults may emerge. They are usually killed, however, in the process of crawling over the treated surfaces of exposed wood during the mating and egg-laying process.

Larvae hatching from eggs successfully laid on treated surfaces do not survive their attempt to bore into the wood. Thus, a high degree of success results after sufficient time has passed. Proper treatments remain effective for several years. Where the borate salt solution (Bora-Care) is used, it is said to eventually diffuse entirely through the wood and could conceiveably provide permanent protection of wood that is not exposed to wetting.

■ TREATMENT OF UNFINISHED WOOD

There are some differences in the way treatment is performed on unfinished wood as compared with wood with an applied finish on its surface. When raw, unfinished wood has been heavily damaged by beetles, the powdered portion should be completely removed. The frass and wood fragments should be carefully cleaned up, preferably with an industrial vacuum cleaner. If replacement or reinforcement is needed, this should be done prior to completing the treatment.

Where damage is lacking or is not severe, the surfaces to be treated should be carefully brushed to remove frass and dust clinging to the surface. Suspended wood should be pounded with a rubber mallet prior to brushing to vibrate loose frass from exit holes. Clean wood is better penetrated by insecticides, and new activity can be more easily spotted during subsequent inspections.

The currently labeled residual insecticides are, in general, to be applied as water emulsions, the percent varying with the product. The borate salt (Bora-Care) is a solution and one formulation of chlorpyrifos (Whitmire PT 270 Dursban) is a solution in a pressurized container.

If powderpost beetles are the problem, the insecticide is applied to all exposed wood surfaces by brush, or as a wet spray, to the point-of-runoff. The amount absorbed varies with the amount of damage and the smoothness of the wood surface; the rougher the surface, the more absorbed. If a sprayer is used, very low pressure and a fan-shaped spray pattern should be used. This will prevent excessive misting and bounce-back from the surface, thus reducing hazard and waste.

If old house borers or other round headed borers are being treated, a slightly different treatment procedure is used. If only limited areas are infested, especially in heavy wood members, chlorpyrifos solution (Whitmire PT 270 Dursban) should be injected into the wood through 1/8 in (3 mm) holes drilled into the infested wood according to the labeling. The formulation will move down the grain of many types of wood and will provide deeper penetration than surface spraying or brushing.

Old house borers can be treated by brushing or spraying water emulsion on infested areas to the point-of-runoff, as for powderpost beetles. Penetration of wood surfaces with paint, varnish or wax on them is not satisfactory unless the material is removed before treatment, a process not usually feasible. Treatments should be applied only to known infested areas and slightly beyond.

As indicated previously, the borate salt solution (Bora-Care) will penetrate slowly, by diffusion, deep below the surface of wood. This material will provide control of powderpost beetles and the old house borer. Label directions include the possibiity of applying the solution in attics and crawl spaces as a wet mist with a fogging device as a supplement of brush or spray application. This provides some advantage where access is limited.

TREATMENT OF FINISHED WOOD SURFACES

The beetles that attack hardwoods, the type of wood most often infested on the interior of houses, usually will not lay their eggs on finished wood surfaces. Because of this, such wood is physically protected from reinfestation except for old exit holes and cracks and crevices which allow the beetles access to unfinished areas. This greatly reduces the potential for reinfestation beyond the first generation.

The problem of treating finished surfaces of wood is rather complex. There are many types of wood finishes, and each may react differently to the chemicals. Since the treatment can damage wood finishes, it is advisable to treat a small, inconspicuous area for preliminary observation before treating infested finished wood. There is also serious doubt that the insecticides penetrate through finished surfaces, they may simply evaporate on the surface (Bletchly, 1967).

Unless the finish can be removed, the only beneficial treatment is the application of insecticide by repeatedly injecting it into the beetle exit holes in the surface of the wood and into open joints and crevices between boards. Whitmire PT 270 Dursban is presently the only available formulation for this purpose. Since this would result in good penetration of the wood only if there were many exit holes, it would be feasible only when heavy damage has occurred. If interior trim can be removed, it might be successfully treated through the unfinished surfaces by applying the insecticides as described previously for unfinished wood surfaces.

FUMIGATION

Infestations of wood-boring beetles are controlled most speedily and completely by fumigation. This is a very expensive process, and it offers no residual protection from reinfestation. It is also necessary for the residents to leave the premises for one or more days. But because of the turnover in home ownership requiring certification that structures are insect-free, fumigation has become a more common control procedure in spite of its drawbacks. In addition to acting rapidly, fumigants are useful when an infestation is very extensive or is in building locations that make other control procedures impractical.

Methyl bromide is the fumigant of choice for the control of wood-boring beetles in houses. The procedures for its use were discussed under drywood termite control, and the reader is referred to that discussion. Fumigation for wood-boring beetles is done in the same way, but instead of a concentraton of 2 pounds per 1000 cubic feet (0.91 kg per 28 cu m) of building space, 3 pounds (1.36 kg) is generally recommended, provided the temperature is above 60 degrees Fahrenheit (16 degrees Celsius).

The gas needs to be retained under the tarpaulin for only 24 hours if the space is properly sealed and a minimum of 0.5 pound per 1000 cubic feet (0.23 kg per 28 cu m) of gas remains at the end of the 24-hour period. Manufacturer's directions indicate that a higher dosage is sometimes required and additional gas may need to be added during the fumigation period. This is obviously a procedure for experienced pest control technicians only.

Sulfuryl fluoride, which is commonly used for drywood termite fumigation, is not as generally used for wood-boring beetles because it is not very effective against the egg stage. Because of some other advantages, sulfuryl fluoride has been used by fumigators for beetle control. The dosage used for control of adults and larvae is the same as that for drywood termites.

This dosage is determined by the use of the manufacturer's "Fumiguide" which is used to coordinate fumigant rates with site variables. When control of the egg stage is desirable, the manufacturer's directions call for the use of four times the drywood termite dosage to control the old house borer and ten times the drywood termite dosage to control powderpost beetles. These high dosages render the cost prohibitive and have greatly reduced general use.

Because of the expense involved in fumigating entire structures, attempts have been made to treat localized portions of buildings by covering them with plastic. Some fumigators have covered hardwood wall cabinets with plastic and released methyl bromide. Others have tried fumigating crawl spaces by sealing ventilators and covering the floor above with plastic. These producedures are not usually successful because of the rapid loss of gas through wall voids, etc.

CHAPTER 3 • **REFERENCES**

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CHAPTER 4

WOOD-ATTACKING WASPS, ANTS AND BEES

INTRODUCTION

The insects to be discussed in this chapter all belong to the order Hymenoptera. This is one of the largest insect orders and is beneficial to man since it contains the most important insects (the bees) involved in the pollination of plants. There are, however, a few families in the order that contain species which feed on or nest in wood.

The members of the order are characterized by having four membranous wings (some are wingless), the front pair being much larger than the hind pair. The order name, Hymenoptera, means "membrane wings" and refers to the characteristically thin, clear or translucent wings. There is a great diversity of habits and complexity of behavior represented in the order.

The ants and some of the bees and wasps, are social insects. The adults have chewing type mouthparts. The ovipositor (egg depositor) of the female, located at the tail end, is often modified into a sting (bees and wasps) or a long, slender structure (horntails). The Hymenoptera undergo complete metamorphosis during their development. The larvae of those associated with wood are all grublike, usually legless and pale, yellow-white in color with slightly darker mouthparts.

The type and amount of damage done to wood by hymenopterans varies with the particular family. Only the horntails (family Siricidae) bore in wood and make galleries packed with frass. The carpenter ants (family Formicidae) and carpenter bees (family Anthophoridae) make hollows in the wood for nesting purposes only, and keep the hollows clean and free of frass. Although the amount of damage done to wood in use cannot rank these insects as major pests, they are common enough and conspicuous enough to warrant their consideration in this manual.

THE HORNTAILS OR WOOD WASPS

Because of their superficially wasp-like appearance, the horntails are often called wood wasps. Some authors refer to them as siricids, from the family name Siricidae. In both sexes the last segment of the abdomen bears a hornlike projection. This distinctive structure gives them the widely used common name of horntails. The female bears a long, slender terminal ovipositor as well.

The following discussion of horntails in this manual is not included because they are very common wood pests or because they create a significant amount of damage to structural timbers when they do occur. Rather, this discussion is included because horntails occasionally appear in large numbers in houses constructed of infested wood.

In such cases the adults make conspicuous exit holes in finished surfaces and are very conspicuous and noisy when they fly about indoors. Equally important is the fact that wood showing evidence of past attack by horntails is sometimes included in structures. The significance of such damage should be understood by those concerned with the structural soundness of buildings constructed with such wood.

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FAMILY CHARACTERISTICS

There are about 50 different species of horntails in the family Siricidae, approximately 20 of them occurring in the United States. They belong to four different genera, one of which infests hardwoods. Those in all of the other genera attack softwoods, and some are common pests of coniferous trees used for construction lumber.

The adults are large, superficially wasplike insects usually an inch (25 mm) or more in length. They differ in appearance from wasps in that their bodies are broadly joined together between the thorax and abdomen rather than having a thin "waist" as do wasps (Fig. 4-1). The females are usually larger than the males and have a long ovipositor, which the males lack. Sizes of individuals vary greatly, even in the same species. The adults of the species which attack softwoods are usually black or dark metallic blue, sometimes in combination with markings which are yellowish, reddish or brown. Neither sex bites nor stings, in spite of their dangerous appearance.

The larvae are whitish to creamy yellow in color, usually cylindrical, have very short legs and on their posterior end, a small, dark horny spine which they use for packing frass behind them (Fig. 4-1C). When they are removed from their galleries, they tend to take on a slighly S-shape, with their heads bent down and their tails turned up. Depending on the usual size of the species, they may be up to 1-3/4 inches (45 mm) long.

DISTRIBUTION AND ECONOMIC IMPORTANCE

Species of horntails occur naturally in all parts of the contiguous states where the host trees grow. Those that attack softwoods have been dispersed in infested lumber to many areas where they do not occur naturally. Therefore, horntails may occur in wood in houses in all parts of the United States or its territories. There is one species, the pigeon tremex, which attacks hardwoods. This species is widely distributed in the United States and southern Canada. Indoors, it is found emerging from hardwood fireplace logs, but is a nuisance only and not a pest of structural wood.

Horntails are not considered to be primary forest pests, since they attack trees which are declining or dying from fire, disease or insect damage or other natural causes. They also have been reported to infest newly felled logs and freshly sawed lumber, even redwood, a species usually resistant to insects.

The major economic losses caused by horntails result from the larval and adult borings in trees. The borings reduce the quality of the lumber, leading to its being downgraded. Horntails cause damage in new structures by the emergence of adults from infested structural lumber through various finished surfaces covering the wood. Instances of damage in houses have not been very frequent, but infestations may be very serious when they do occur. Horntails are serious pests when numerous, not because of severe damge to structural members, but because the exit holes are very conspicuous and the adults are very noisy and appear to be dangerous.

BIOLOGY AND HABITS

Very little study of the biology of North American species of horntails has occurred. Morgan (1968) provided a comprehensive review of

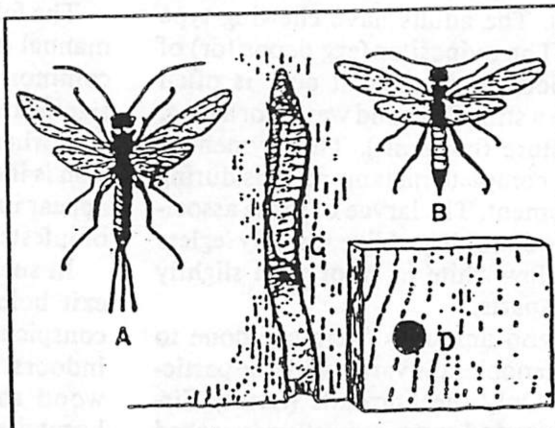


FIGURE 4-1. A. Adult female horntail. B. Adult male. C. Larva in gallery. D. Exit hole made by adult. Courtesy of University of California, Berkeley.

available literature, and much of the information reported has come from that source.

The adults are active in bright sunshine during the late spring, summer and early fall. Mating takes place in the treetops, and the females descend to the trunks of trees to lay their eggs. Horntails attack trees which are in a natural decline or have been cut recently. The female inserts her slender ovipositor into the bark and wood to a depth of 5/16 to 13/16 inch (8 to 20 mm) and deposits several eggs, withdrawing her ovipositor slightly after each egg is released. This process is repeated over a priod of about 10 days. Depending on the species, the female may be capable of laying from 300 to 4,500 eggs. At the time the eggs are laid, spores of fungus stored in special glands at the base of the ovipositor are introduced into the egg tunnel.

The fungus grows rapidly prior to the hatching of the eggs and provides the larvae with nourishment. According to Morgan (1968) the larvae do not swallow any wood, but secrete saliva which digests the fungal material in the wood, and they then ingest the predigested nutrients. The wood fragments which they have chewed off are passed behind them after the fungal nourishment has been extracted. Since the larvae depend on the fungal growth for food; the wood which is attacked must be in a condition to support its growth. This generally means that the moisture content must be above the fiber saturation point (30 percent).

The young larvae bore cylindrical tunnels at right angles to the oviposition tunnel. They feed at first in the sapwood but, as they become larger, they go into the heartwood. After feeding for a time there, they turn outward and tunnel back into the sapwood. Thus, the larval tunnel is typically roughly C-shaped and from 10 to 30 inches (25 to 75 cm long) long, depending on the species.

As the larvae tunnel, they pack the frass tightly behind them. They also include in the frass their larval skins, which are shed each time they molt. There may be 3 or 4 molts, and the larval stage may require 2 or 3 years to be completed outdoors. If the wood dries out quickly, as it does in lumber sawed from infested logs, the time for development may be prolonged to 4 or 5 years.

Pupation occurs in a silken cocoon spun at the end of the larval tunnel at various depths usually 3/4 to 1 inch (18 to 25 mm) below the surface of the wood. If the tunnels are too deep, as they often are, the adult is unable to chew its way out and dies in the tunnel (Chandler, 1959). The pupal stage lasts approximately 6 weeks.

The adults make perfectly round exit holes as they emerge. The holes may be cut through many types of materials covering the wood in which they developed. Adults have been reported emerging through hardwood floors, wood siding and paneling, plaster and plasterboard, and even sheet lead of considerable thickness.

■ SIGNS OF INFESTATION

The most common evidence of horntail infestation found by inspectors is tunnels tightly packed with frass, with the tunnels visible on the surface of the wood where they have been sawed through in the milling of the lumber.

If the infestation has been active, there may be adult exit holes through the surface of structural members or through any of the materials which have been applied over the infested wood. Frass beneath exit holes is seldom reported (Ebeling, 1975). Exit holes usually appear within the first 3 years after the wood has been used in construction.

It would be pure coincidence if the inspector found live adult horntails, but dead ones might be found around screened ventilators or in spider webs. The horntails might also be described by the occupants of the house if emergence has occurred indoors at a time when they would have been noticed.

■ CHARACTERISTICS OF DAMAGED WOOD

Both the exit holes and the larger tunnels are circular in cross-section and 1/6 to 1/4 inch (4 to 6 mm) in diameter (Fig. 4-1D). There is considerable variation in the size of the tunnels because of their being made by young and old larvae and because of natural differences in the sizes of various species of horntails. The tunnels exposed by the milling of the lumber may appear to be oval in cross-section because of the angle at which they were cut.

They wind in many directions in the heartwood and sapwood and are tightly packed with coarse frass which cannot be easily jarred or shaken out, unlike that of the old house borer. The tunnels quite commonly are surrounded by soft, decayed wood. When viewed in cross-section, there sometimes is a faintly grayish staining visible in light-colored wood as a thin "halo" a few millimeters from the tunnel. This staining is associated with the fungal attack.

POTENTIAL FOR DESTRUCTION

The amount of horntail damage found in structural timber is usually so small as to be of no practical concern. When a live infestation is incorporated in a new building, larval development may proceed, and adult horntails eventually emerge. However, since they are unable to reinfest seasoned wood, such live infestations and any resulting damage are usually unimportant. Probably the greatest concern is the alarm caused by the dangerous looking, but harmless, adults that might emerge indoors. There is one report of a mass exodus from a housing project in Wisconsin when large numbers of horntails emerged in the new homes (Friis, 1961).

PREVENTION

Damage caused by horntails to wood in use can be prevented by proper kiln-drying of green lumber sawed from infested logs. Although kiln-drying will kill horntail larvae that have survived the milling operations, the relatively low value of such lumber made this treatment economically impractical in the past. There are current indications that the value of even insect-damaged lumber is great enough to warrant kiln-drying. If kiln-drying is not specified, some infested lumber will no doubt continue to be used in new construction and will result in problems with adult emergence during the first 2 to 4 years of the structure's existence.

INSPECTION

When inspecting a house for the presence of wood-destroying insects in general, evidence of horntail larval damage may be encountered on the surface of any of the exposed, unpainted wood. The round exit holes of the adults may be found on the outside of the structure in wood, or extending through wood or composition siding or trim. Inside, they may be encountered in any wall, ceiling or floor material or trim covering coniferous wood structural members. No special procedures, other than careful visual inspection, are necessary to determine the presence or absence of horntail damage.

Horntails are of such minor economic concern in structures that it is only important to correctly identify the evidence in order to place it in proper perspective and to reduce the property owner's or buyer's anxiety.

CONTROL

In most cases where structural timbers in a house are infested, no control is necessary, since the emergence of the adults marks the end of the infestation.

Exit holes exposed to the weather probably should be sealed with an appropriate filler material to prevent water seepage and subsequent decay. Those holes found indoors in living spaces should likewise be filled and spot painted. Because there can be several different emergences over a period of time as a result of different infestations and different environmental conditions in the wood, it is most practical to wait until about 3 years after a house is constructed to patch and repair damaged areas indoors.

In those rare instances where it is vital to stop the continued emergence of adults, fumigation of the structure under a tarpaulin as for drywood termite control is a possible answer. Horntails are much more difficult to kill in wood than are many other wood borers. They burrow more deeply than many, and their frass is packed extremely tightly in the galleries.

There are British reports of successful

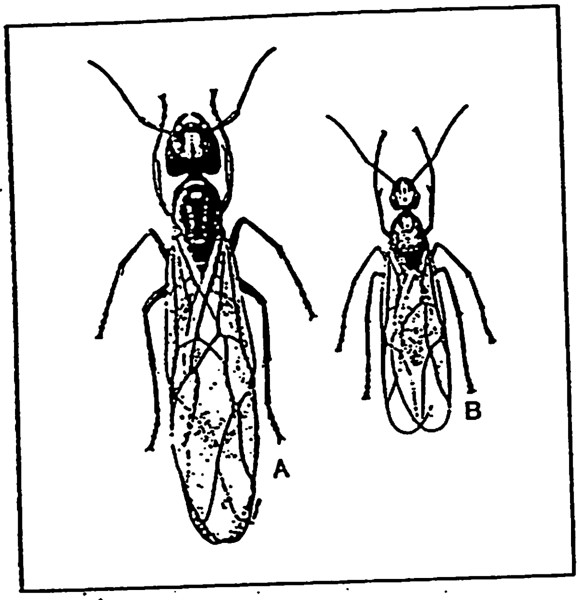


FIGURE 4-2. A. Carpenter ant queen with wings. B. Male carpenter ant. Courtesy Connecticut Agricultural Experiment Station.

fumigation of timbers up to 4 inches (10 cm) thick by using 3 pounds of methyl bromide per 1,000 cubic feet (1.36 kg per 28 cm m) applied for 24 hours at not less than 90°F (32°C) NPCA, 1964. They also report an apparently successful sulfuryl fluoride (Vikane) fumigation of an apartment house in California using 2 pounds per 1,000 cubic feet (0.9 kg per 28 cu m) for 24 hours. Any such treatments would be restricted by labeled dosage rates current at the time of application.

CARPENTER ANTS

Ants that damage wood are known as carpenter ants. As do all other ants, they belong to the family Formicidae. There are over 500 native species in this family, but only a very few of them are of any concern as destroyers of wood. All of the carpenter ants of economic importance belong to one genus, *Camponotus*, and are very similar in appearance and habits. For that reason, it is not necessary to discuss each species separately.

■ CHARACTERISTICS

Carpenter ants are among the largest species of ants that occur in the United States. Several castes or forms of adults are found in mature colonies. There are queens (winged and unwinged), winged males and several sizes of unwinged workers. The winged queens (alates) may be up to 3/4 inch (18 mm) long including the wings (Fig. 4-2A). The males are considerably smaller, being up to 7/16 inch (11 mm) long (Fig. 4-2B).

There is usually only one functional, wingless queen in a colony, and she is up to 9/16 inch (14 mm) long (Fig. 4-3A). There are several sizes of workers. The minor workers are the smallest, averaging 5/16 inch (8 mm) in length (Fig. 4-3C), though some species may be smaller. The major workers are up to 7/16 inch (11 mm) long (Fig. 4-3B) in the common species and may be slightly larger. There are several sizes of intermediate workers in between the two extremes.

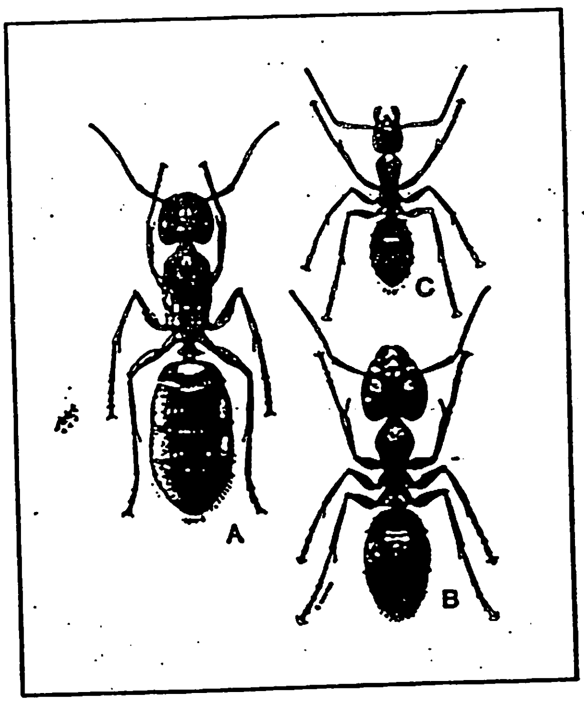


FIGURE 4-3. A. Wingless carpenter ant queen. B. Major worker. C. Minor worker. Courtesy Connecticut Agricultural Experiment Station.

The carpenter ants are typical of all ants in having a very narrow waist (unlike termites) and wings of two different sizes, the front ones much larger than the hind ones (unlike termites with equal-sized wings). The adults of those species found nesting in houses are predominantly black. However, some may be partially reddish-brown to yellowish.

The larvae are small, legless, white and grublike. They are helpless and must be moved, fed and cared for by the adults.

The pupal stage which follows larval development is completed inside tan or cream-colored silken cocoons which are often erroneously referred to as "ant eggs."

DISTRIBUTION AND ECONOMIC IMPORTANCE

Various species of carpenter ants occur in all parts of the United States, even at elevations up to 9,000 feet (2,700 m). In the Pacific Northwest and in the Northeast, they are considered to be the most common pests of wood in structures. In the Caribbean region they are of little, if any, importance in houses. They are occasionally pests in Hawaii in areas recently cleared of chaparral. Houses near wooded areas, cleared land, or brush-covered vacant lots are more likely to be invaded. Disturbing natural nesting areas triggers movement to structures (Furniss, 1944).

Carpenter ants are generally of relatively little economic importance as destroyers of wood in houses. If an infestation is of long standing, however, there may be enough damage to require extensive repairs. Usually, at most, only minor repairs are needed. Besides causing some damage to wood in buildings, carpenter ants are also nuisances in the same way that other ants are when they crawl around in houses foraging for food or water.

BIOLOGY AND HABITS

Carpenter ants, as all ants, are social insects. They live in colonies composed of individuals having different forms (castes) and performing different functions in the colony. As previously described, the adult forms in a colony consist of various sizes of workers and the wingless, egg-laying queen. When a colony has reached a certain stage of development, and at certain seasons of the year, there are also numerous winged males and females present.

The native carpenter ant that has had its biology most thoroughly studied is the black carpenter ant, *Camponotus pennsylvanicus* (DeGeer). It is very common in the eastern and central United States. Most of the information which follows applies to that species, but various reports on other native species indicate that their biology and habits are similar.

Anytime from early spring until the midsummer months, rather large numbers of winged males and females emerge from established colonies. Environmental mechanisms trigger the "swarming," since flights occur simultaneously in a general area, sometimes over a period of several days. This allows breeding of individuals from different colonies, an important genetic consideration since all of the members of a colony are usually the offspring from a single pair. Mating occurs in flight. The males die shortly thereafter, and the females begin a search for a place to establish a new colony. The female breaks off her wings just before or just after a nesting site is selected.

Carpenter ants burrow into wood to make nests, not for food. In nature, they make their nests in dead portions of standing trees, stumps, logs, or under fallen logs or stones, sometimes with galleries extending into the ground. They also nest in structural timbers if they find suitable conditions. Most species prefer to nest in moist wood that has begun to decay. They attack both hardwoods and softwoods. Laboratory experiments indicate that the black carpenter ant cannot successfully establish a colony in wood below 15 percent moisture content (Simeone, 1954). The mated female finds a small natural cavity in wood or soil, or excavates one, and seals herself in with a wood fiber mixture. Within a few days she begins to lay her first brood of 15 to 20 eggs. Under favorable temperature conditions, these hatch into larvae in approximately 3 weeks.

The queen cares for the larvae and feeds them with a fluid secreted from her mouth. This nourishment is derived from stored fat and from metabolic conversion of the now-useless wing muscles. During the two or more months required for the development of the first brood into workers, the female never leaves the brood chamber or takes any nourishment. The resulting adult workers are all very small, but immediately take over responsibility of caring for and providing food for the incipient brood and for the queen. They enlarge the nest as the colony population increases. The queen's sole responsibility then becomes egg laying.

In subsequent generations, workers of various sizes are produced. They are all females, but are undeveloped sexually and do not produce eggs. In general, the largest ants guard the nest, battle enemies, forage for food, and bring food to the nest, where it is transferred to the smaller workers. The smaller workers primarily expand the nest and care for the young. These ants cannot sting. But they have the ability to bite painfully, and can emit formic acid as an additional defense.

The food of carpenter ants consists primarily of honeydew, which is sweet, partially-digested tree sap gathered by the workers from aphids and some other insects which they find on foliage and roots of trees. Carpenter ants also feed on the remains of insects and on plant and fruit juices. When they forage inside houses for food, they are attracted to sweets and to most kinds of meats, grease and fat. Most of the food gathered by the workers is consumed instead of being carried back to the nest. Workers feed the other colony members, adults and larvae, by regurgitating food and transferring it mouth-to-mouth.

During the first year the colony remains small, consisting of the queen, about 10 to 20 workers and some immature forms. In succeeding years the population grows rapidly until it numbers 2 or 3 thousand individuals. It usually requires 3 to 6 years for this size to be reached, at which time winged reproductives (swarmers or alates) are produced each year. Swarmers usually appear in late summer, but spend the winter in the nest and emerge the following spring or summer. Colonies rarely grow larger at this point, but they indefintely continue to produce reproductives and replenish the workers which die. If the colony becomes stressed from lack of food and water, they will resort to cannibalism, and the queen, with a few workers, will survive for long periods.

Houses are very commonly infested by the movement of a colony, or part of a colony, into the structure. Fertilized queens also establish new colonies in houses. In structures, timbers that are soft, damp and partially decayed are most frequently selected as nesting sites by carpenter ants. There are some species that are capable of nesting in sound wood, but even these prefer softened wood to start a nest. Once a nest is established, the workers will extend the galleries into sound wood adjacent to the partially decayed portion.

It is not uncommon for carpenter ants to nest in houses without attacking the timbers. They simply use existing cavities, including wall voids, hollow flush panel doors, termite galleries in wood, etc., in almost any part of a house. In undisturbed areas such as attics, inside stored furniture, and on seldom-used shelves, they may establish a nest in debris or even out in the open. They sometimes nest in foamed plastic or fiberglass insulation. Consequently, carpenter ants cannot always be considered pests of wood. Occasionally, they occupy an existing cavity indoors and then expand it by invading adjacent timbers.

Whether for nesting or for foraging only, carpenter ants enter houses in many different ways. Tree branches or power or telephone lines contacting a house are a source of access. Carpenter ants get inside through cracks and crevices around windows, in foundation walls, through ventilation openings, and through heating ducts and air conditioners. They can also be brought into the house in firewood.

■ SIGNS OF INFESTATION

The most obvious sign of infestation is the sighting of large, black workers inside the house. Occasionally, a person will turn on a light in a kitchen or bathroom at night and find large numbers of the ants seeking water in the sink. During very warm weather, the ants are most active at night, and daytime activity is so reduced that there may be little evidence of the ants except after dark. The ants are active the year round if nesting in heated portions of houses; otherwise, they become inactive during cool weather.

During the spring or early summer, there may be swarmers inside or around the house. Those indoors tend to fly toward the windows and to congregate there.

There may be piles or scattered bits of very fibrous and sawdust-like frass which the ants have removed from the wood. If from decayed wood, the pieces tend to be darker and more square-ended. The frass can be distinguished from sawdust produced during construction, or from the very similar carpenter bee frass, by the fact that there are fragments of ants and other insects mixed with the wood fibers. The frass is expelled from cracks and crevices or from slitlike openings called "windows" made by the ants. The frass is quite often found in basements, dark closets, attics, under porches, and other out-of-the-way places.

The slitlike openings are themselves a positive sign of these ants when found in association with other evidence. They usually are directly above the frass.

Faint rustling and even gnawing sounds can be heard in the wood or cavity when ants are active. The sounds can best be heard when background noise is at a minimum.

On very rare occasions, there might be actual failure of wood in service. This will usually be result of some sudden excessive stress on the damaged member, such as a shift of heavy furniture, a wind storm, or a heavy snow accumulation on a roof.

CHARACTERISTICS OF DAMAGED WOOD

The damage to wood is discovered when the surface is broken open. The only external evidence of attack is the small, inconspicuous "windows" made in the surface by the ants.

The galleries extend both along the grain of the wood and around the annual rings. The softer, spring growth (early wood) tends to be removed first. The harder-grained summer wood is penetrated at frequent intervals, so there is complete access between the galleries (Fig. 4-4). The surfaces of the galleries are as smooth as if they had been sandpapered and are perfectly clean. The general appearance of the galleries is similar to those made by drywood termites, but there are no fecal pellets, and the frass is completely removed except for occasional deposits in unused galleries.

POTENTIAL FOR DESTRUCTION

Carpenter ants do not pose a serious threat to the soundness of structural timbers unless they are ignored for long periods of time. If the occupants of the house are aware of the numerous worker ants in the vicinity of the house and see the swarmers produced each spring or summer, they cannot remain unaware of the presence of an infestation. Once the infestation is discovered, control measures can simply and effectively stop the problem quickly.

If the ants are ignored, there can be destruction of wood, and expensive repairs may be needed. This most often occurs in recreational structures that remain unoccupied for long periods of time and that may be constructed in such a place and in such a way as to invite ant invasion.

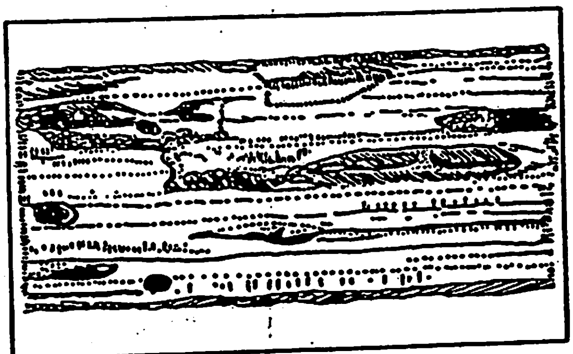


FIGURE 4-4. Carpenter ant damage. From Insects Affecting Forest Products and Other materials by W.J. Chamberlain. Used with permission of Oregon State University.

PREVENTION

The prevention of attack by carpenter ants is in many ways similar to the prevention of subterranean termite attack. Since carpenter ants are most likely to initiate attack in damp wood that has partially decayed, this condition should be avoided. Proper clearance between wood and soil, good drainage and ventilation, proper roof flashing, and tight exterior wood joints are all good preventive practices. If wood is likely to be wetted from time-to-time, it should be pressure-treated as described for subterranean termite prevention. Areas such as wooden porches and wooden support columns are particularly susceptible to decay and to ant attack. Proper maintenance of all these features is equally important.

Proper sanitation of the building site will help reduce the chance of attack. All stumps, logs, wood debris, etc., should be removed from the vicinity of the house. Firewood should not be stored near the house, and it should be carefully inspected for carpenter ants before being brought indoors.

Where the size of the lot permits, any ant colonies within 100 yards (90 m) of the house should be destroyed by removal or treatment with chemicals as will be indicated in the control section.

These procedures will not totally prevent carpenter ant attack in houses, but they will greatly reduce the incidence of invasion.

INSPECTION

Inspection for carpenter ants begins with an interview of the occupants of the property. They should be asked about the presence of ants and where they were seen. They also should be asked whether they have found any ant frass or if there are moisture problems in any part of the structure.

The most difficult and most important part of the carpenter ant control is locating the nest or nests. Once they have been found, control is relatively easy. Therefore, inspection procedures should be aimed at finding the nest sites, both indoors and outdoors.

The most obvious places to look for carpenter ants are those areas most likely to have a high moisture content. These include the bases of walls in closest proximity to the soil, wooden porch floors and columns, wood subject to plumbing leaks and condensation, window and door sills, roof edges, areas around roof flashing, and areas between roof and ceiling in flat-roofed decks or porches. Any wood in soil contact should be carefully examined, whether it be a structural member or wood debris. Inspection for these conditions would require careful examination of the outside of the structure as well as in the attic and crawl space or basement.

Since carpenter ants do not confine their nests to damp wood, it is equally important to examine the interior of the house for signs of ant activity. They have been found nesting in virtually every part of houses. The edges of floors and ceilings and window and door trim should be carefully examined. Ants commonly nest in wall voids above windows and doors and inside hollow doors. The inside of furniture in long-term storage should be carefully inspected.

In addition to the house itself, the inspector should look for ant colonies and ant activity in the yard near the house. Trees, fence posts, stumps, and logs should all be examined for signs of ants.

When the ants themselves are found, they should be observed long enough to determine the general direction in which they are traveling. It is then possible to follow them back to the nest area. If the exact site of the nest is not obvious, pounding on the wood and listening for the typical dry, rustling sound produced by the ants is helpful in pinpointing the location.

CONTROL

In order to obtain satisfactory control of carpenter ants as nuisances, it is necessary to treat all colonies both in and near the house.

Once the nests have been located, they should be treated with residual contact insecticide applied as a dust or spray. It is sometimes helpful to drill 1/4 inch (6.25 mm) holes at 1-foot (30 cm) intervals into the galleries or into the void in which the nest occurs. A nozzle fitting tightly into holes should be used to get good coverage. After treatment, the holes should be plugged with short lengths of wooden dowel—or with corks—of proper size. Dusts are particularly effective in the nests. All of the approaches and areas surrounding the nest also should be treated.

Indoors, this is best accomplished by spraying. Simply treating the areas where ants are seen and not locating and treating the nests is seldom satisfactory. Some of the ants do not leave the nest and would not be affected by such a treatment. Considering that individual carpenter ants can live for 6 months or more without feeding, it is obvious that nest treatment is essential.

Any of the insecticides which are currently labled for ant control should be effective if the nests are carefully treated. Examples of such insecticides are bendiocarb (Ficam), boric acid, chlopyrifos (Dursban), cypermethrin (Demon), diazinon, fenvalerate (Tribute), propoxur (Baygon), and sodium borate.

Indoors, galleries and wall voids can be treated with silica aerogel (Drione; Whitmire PT 230 Tri-Die) or boric acid dust, which will provide long-term residual protection if the treated areas are dry.

In order to aid in carpenter ant control and to help prevent future attacks, high moisture conditions in wood in the structure should be eliminated.

CARPENTER BEES

The common name of carpenter bees is used for two closely related groups of bees in the family Anthophoridae. One of the two groups are small, metallic-colored bees that nest in the stems and canes of pithy plants (genus *Ceratina*). They will not be treated further. The other group are all larger and belong to the single genus, *Xylocopa*. They construct nests in wood, occasionally in structural timbers, and are the subject of the following discussion.

■ CHARACTERISTICS

There are nine species of the larger carpenter bees in the contiguous states (NPCA, 1963), and at least one species in Hawaii and in Puerto Rico. The adults are generally stocky, black or blue-black in color, and up to 1 inch (25 mm) or slightly more in length. The thorax is covered with yellow, orange, or white hairs, and the abdomen, especially on the top side, is bare and shiny. The yellow-marked eastern species especially resembles bumblebees.

Some of the species have greenish or purplish reflections and, in some, the males are entirely buff or pale yellow. They may be distinguished from bumblebees by the fact that they are bare on top of the abdomen instead of covered with hair as are the bumblebees (Fig. 4-5). Also, female carpenter bees have a dense brush of hairs on the hind legs, as compared with the more openly constructed pollen baskets on the legs of bumblebees.

The larvae are white, legless, and grublike and remain entirely inside the wood. The pupae start out very light-colored and gradually darken to more nearly resemble the adults as they develop. They likewise, remain entirely in the wood.

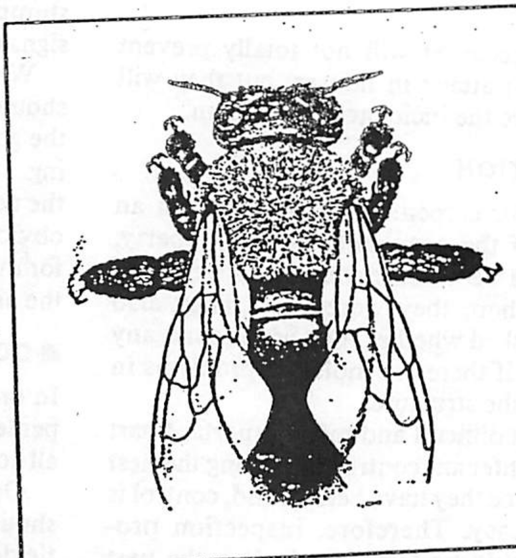


FIGURE 4-5. Carpenter bee adult. Courtesy of F. E. Wood, University of Maryland.

■ DISTRIBUTION AND ECONOMIC IMPORTANCE

Of the species of wood-invading carpenter bees in the contiguous states, only three nest consistently in structural timbers (Hurd, 1958). They are found in virtually all parts of the country and can be transported in infested wood from one area to another. There is one species in Hawaii that nests in structural timbers. It has been introduced into the Mariana Islands (Hurd, 1958). There are carpenter bees in Puerto Rico, but they are of no concern as pests in structures (personal communication, July 1975, Luis F. Martorell, Professor Emeritus, Department of Entomology, University of Puerto Rico, Rio Piedras, Puerto Rico).

Carpenter bees are most often simply nuisances in and around structures. They are confused with bumblebees by homeowners who are concerned about being stung. The male bees are very aggressive and behave as if they will attack intruders into the nest area. They do not possess stingers and are harmless. The females are not aggressive and, although they are capable of doing so, very seldom sting unless handled or otherwise seriously molested.

Structural damage by carpenter bees in occupied buildings is seldom of any consequence. They are large, noisy insects, and make rather conspicuous holes in wood. For these reasons, they attract much attention when present and should be recognized so that their relatively minor potential for damage can be properly evaluated.

■ BIOLOGY AND HABITS

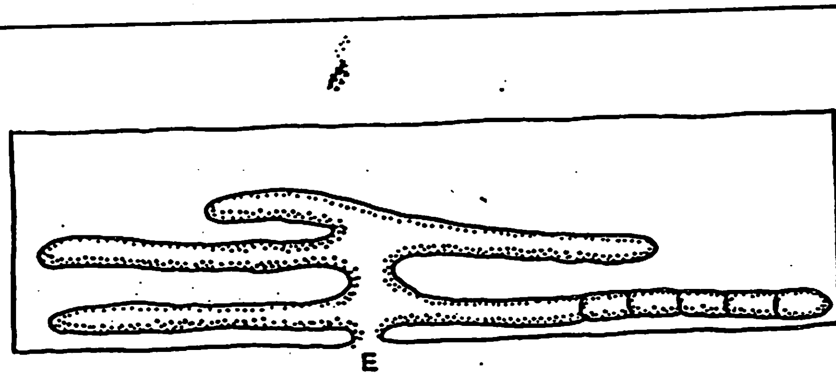
Xylocopa virginica (L.), known by the approved common name "carpenter bee," is the most prevalent wood-attacking species east of the Rocky Mountains. The biology of this species has been described in great detail (Rau, 1933; Chandler, 1958; Balduf, 1962), and the life history of this species will illustrate the life history of carpenter bees in general.

The adults overwinter in abandoned nest tunnels. They emerge in the spring, usually April or early May, and feed on nectar. Mating occurs within a few weeks, after which the males die. Activity continues year around in Florida, where there are two generations per year.

Mated females begin to prepare nests either by excavating a new tunnel or, more often, cleaning out and expanding an old gallery. Many females live two years, and often two or three females are present in each nest, but only one works and lays eggs (Gerling and Hermann, 1978). When several generations of bees have shared a common nesting site, the galleries may become quite branched and interconnected (Fig. 4-6).

The original entry is most commonly made by the female boring into the lateral face of a structural timber in a well-lighted but sheltered location. Entry is less often made on the underside or end of a board. The hole is perfectly round and approximately 1/2 inch (12 mm) in

FIGURE 4-6. Carpenter bee nests as constructed in a 1 in. by 4 in. (2.5 cm by 10 cm) board. E designates the entry hole on the narrow face of the board. Adapted from Balduf, 1962. Used with permission of the Entomological Society of America.



diameter. Except when started on the end of a board, the tunnel turns abruptly at a right angle, after being extended approximately the length of the female's body across the grain of the wood. The tunnel is extended with the grain from 4 to 6 inches (10 to 15 cm) in a new site.

An old gallery may be extended or used without further burrowing. If an old gallery is repeatedly extended by succeeding generations, it may ultimately reach 6 to 10 feet (2 to 3 m) in length. The galleries are excavated solely by the females' using their mandibles (jaws), and are almost always a constant distance from each of the two wide faces of the timber.

The female provisions the end of the brood gallery with a mass of pollen and nectar approximately the size of her abdomen and lays an egg on the mass. She seals off this portion of the gallery with a partition composed of wood pulp and saliva. The process is repeated at the rate of one a day until, usually, there are six cells in a row.

Having completed their function, the adults slowly decline, and die within a few weeks.

The development from egg to adult requires 5 to 7 weeks, depending on average temperature. Those bees which occur in the foothills and mountains along the West Coast (*Xylocopa tabaniformis orpifex* Smith) require up to 3 months to complete development. Following emergence from the pupal stage, the adult bees remain within the cells for a day or two, drying and feeding on any remaining pollen.

Because there is considerable variation in the time required for development of each stage (Simeone, 1972), there is no predictable sequence for the emergence of adults in relation to their position in the gallery. All of the adults from a single gallery, however, emerge over a relatively short period of time.

The emergence of the adults usually occurs in late summer. Although they are sexually mature, they do not mate until the following spring. They remain in the vicinity of the brood galleries, feeding on nectar and pollen, until cold weather forces them into hibernation in the old galleries. No pollen is stored, except for consumption during inclement weather, and little if any boring occurs prior to hibernation.

It is common for carpenter bees to continue to utilize the same nesting site for many years if it is a favorable one. One site was reported to be continuously used for 14 years.

■ SIGNS OF INFESTATION

There are several ways in which the inspector may determine the presence of carpenter bee attack in a structure. The most obvious one is the bees themselves. They are present around the outside of the house during the late spring and early summer and again in late summer and early fall.

Those bees present during the early part of the season are the ones which excavate galleries in the wood. Because of this, there may be burrowing sounds, which resemble a vibration on the wood surface.

In addition, there will be rather coarse sawdust-like frass being expelled from the entry holes. The frass accumulates on surfaces below the site of activity. The frass is usually the color of freshly sawed wood and varies with the species of wood under attack. There are no fragments of insects mixed with this frass, as is the case with carpenter ant frass, although it is otherwise similar.

If there has been bee activity in the area for some time, there may be yellowish to brownish streaks of fecal material on surfaces immediately below the entry holes. This streaking is most easily seen on light surfaces.

When the bees are not active, the only signs of infestation likely to be seen are the 1/2 inch (12 mm) round entry holes made by the female bees.

■ CHARACTERISTICS OF DAMAGED WOOD

Carpenter bees usually choose wood that is soft and easy to work. They particularly like California redwood, cypress, cedar, white pine, and southern yellow pine. Other woods, even hardwoods, may be chosen if they have been softened by being unprotected and exposed to the weather for extended periods of time. Bare wood is preferred. Carpenter bees avoid well painted wood and wood with bark on it. If the surface is stained or has a very thin coating of paint on it, they will attack it. They also will tunnel wood that has been pressure-treated with metallic salts for above-ground use, such as in decks.

The only external evidence of attack is the entry holes made by the females. If the wood is pried open or has been damaged by woodpeckers subsequent to bee attack, the internal galleries can be seen (Fig. 4-6). They are smooth-walled and tend to be a very uniform 1/2 inch (12 mm) in diameter. If they have been used for several generations, they become more irregular and up to 1 inch (25 mm) in diameter.

■ POTENTIAL FOR DESTRUCTION

In areas where carpenter bees are common, the amount of damage that they can do in a structure varies directly with the amount of unpainted wood surface exposed to their attack and with the suitability of the wood for their entry. In addition, there must be a nearby source of infestation, since these bees do not disperse widely from a suitable nesting site.

If the infestation is discovered before a large population has developed, very little damage of a serious nature will have occurred. It takes several years of almost total neglect for carpenter bees to cause damage serious enough to cause structural failure. East of the Rocky Mountains, such large populations of bees are most likely to occur in the southern reaches of their distribution (Balduf, 1962). They can, however, be indirectly responsible for very unsightly damage when woodpeckers attack infested wood in an effort to obtain the bees as food. When thin wood, such as siding, is so attacked, it may be completely penetrated. Decay may follow such attack in wood exposed to rain.

■ PREVENTION

The only way to prevent attack by carpenter bees is to keep all exposed wood surfaces well coated with paint. If interiors of storage areas, garages, etc., have unpainted wood exposed, doors and windows should be kept tightly closed or screened during the spring and early summer when the bees are seeking nesting sites.

Wood pressure-treated with organic preservatives such as pentachlorophenol and with heavy loadings of metallic salts is resistant to carpenter bee attack.

■ INSPECTION

The nests of carpenter bees are not difficult to locate when the bees are active. When they are not active, it is necessary to concentrate inspection efforts on those surfaces likely to be invaded. Some of the more common sites in buildings include headers, siding, roof eaves, wooden shingles, porch ceilings, window sills, woodwork, doors, etc. (NPCA, 1963). Those surfaces which are bare or poorly coated with stain or paint shoud be inspected very carefully. Well lighted but protected locations are also favored. The unpainted back sides of gable ventilators and of shutters are sometimes points of entry hard to discover.

In addition to the structure itself, the inspector should give attention to wooden poles, posts, fences, and lawn furniture in the vicinity of the house, since they may be a source of infestation.

■ CONTROL

Any insecticide labeled for bee control, applied into the entry holes will kill bees which come into contact with the residue. Dust formulations are preferred for treatment inside the nests. Carbaryl (Sevin) and boric acid formulations are available. Several days after treatment, the holes should be plugged with short lengths of dowel rod of the proper diameter, or with plastic wood. Plugging the holes without applying insecticide can lead to the production of new holes next to the plug when bees inside attempt to emerge, or nesting females seek reentry into galleries in use.

Treating the external surfaces in the vicinity of the entry holes with any insecticide labeled for bee control will discourage continued bee activity. Chlorpyrifos (Dursban), cypermethrin (Demon), diazinon, fenvalerate (Tribute), and propoxur (Baygon) are examples of registered materials. It may be necessary to repeat applications at weekly intervals during the nesting season in order to maintain control if bees are moving in from surrounding areas.

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