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A Guide to the Insect Borers, Pruners, and Girdlers of Pecan and Hickory

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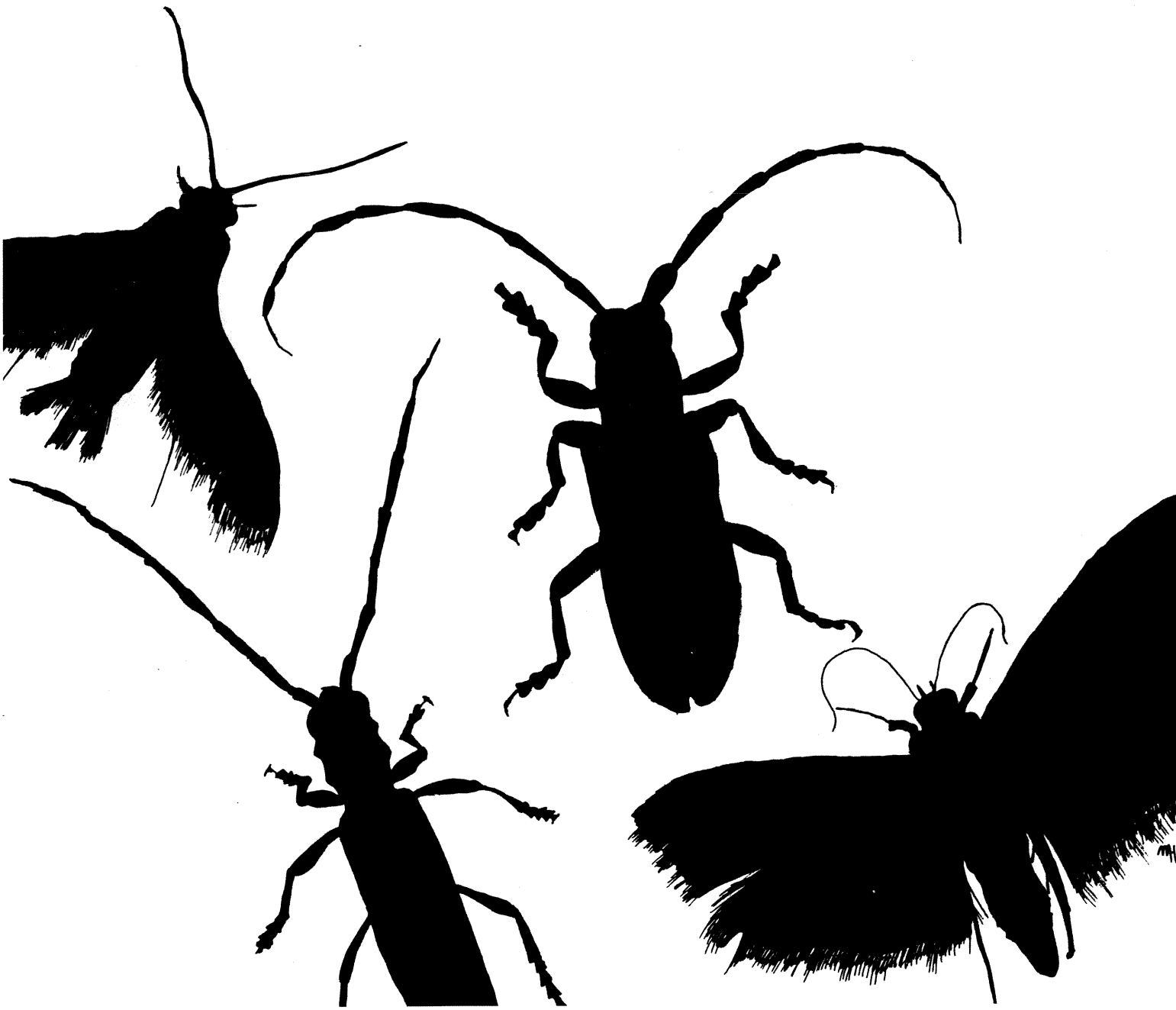

SUMMARY

Many insect borers, pruners, and girdlers attack, damage, and kill pecan and hickory trees. By using the information contained in this publication, resource managers, landowners, and other interested people should be better able to identify and manage these pests. Yellow-bellied sapsuckers are also discussed because damage caused by these birds is often confused with that of insect borers. Class, order, and family names of these pests are listed in the Appendix as additional information for the reader.

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A Guide to the Insect Borers, Pruners, and Girdlers of Pecan and Hickory

J. D. Solomon and J. A. Payne

INTRODUCTION

Pecan, *Carya illinoensis* (Wangenh.) K. Koch, and at least 10 species of hickory, *Carya* spp., are native to the Eastern United States. Eight of these are economically important when grown for timber production, commercial nut production, ornamental purposes, and wildlife food. Pecan is best known for its nutritious nuts, which are produced in quantities that make them a major economic commodity, but is also a prized species for use in fine furniture and paneling (Kennedy and others 1981). During recent years, it has been commonly called the "black walnut of the South," and interest in commercial plantings is growing because of its high stumpage value (Adams and Thielges 1976-77). The hickories have long been known for their use in the manufacture of handle stock, sporting goods, and some furniture.

Insect borers, pruners, and girdlers are injurious pests of pecan and hickory. Although most of these pests have a wide distribution, they seldom threaten trees over large areas. Damaging populations typically occur on a local basis, such as a nursery, individual nut-producing grove, forest stand, young timber plantation, or ornamental trees in a neighborhood or small geographic locality. Much has been written on the insect pests affecting the nuts and foliage of pecan, but little has been published on the insect borers affecting the tree itself. The cryptic habits of the insect borers have hampered efforts to document this group of pests. Known information is widely scattered and found in older literature, much of which is not generally available to those who need to use it.

The terminals, branches, trunks, and roots of trees of all sizes are vulnerable to borers. Natural regeneration is sometimes heavily infested by girdlers and pruners. Nurseries and young plantings located close to heavily infested stands or woodlots are most likely to be damaged. Loss of terminals and main stems in young timber plantations adversely affects tree form. Pruners and girdlers can drastically reduce the number of nut-bearing branches and subsequent nut crop of nut-producing trees. Girdled branches can create cleanup problems on residential properties. Young transplanted trees are particularly susceptible to borers and often need protection. Borer holes and associated stain and decay cause defects in the wood that reduce its value for lumber, veneer, handle stock, and other products. Wormholes and bark scars also adversely affect the aesthetic beauty of shade and ornamental trees. Borers sometimes invade the cambium and callus around new grafts and prevent union of scion and stock; recently top-worked trees have suffered serious damage in the past. Stressed trees are particularly susceptible to bark beetles and pin-hole borers. Bark beetles have caused widespread mortality of hickory during extended periods of drought. Yellow-bellied sapsuckers are included in this guide because the holes they peck in the bark are often confused with those caused by insect borers.

Impact from pests can be minimized through good management. Cultural practices that maintain and promote tree vigor are of utmost importance. New plantings should be on good sites, preferably away from heavily infested stands, woodlots, or old, deteriorating orchards. Adequate space, water, and nutrients should be provided. Efforts should be made to keep injuries such as cuts, bruises, and broken limbs resulting from cultivation, mowing, thinning, and harvesting equipment to a minimum. Injuries that do occur should be promptly treated to speed the healing process. Practices such a "pick-up and destroy" and "prune-out and destroy" can help to reduce damage by girdlers and pruners, especially when practiced on an area or neighborhood basis. When possible, practices should be adopted that favor natural controls such as predators, parasites, and insect pathogens. Chemical control may occasionally be needed.

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This publication should aid forest managers of timber resources, farm managers of nut producing groves, extension and pest control personnel, and homeowners to identify, manage, and control the major insect borer, pruner, and girdler pests of pecan and hickory. Descriptions and illustrations of the pests and their damage—including galleries, frass, size and portion of tree infested, and tree condition—are presented to aid in identification. Information on biology and control are given to help in predicting damage, managing populations, and making control decisions. Specific chemical controls are not given in this publication. For the latest information on pesticides contact your State Forester, Extension Agent, or the nearest office of State and Private Forestry, USDA Forest Service.

PECAN CARPENTERWORM
Cossula magnifica (Strecker)

Importance.—The pecan carpenterworm, *Cossula magnifica* (Strecker), is primarily a pest of pecan, but is also found in the hickories and reportedly some oaks throughout the Southern United States and Mexico (Baker 1972, Matz 1918, Moznette and others 1931). It attacks the branches and trunks of trees of all sizes, but shows a preference for trees 8 to 31 cm d.b.h. Small branches may break or dieback at the tunneled sites. Although very few trees break or die from carpenterworm attack, heavy repeated attacks may structurally weaken the tree, reduce its vigor, and provide entryways for decay fungi and other pathogens. The value of sawlogs and lumber from infested trees is markedly reduced because wormholes will cause the wood to be degraded. Although populations may be heavy locally, widely scattered infestations and sporadic appearance minimize the overall economic impact of the pecan carpenterworm.

Description.—The adult is a grayish moth mottled with brown and black blotches (fig. 1A) (Moznette and others 1931, Baker 1972, Gill 1924). The forewings are mottled with small brown patches, and each has a large brownish area at the distal end; the hindwings are uniformly darker without distinct markings. The wingspan ranges from 37 to 44 mm. The larva is pinkish in color and naked or only sparsely covered with short fine hairs that arise from the numerous tubercles (fig. 1B). The head, cervical shield, and anal plate are shiny dark brown. The full-grown larva may reach 37 mm in length. The pupa is brown and has a sharp projection on its head that is used to help force its way through the pupal cell and along the larval burrow to the exit hole.

Evidence of Infestation.—The earliest signs of attack are entrance holes, sap-stained bark, and small quantities of moist frass on the small branches during

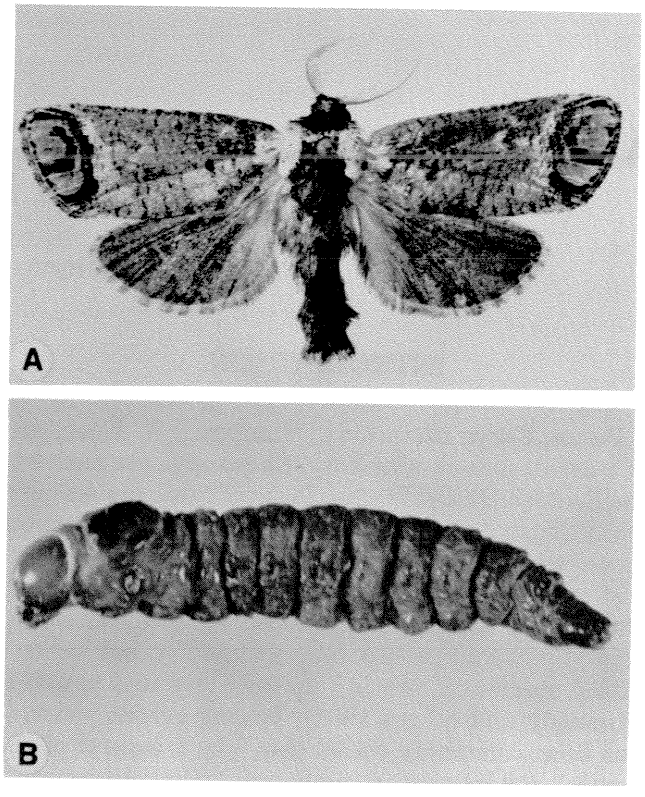


Figure 1.—*Life stages of* Cossula magnifica: *(A) adult moth; (B) mature larva.*

summer and early fall (fig. 2A). Dissecting the infested branch will reveal the larval tunnel (fig. 2B). However, these signs are often overlooked because the infested branches may be high above the ground, and the frass becomes scattered as it falls to the ground. It becomes easier to recognize the attacks when the larvae later bore into the trunk during the autumn (Moznette and others 1931, Turner and others 1918). Although attacks may occur at any point on the trunk, they are usually concentrated around the basal part of the trunk from groundline up to about 1.2 m. Attacks in the trunk are characterized by a small circular entrance hole about 6 mm in diameter with sap-stained bark below the entrance and a few excrement pellets and fine frass in bark crevices (fig. 2C). Pellet-like frass often accumulates in piles on the ground around the base of infested trees. Entrance holes are enlarged to about 9 mm just prior to pupation. Brown pupal skins may be found protruding from entrance holes during emergence in May and June. Entrances to galleries heal over leaving uniformly round or oval bark scars for several years as evidence of previous attacks.

Biology.—Eggs are deposited on the bark of small branches in the tops of trees after emergence and mating of the adult moths from late April through June (Baker 1972, Moznette and others 1931, Gill 1924). The newly hatched larvae first attack small twigs and

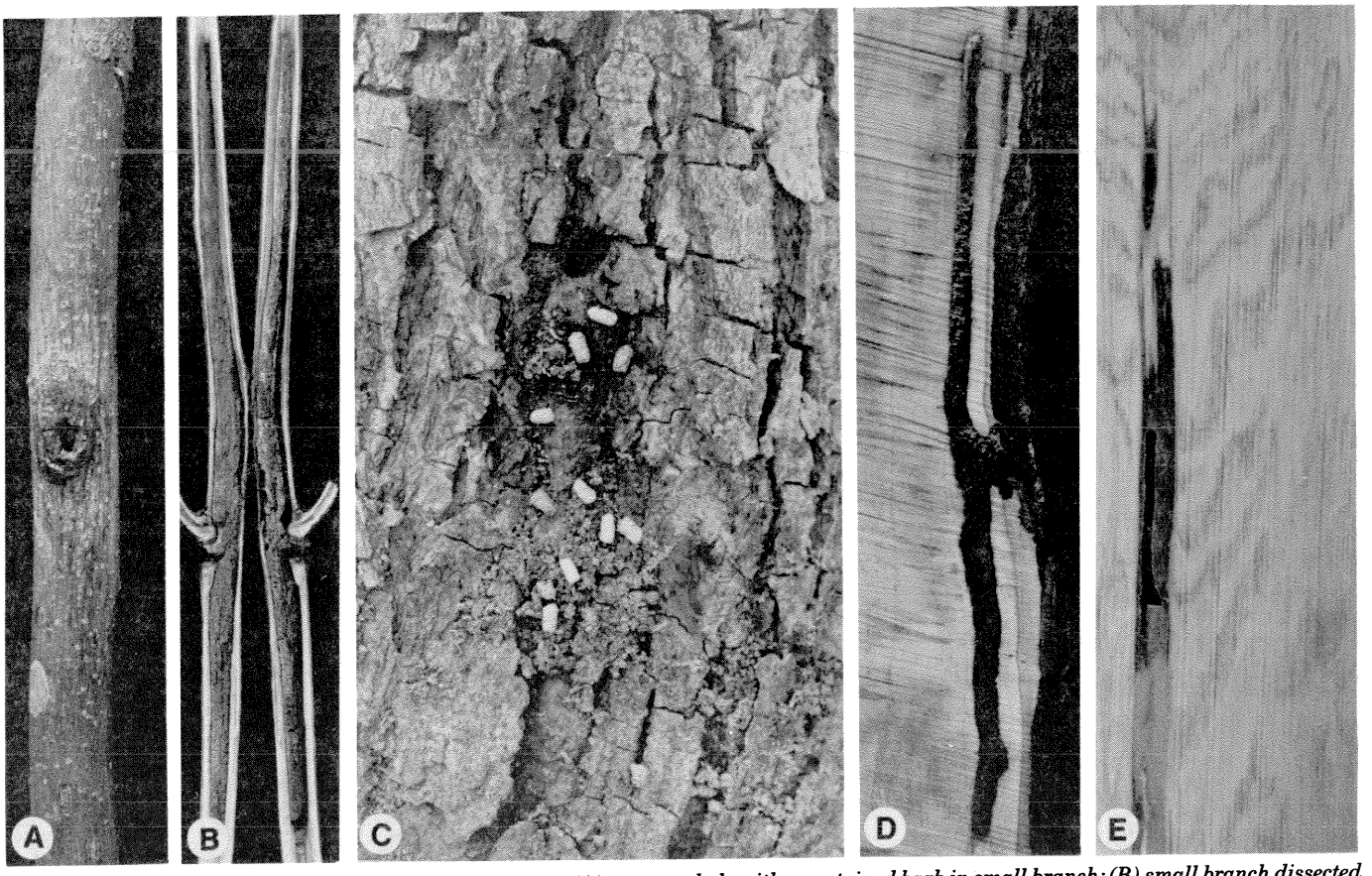


Figure 2.—*Injury by larvae of* Cossula magnifica *in pecan: (A) entrance hole with sap-stained bark in small branch; (B) small branch dissected to expose gallery; (C) entrance hole, frass, and stained bark in large trunk; (D) completed gallery in wood of large trunk; (E) wormhole and stain defects in lumber.*

branches and tunnel out the pithy center (fig. 2B). When the larva becomes too large for the small twig, it crawls out and enters a large branch. Entrances in twigs and small branches are usually made adjacent to buds, leaf petioles, or small secondary branches. The larva may tunnel up to 10 cm in both directions from the entrance hole, leaving only shells of small branches 10 to 13 mm in diameter. By early fall the larvae vacate their branch galleries, crawl downward on the bark, and bore into the trunk and large branches. Larvae attacking the trunk usually initiate galleries in bark crevices and tunnel horizontally or obliquely upward for 13 to 32 mm, then vertically for another 6 to 13 cm (fig. 2D). Many larvae also tunnel downward from the point of entrance another 5 to 10 cm. The cross-section of the vertical portion of the gallery is usually round, and about 6 mm in diameter. The wormholes and associated stain and decay show up as defects in the lumber (fig. 2E). The insect overwinters as a larva within the gallery. The following April or May the mature larva enlarges the entrance hole and then encloses itself and pupates in the upper end of the gallery behind a very peculiar but characteristic barrier or network of threadlike material. The sharp projection on the head end of the pupa enables the pupa to move through the barrier and down the tunnel to the entrance hole for emergence. Entrances to vacated galleries heal over, leaving uniformly round or oval bark scars in the bark (fig. 3). Although little is known about the life history, there appears to be one generation per year.

Control.—Although reported to occur throughout the South from North Carolina to Florida and west to Texas, infestations are generally widely scattered (Boethel and others 1980). Trees planted as ornamentals or in orchards, groves, or other open-grown situations are generally more heavily infested than those growing in well-stocked forest stands. Care should be exercised so that new plantings are not established adjacent to old orchards or stands heavily infested with carpenterworms. Keeping the trees in vigorous condition and free of disease cankers and mechanical injuries will help to prevent infestation. Two tachinid parasites, *Phorocera comstocki* Williston (Leiby 1925) and *P. signata* Aldrich and Webber have been reared, but little is known of their effect on carpenterworm populations. Small numbers of borers can be controlled by injecting a fumigant into the gallery and then using clay or putty to plug the entrance hole. Insecticides used periodically in groves to control nut

Figure 3.—*Round, oval scars in bark provide evidence of previous attack by* Cossula magnifica.

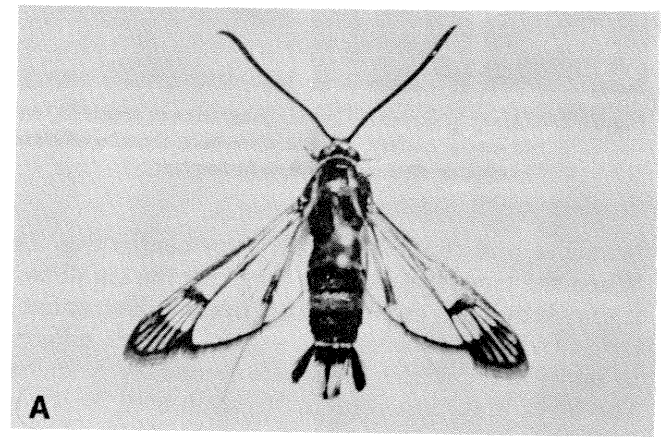
and foliar insects provide some, but not complete, control of carpenterworms. Chemical control specifically for pecan carpenterworm is seldom justified (Boethel and others 1980).

DOGWOOD BORER
Synanthedon scitula (Harris)

Importance.—Although the dogwood borer, *Synanthedon scitula* (Harris), is perhaps best known for its economic damage to the flowering dogwood for which it is named, it sometimes causes serious damage to pecan (Herrick 1904, Moznette and others 1931). It has also been found attacking hickory, oak, and many other species. It is known from southeastern Canada southward over the Eastern United States west to Texas. Damage results from the larvae feeding just beneath the outer bark in the phloem and cambium. Individual branches and even young trees may be completely girdled and killed, but most often the stem is only partially girdled or patches of bark killed. Attacks may occur at any point on the trunk and branches of trees of all sizes. Trees that are wounded, diseased, or in poor vigor are most susceptible to attack. It often attacks grafted and budded trees, destroying much of the cambium and callus tissue and preventing the union of scion and stock. Topworked trees have suffered serious damage in the past.

Description—The adult is a delicate bluish-black clearwing moth with yellow markings on the thorax, yellow-banded legs, and yellow stripes on segments two and four of the abdomen (fig. 4A) (Herrick 1904, Pless and Stanley 1967). Wings are transparent with bluish-black margins and have a wingspan of 14 to 20 mm. Eggs are pale yellow to brown, elliptical in shape, and about 0.5 mm long and 0.4 mm in diameter. Larvae are off-white to cream colored with reddish-brown heads, and range in size from less than 1 mm when newly hatched to 14 mm when mature (fig. 4B). The prothoracic shield has two dorsal yellowish-brown spots. The pupa is brown and remains inside a cocoon until time for adult emergence.

Evidence of Infestation.—The most easily recognized early sign of attack is the presence of fine frass that has been extruded from the tunnels through small openings in bark crevices (Herrick 1904, Underhill 1935). By cutting away the outer bark, larval tunnels and feeding larvae can be exposed (fig. 4B). When inspecting trees for damage, it is important to examine the lower trunk of young trees, especially around and just above the groundline. Trees wounded,



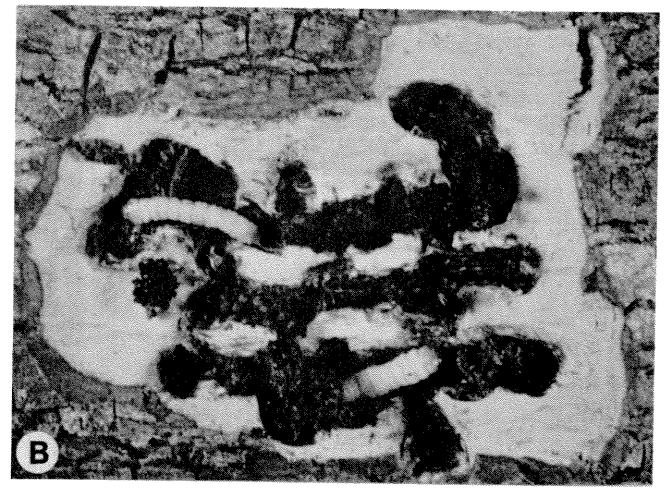


Figure 4.—*Life stages and tunnels of* Synanthedon scitula *in pecan: (A) adult clearwing moth; (B) bark removed exposing the larvae and burrows.*

diseased, or in poor vigor are most susceptible to attack and should be inspected frequently. After trees have been infested for a year or so, the dead bark over the borer tunnels begins to loosen and break away, sometimes exposing the wood beneath (fig. 5A). Trees that are badly infested may have an unhealthy appearance, exhibit dieback of branches in parts of the crown, and send out sprouts from near the groundline. Mortality occurs if trees are completely girdled. Graft failures should be inspected closely for evidence of infestation. Frass around fresh wounds and points of grafting and budding can mean the beginning of an infestation. Small brown pupal skins may be found protruding from the bark from April through October (fig. 5B). Exposure of infested sites by prying the bark loose frequently reveals one to a dozen or more larvae of various sizes feeding close together in localized tunnels.

Biology—Adults emerge from April to October with the greatest number appearing in the early part of the year (Pierce and Nickels 1941, Pless and Stanley 1967). Eggs may be deposited on the bark anywhere along the trunk or branches, although most are placed close to wounds, on or adjacent to frass, near openings produced by other borers, and around grafts or buds.

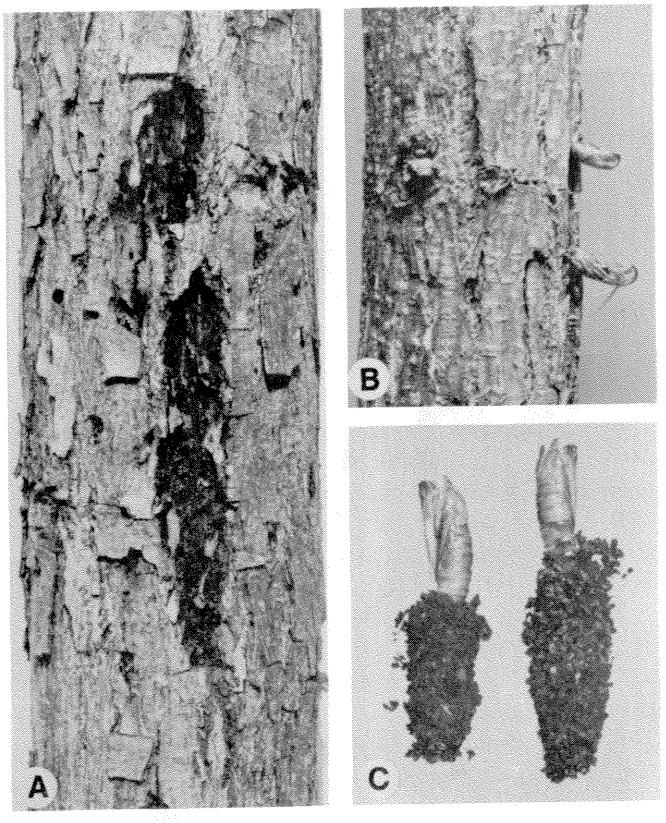


Figure 5.—*Evidence of attack by* Synanthedon scitula *in pecan: (A) active attack on trunk of young tree; (B) pupal skins in bark are positive signs of infestation; (C) dark-brown frass-covered cocoons just under the bark with protruding pupal skins.*

The eggs hatch in 8 to 9 days. Newly hatched larvae are small, fragile, and very sensitive to humidity; many die from dessication before locating a suitable niche to begin boring. The newly hatched larvae are able to move short distances and usually seek wounds, fresh grafts, and tunnels of other borers to become established, although a few are able to successfully establish burrows at uninjured sites. Larvae make irregularly shaped tunnels or burrows that spiral upward in the bark and cambium. Although the sapwood may be etched, no burrows are made into the sapwood. Larvae of various sizes overwinter in their burrows and are able to withstand a wide range of temperatures. The following spring the immature larvae continue feeding, while the mature ones pupate. The mature larva usually prepares a cocoon of frass and silken threads in the burrow beneath the outer bark for pupation (fig. 5C). Pupae within cocoons are rarely found in the leaves and trash around the base of the tree. The pupal stage lasts 8 to 12 days. There is one generation per year, with some evidence of a second generation in its southern range.

Control.—Except under conditions favorable for the borers, natural enemies usually keep infestations in check (Pless and Stanley 1967, Underhill 1935). Parasites that have been recovered are four braconids, *Apanteles sesiae* Viereck, *Agathis buttricki* Viereck, *Microbracon sanninoidae* Gahan, *M. mellitor* Say, two ichneumonids, *Phaeogenes ater* Cress., *Scambus (Itoplectis) conquisitor* Say, and one eulophid, *Hyssopus sanninoidae* Gir. In some cases, up to 50 percent of the larvae are parasitized. A disease caused by the fungus *Cordyceps* sp. has been found but is not prevalent. Woodpeckers excavate a small number of larvae. Adhering to recommended cultural practices for keeping trees vigorous and free of bark injuries is important in preventing serious damage due to dogwood borers. Direct control is seldom needed in natural stands but is sometimes needed in groves, nurseries, and ornamental trees (Pierce and Nickels 1941).

AMERICAN PLUM BORER
Euzophera semifuneralis (Walker)

Importance.—The American plum borer, *Euzophera semifuneralis* (Walker), a pest of pecan and hickory, has a wide host range, being especially troublesome to fruit trees (Blakeslee 1915, Pierce and Nickels 1941). It is widely distributed throughout the United States and is also found in Canada, Mexico, and Columbia, South America (Heinrich 1956, Forbes 1890). It is primarily a pest of trees in poor vigor, usually attacking trees that have been mechanically wounded or infected by canker-type fungous diseases. The larvae rarely succeed in establishing themselves on healthy, uninjured trees. Damage results from the

larvae feeding in the cambial area, sometimes girdling and killing small trees. It may also be found feeding on the callus tissue of recently grafted or budded trees. Graft failures are sometimes attributed to this borer.

Description.—The adult has a light-gray body with grayish-brown forewings that have a broad, wavy band of black and brown markings (fig. 6A) (Blakeslee 1915, Heinrich 1956, Forbes 1890). The hindwings are smokey gray with a distinct black margin. The wingspan ranges from 17 to 25 mm. Eggs vary from dull white when deposited to pink or brown as incubation progresses. Each egg is oval and measures about 0.6 mm long and 0.4 mm in diameter. The larva is white when newly hatched but the color varies from dull white to pinkish or reddish brown as it develops (fig. 6B). The head is dark brown and the cervical shield is pale yellow with black markings on the sides. Full-grown larvae range from 16 to 28 mm and average about 25 mm in length. The pupa is brownish black and is found inside a white silken cocoon.

Evidence of Infestation.—The most obvious sign of infestation is an accumulation of dark-brown or black frass adhering to the bark at the site of attack (Blakeslee 1915, Pierce and Nickels 1941). The frass typically is made up almost entirely of excrement pellets stuck or adhering loosely together by sap exudate and silken threads. Attacks are limited almost entirely to trees with mechanical wounds, frost damage, sun scalds, disease cankers, pruning wounds, and recent grafts and buds (fig. 7A). Patches of dead or diseased cambium or partially girdled stems are favored sites for invasion. Larvae, larval burrows that extend into the living tissue, and accumulations of frass can be exposed by lifting pieces of dead bark. The presence of one or more loosely woven cocoons of white silken threads under the bark is very characteristic of the American plum borer (fig. 7B). The white silken cocoons distinguish this borer from the dogwood borer, which has dark-brown or black cocoons usually entirely covered with frass. Attacks may be found on trees and branches of all sizes, but they are most commonly found on the lower trunk just above the groundline.

Biology.—The insect overwinters as a larva in a white silken cocoon under loose bark near the entrance to its feeding burrows (Blakeslee 1915, Pierce and Nickels 1941). Pupation occurs within the cocoon during March and early April and lasts 20 to 30 days. Adults emerge during April and May. The females mate and begin ovipositing 1 to 3 days after emer-

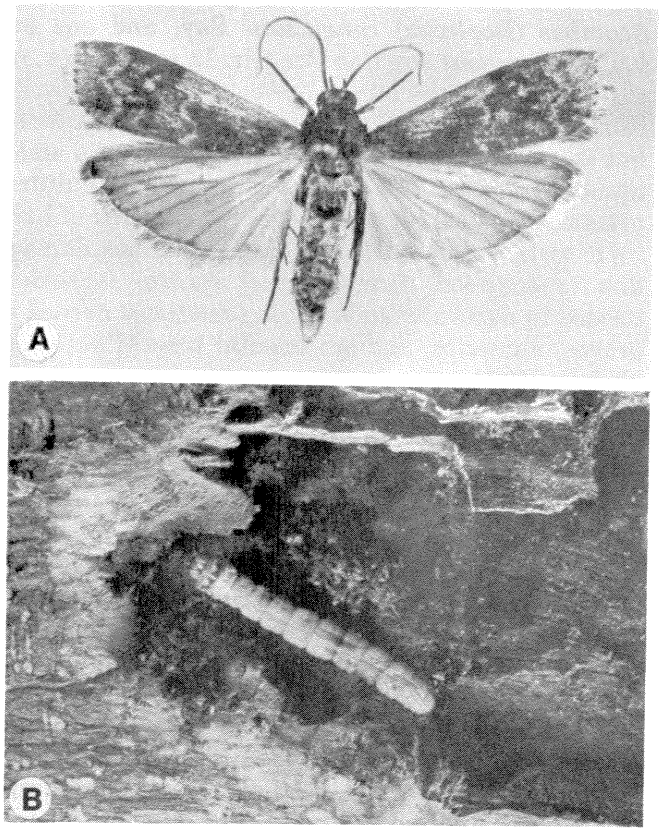


Figure 6.—*Life stages of* Euzophera semifuneralis: *(A) adult moth; (B) nearly grown larva.*

Figure 7.—*Evidence of infestation by* Euzophera semifuneralis *in pecan: (A) bark removed to expose tunneling injury; (B) closeup of white silken cocoons in mined cavity.*

gence and deposit eggs for 1 to 4 days. Females deposit from 12 to 74 eggs singly on twigs or in small groups in cracks and crevices of the bark of suitable host trees. The eggs hatch in 8 to 14 days and the young larvae seek wounds, cankers, and other suitable sites to begin feeding. The larval development period is 4 to 6 weeks. The mature larvae construct loosely woven cocoons of white silken threads under the bark for pupation. The pupation period for summer broods lasts 10 to 18 days, about half the time required for spring pupation. There are two or more generations per year. Larvae may be found almost continuously, indicating considerable overlapping of broods.

Control.—Because the insect is largely incapable of establishing itself in healthy, vigorous, uninjured trees, damage is unlikely except when trees suffer from frost injury, sun scald, mechanical wounds, or canker-type fungous diseases (Blakeslee 1915, Kelsey and Stearnes 1960, Pierce and Nickels 1941). Therefore, good cultural practices that prevent such injuries help to minimize damage from the American plum borer. Five ichneumonid parasites, *Mesostenus thoracicus* (Cress.), *M. gracilis* Cress., *Itoplectis marginatus* (Prov.), *Pimpla* sp., and *Idechthis* sp., help to suppress infestations. An unidentified threadworm parasite has also been reared. Predators include larvae of the ostomid, *Tenebrioides corlicalis* Melsheimer, ants, and woodpeckers. Chemical control is possible but seldom needed.

ACROBASIS SHOOT BORERS
Acrobasis spp.

Importance.—The acrobasis shoot borers are pests of pecan and hickory as well as black walnut and butternut from Ontario and Quebec in southeastern Canada southward to Florida and west to Texas in the United States (Baker 1972, Neunzig 1972). Some of the more important species include *Acrobasis nuxvorella* Neunzig, *A. juglandis* (LeBaron), *A. caryivorella* Ragonot, and *A. demotella* Grote. The acrobasis shoot borers are perhaps best known for their damage to foliage and nuts, although they often act as shoot borers during spring when growth begins (Payne and others 1979, Neunzig 1972). Boring and tunneling by the shoot borers cause many new tender shoots to become stunted, distorted, or die. Seedlings in nurseries can suffer serious damage. Mortality to the terminals of young trees intended for timber production is perhaps the most damaging type of injury (Kearby 1978). The destruction of terminals causes reduced growth and dichotomous branching, which results in forks, crooks, and abnormal branching. Repeated terminal injury during early growth can adversely affect the tree form that is so important when the goal is production of saw logs for lumber, veneer, and other products.

Description.—The adults are grayish to brownish moths with reddish, black, or white markings on the forewings and a wingspan of 12 to 20 mm (fig. 8A) (Payne and others 1979, Gill 1925, Neunzig 1972). The eggs are oval to elliptical, convex above and flattened below, with a reticular micropattern on the outer surface of the chorion. When first deposited, the eggs are greenish white, but they gradually assume a whitish and then reddish tinge as development progresses. Eggs vary from 0.5 to 0.8 mm in length and 0.25 to 0.36 mm in width. Newly hatched larvae are pale reddish brown and about 0.8 mm long. Mature larvae (fig. 8B) are cylindrical, taper slightly toward each end, and 10 to 19 mm in length. Head and mouthparts are dark yellowish brown; the prothoracic shield is pale brown; and the body is olive green to jade green, usually darker dorsally than ventrally. The newly formed pupa is olive green but gradually changes to light brown.

Evidence of Infestation.—Shoot damage occurs almost entirely during the spring (Martinat and Wilson 1978, Neunzig 1972, Payne and others 1979). The earliest evidence of injury may be holes in the swelling and unfolding buds. The majority of attacks to the shoot occurs after the buds have opened, but before there is much elongating or unfolding of the leaflets. Entrance holes are usually made into the basal part of the shoot just above the terminal leaf scar of the previous season's growth. However, some larvae make entrance holes some distance out on the shoot, usually where the inner base of a petiole joins the shoot (fig. 9A). Small amounts of frass are extruded from the gallery entrance and silked together to make a short loose tube, often forming an extension of the tunnel in all except *A. demotella,* whose larvae do not form a frass tube. The frass tube often becomes prominant as loosening bud scales and additional frass are silked together. Tunnels excavated in the tender shoots by the larvae range from 6 to 45 mm long (fig. 9B). The injury usually causes the terminal parts of the tender shoot to wilt, turn yellow and then brown, and die (fig. 9C). Tunneled shoots sometimes become enlarged, swollen, or gall-like. Injured shoots that survive often become stunted and deformed and lose apical domi-

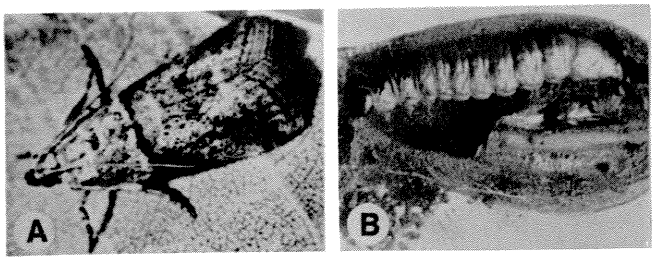


Figure 8.—*Life stages of* Acrobasis *spp.: (A) adult moth; (B) larva in burrow.*

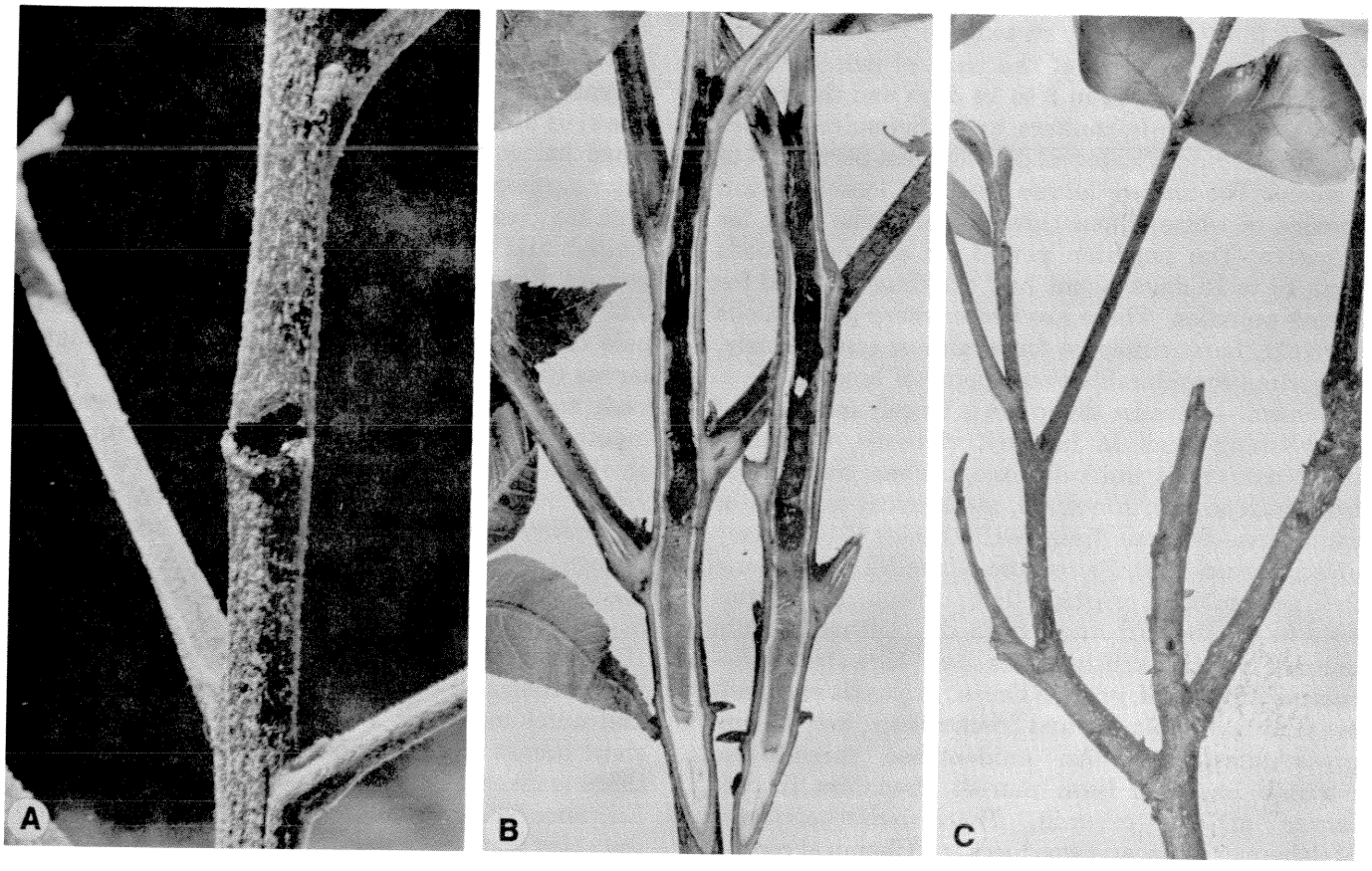


Figure 9.—*Signs of infestation by* Acrobasis *spp. in pecan: (A) entrance hole in terminal shoot; (B) young shoot dissected to expose gallery; (C) shoot terminal killed by larval tunneling.*

nance to a lateral shoot. The different species of *Acrobasis* can be partially separated by habits in attacking buds and shoots, site of entrance into the shoot, amount of tunneling, and characteristics of the frass tube and/or silking together of adjacent leaves, petioles, and shoots (Neunzig 1972).

Biology.—The shoot borers overwinter as partially grown larvae in tightly woven cocoons called hibernacula, typically found where a bud joins the stem (Neunzig 1972, Martinat and Wallner 1980, Payne and others 1979). The larvae emerge from the hibernacula in early spring and tunnel into the swelling buds and tender new shoots. When mature, a few larvae pupate within the galleries, but most vacate the tunnels and pupate under barkplates or drop to the ground and burrow into the litter or soil and pupate. The pupal stage lasts 11 to 18 days. Moths emerge and deposit eggs singly or in small groups, usually on nuts near the base of calyx lobes, on or near buds, and on the underside of leaflets. The eggs hatch in about 7 to 10 days. There may be one to four generations per year depending on species and north-south location. In the fall, third instar larvae construct and overwinter in hibernacula on or adjacent to a bud. Only during the spring do the larvae attack the shoots; later broods feed on the nuts and foliage (Payne and others 1979).

Control.—Natural enemies help in keeping the acrobasis shoot borers in check. Parasites are probably the most important group of natural controls; many species of parasites have been reported (Neunzig 1972, Martinat and Wallner 1980, Gill 1925). When new plantings are established, they should be located away from existing areas containing *Carya* and *Juglans* spp. Corrective pruning during early growth may be the best alternative to control, especially when plantings are intended for timber purposes (McKeague and Simmons 1978). Pruning should be done in May or early June, soon after the current season's shoot damage ceases. The pruning technique should retain the strongest newly developing shoot as the new terminal. Corrective pruning aims to reestablish apical dominance by one shoot in order to correct forks that may have resulted from terminal bud injury, thus improving tree form. Insecticides may be necessary when infestations are heavy (Payne and others 1979).

HICKORY SHOOT CURCULIO
Conotrachelus aratus (Germar)

Importance.—The hickory shoot curculio, *Conotrachelus aratus* (Germar), attacks pecan and hickory throughout the Eastern United States from Massa-

chusetts south to Florida and west to Texas and Kansas (Phillips 1964, Schoof 1942, Brooks 1922). Injury results from both adult and larval feeding. Injury from larvae tunneling within the new shoots and leaf stems is most damaging, resulting in premature foliage loss and weakening or death of nut-producing shoots. Loss of terminals in young trees intended for timber production can result in forks and abnormal trunk development. Heavy damage has occurred in twigs and shoots on young budded trees in nurseries. Severe infestations are found most often on unmanaged trees or in groves adjacent to woodlands containing native pecan and hickory trees (Payne and others 1979). Fifty percent or more of the shoots can become infested. Two other curculio shoot borers, *C. elegans* (Say) and *C. tibialis* Brooks, cause injuries similar to *C. aratus* but are less prevalent.

Description.—The adult is a weevil-type beetle with a short, stout snout that is slightly curved and about one-third the length of the body, or about as long as the head and thorax combined, and has the sternum grooved for reception of the beak (fig. 10A) (Brooks 1922, Payne and others 1979, Schoof 1942). The color is dull grayish to reddish brown with an indistinct broad band of yellowish pubescence behind the middle of the elytra and a narrow line of the same color on each side of the thorax. Adults average about 5 mm long and 2 mm wide. The egg is oval to oblong, creamy white, semitransparent, and averages 1.1 mm long and 0.7 mm in diameter. The larva is yellowish white with a brown head and black jaws and has a scattering of short but noticeable setae (fig. 10B). The larva is legless, slightly curved or crescent shaped, and averages about 6.0 mm long and 1.5 mm in diameter. The pupa is delicate and white but gradually darkens.

Evidence of Infestation.—Soon after growth begins in the spring, feeding and oviposition puncture marks made by adult curculios can be found on tender shoot tips and leaf petioles (Brooks 1922, Phillips 1965, Payne and others 1979). Egg punctures are characterized by dark triangular V-shaped marks or spots 3 mm long on the green bark. These dark puncture marks occur singly just above each leaf axil, but there may be 3 to 10 punctures per shoot. The favorite feeding place of the larva is in the bulblike swelling at the base of the leaf petiole, but it also mines in the pith of new shoots and leaf stems (fig. 11A). An active larval gallery usually has a small amount of dark frass at the entrance (fig. 11B). Dissection will reveal the crescent-shaped larvae. The burrows or galleries may range from 25 to 51 mm long (fig. 11C). The affected shoot tips and leaves usually become yellowish or brown and wither on the tree or drop away. Shoots that are heavily tunneled often break and drop without turning yellow and withering. Late summer and fall feeding by the newly emerging adults cause feeding puncture wounds along the shoot and leaf petioles, but late season damage is negligible.

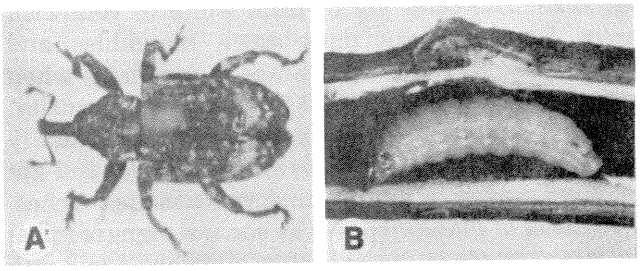


Figure 10.—*Life stages of* Conotrachelus aratus: *(A) adult weevil; (B) mature larva.*

Biology.—The hickory shoot curculio overwinters in the adult stage in litter, trash, or debris on the ground near host trees (Brooks 1922, Payne and others 1979, Schoof 1942). Adults emerge from hibernation and become active in early spring as buds begin unfolding and shoot growth begins. Feeding begins in late March and April in the south and 2 to 4 weeks later in the northern range. After feeding for a short time, females deposit eggs singly in puncture niches in the tender shoot tips and leaf petioles just above the enlarged petiole base. Eggs hatch in about a week and the larvae begin feeding and tunneling within the tender new growth where they complete their larval development. When fully grown by midsummer, the mature larvae vacate their galleries, drop to the ground beneath the tree, and burrow into the soil to a depth of 12 to 51 mm where they form unlined, earthen cells for pupation. The pupal period lasts for 2 to 3 weeks. The adult curculios emerge from the ground mostly during August and September. Emerging adults are comparatively inactive and feed very little before entering hibernation in the autumn. There is one generation per year.

Control.—Fifty percent or more of the larval population may be destroyed by parasites (Brooks 1922). The three species of parasites identified from the larvae are two tachnids, *Myiophasia globosa* (Townsend) and *Cholomyiae inaequipes* Bigot, and one chloropid, *Chaetochlorops inquilinus* (Coquillett). New plantings should be established, when possible, away from heavily infested woodlots. Sanitation and cultural practices such as clipping, collecting, and destroying infested shoots can reduce populations when only a single or few high-value trees isolated from surrounding host trees are involved. Elimination of trash and debris can also help to eliminate hibernation sites. Chemical control is usually not necessary but occasionally may be needed when many adults are present or when there is a history of damage (Payne and others 1979, Phillips 1965, Brooks 1922). Up to three spray applications, beginning in early spring when unfolding buds have 6 to 25 mm of new growth, may be necessary to control the adults before they lay their eggs.

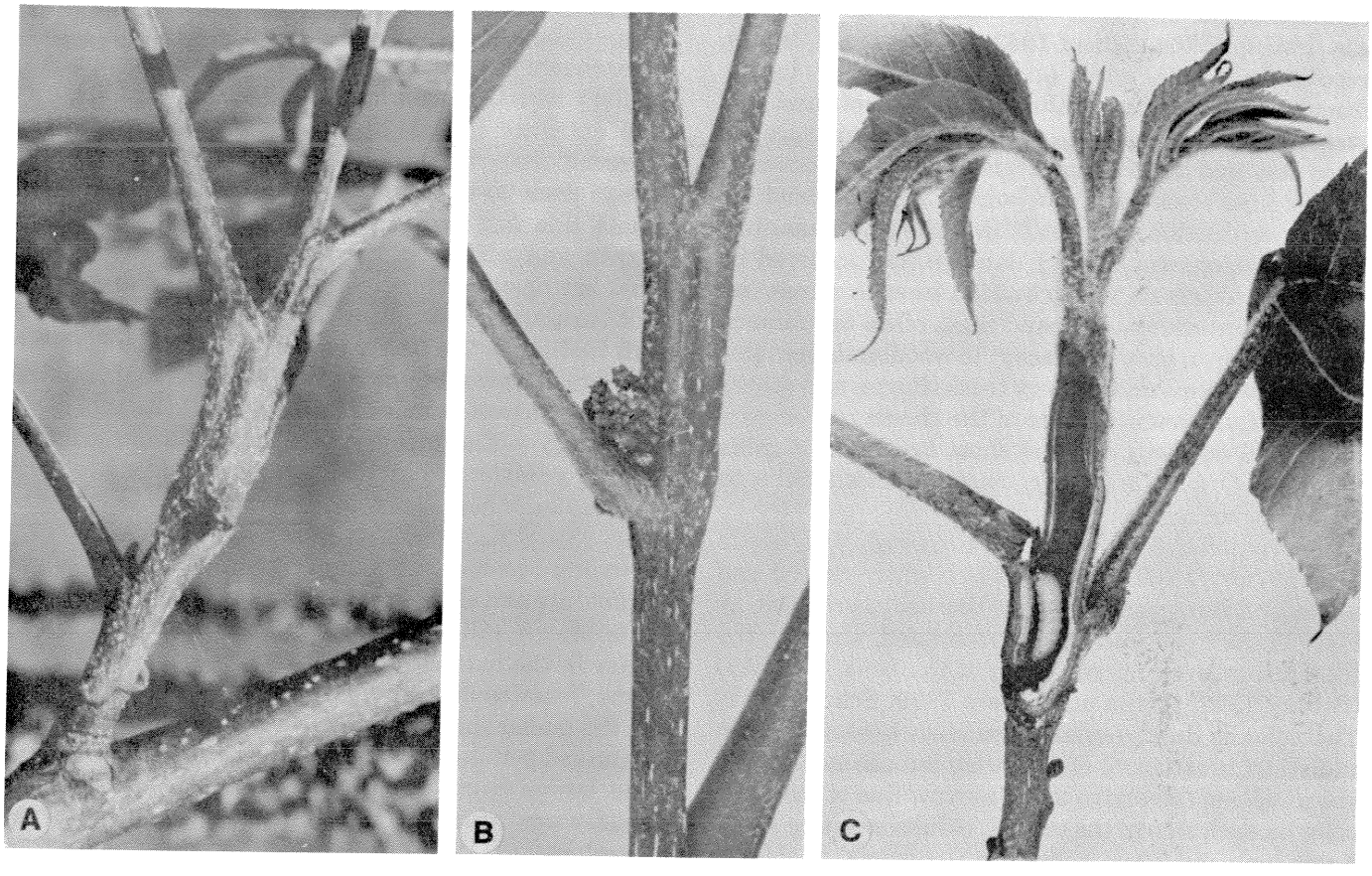


Figure 11.—*Young hickory shoots infested by* Conotrachelus aratus: *(A) swollen shoot with larval entrance hole; (B) dark frass being ejected from gallery entrance; (C) terminal dissected to expose gallery and young larva.*

HICKORY BORER

Goes pulcher (Haldeman)

Importance.—The hickory borer, *Goes pulcher* (Haldeman), is found from southern Canada throughout the Eastern United States, and although primarily a pest of the hickories, will occasionally attack pecan (Baker 1972, Beal and others 1952, Solomon 1974). The larvae tunnel in the sapwood and heartwood of young trees 2 to 14 cm in diameter, mostly from groundline up to about 5 m. Attacks in large trees are infrequent and usually restricted to the branches. Borer injuries in vigorously growing trees usually heal within a few months after the borers emerge, but in trees of poor vigor, up to 3 years are reguired. Galleries that heal slowly are frequently occupied by ants for nesting sites and sometimes kept open indefinitely, thus permitting the establishment of stain and decay fungi. Trunks weakened by tunnels, woodpecker excavations, and decay occasionally break during windstorms. The holes, together with the associated stain and decay, degrade the wood for any commercial use.

Description.—The adult is a typical long-horned beetle with a prominent lateral spine on each side of the pronotum (Solomon 1974). The beetle is light brown with dark elytral bands at the base and just beyond the middle of the wing covers (fig. 12A). They are moderately robust, elongate, and range from 17 to 25 mm long and 5 to 8 mm wide. Females are slightly larger than males and have heavier abdomens but slightly shorter antennae. The eggs are yellowish white, elongate, and average 4 mm long and 1 mm in diameter with a parchment-like surface texture. The larva is slightly robust, fleshy, and generally cylindrical but very slightly flattened dorsally and ventrally; the thoracic segments are slightly broader anteriorly (fig. 12B). The color varies from white to yellowish except for prominant dark-brown mandibles and amber spiracles. Larvae average 4 mm long when newly hatched and reach 18 to 28 mm at maturity. The pupa is white to greenish initially, but gradually becomes yellowish, and its eyes, mandibles, and appendages darken as adult transformation approaches.

Evidence of Infestation.—The earliest signs of infestation are single or small groups of niches 4 to 8 mm in diameter chewed in the bark exposing the

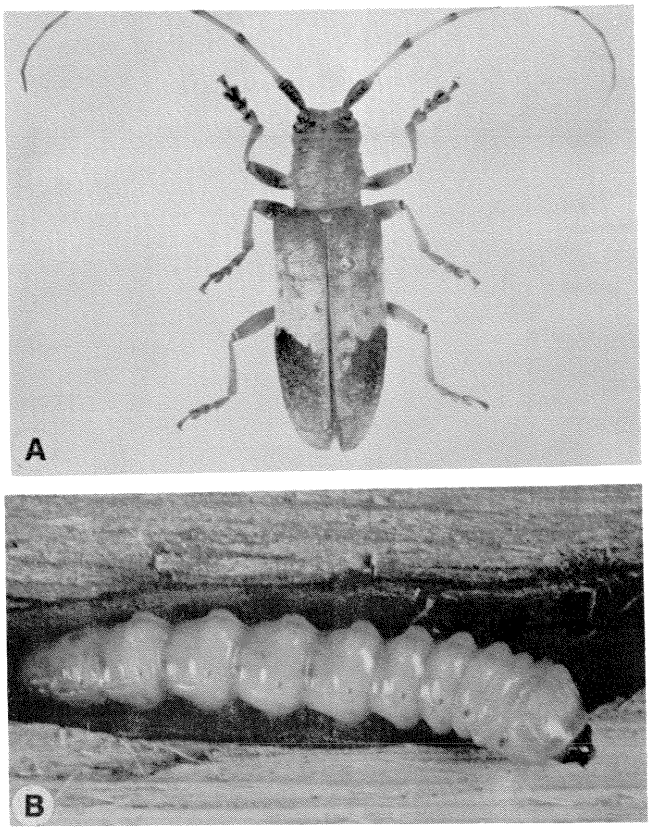


Figure 12.—*Life stages of* Goes pulcher: *(A) adult beetle; (B) mature larva.*

yellowish-brown phloem beneath (fig. 13A) (Beal and Massey 1942, Solomon 1974). However, the most obvious evidence is the sap-stained bark and yellowish frass protruding from the elongate entrance hole (fig. 13B). Sap oozing from the point of attack initially darkens the bark, but in succeeding years the stain becomes bleached or yellowish brown. The frass extrudes from the entrance in curved shapes or ribbon-like pieces that accumulate on the ground below. Numerous excelsior-like wood fibers 8 to 12 mm long in the frass signal larval maturity and approaching pupation. Each borer leaves two holes, an elongate entrance hole and a 7-mm round exit hole (fig. 13C). As these wounds heal, the bark scar at the entrance site appears slightly sunken, with a small bulge around the periphery. The exit hole heals in much the same way that a branch stub is overgrown. The bark scars remain in evidence for several years. Wormholes 10 to 13 mm in diameter in sawn lumber provide good evidence of hickory borer infestation (fig. 13D).

Biology.—The adults emerge during May and June (Solomon 1974). After feeding on tender twigs, leaf petioles, and leaf midribs and then mating, the female begins ovipositing. She chews an oval niche in the bark, then forces her ovipositor through the opening and downward between the bark and sapwood to lay a single egg. One female will deposit up to 14 eggs under experimental conditions on caged trees but would probably deposit many more under natural conditions. Adults live from 11 to 32 days. Females usually deposit their eggs singly, although clusters of two or three egg niches are sometimes found. Open-grown trees and those growing near openings are most frequently selected for oviposition, with a preference shown for branch crotches. The larvae produce small mines 1 to 2 cm in diameter under the bark and then bore directly into the sapwood. The galleries extend horizontally or obliquely upward in the sapwood and heartwood for 2 to 5 cm, rise vertically for another 6 to 12 cm, then turn horizontally back to the surface (fig. 13E). By the time the larva pupates, galleries range from 9 to 16 cm long and 10 to 13 mm in diameter. The life cycle is 3 to 5 years. During late fall and early spring of the final year of the life cycle, the mature larva prepares a pupation chamber at the uppermost portion of the gallery by plugging the gallery tightly with long excelsior-like fibers. Pupation lasts for 15 days. The new adult chews a round exit hole at the upper end of the pupal chamber to emerge.

Control.—Woodpeckers, one of the most important natural enemies, may capture up to one-third of the larvae (Solomon 1974). Some natural mortality is found in vigorous trees that produce heavy sap that oozes from the oviposition sites. Direct controls have not been investigated, but borers in individual trees can be controlled by injecting a fumigant into the galleries, then plugging the entrance holes with clay or putty. Where problems exist in plantings near or adjacent to forests, removal of brood trees in the adjacent woodland is advised.

BROADNECKED ROOT BORER
Prionus laticollis (L.)

TILEHORNED PRIONUS
Prionus imbricornis (Drury)

Importance.—The broadnecked root borer, *Prionus laticollis* (L.), and the tilehorned prionus, *P. imbricornis* (Drury), are pests of pecan and hickory as well as many other trees from southern Canada throughout the Eastern United States and extending west to the Plains States (Payne and others 1976, Linsley 1962). Injury occurs from the larvae feeding on and destroying the roots. The larvae feed first on the root bark, but they soon enter the wood, completely hollowing large roots and often severing them. The larvae move from root to root through the soil, feeding on the surfaces of smaller roots as they go, causing many injuries and wounds. Open-grown mature trees and those weakened by disease, drought,

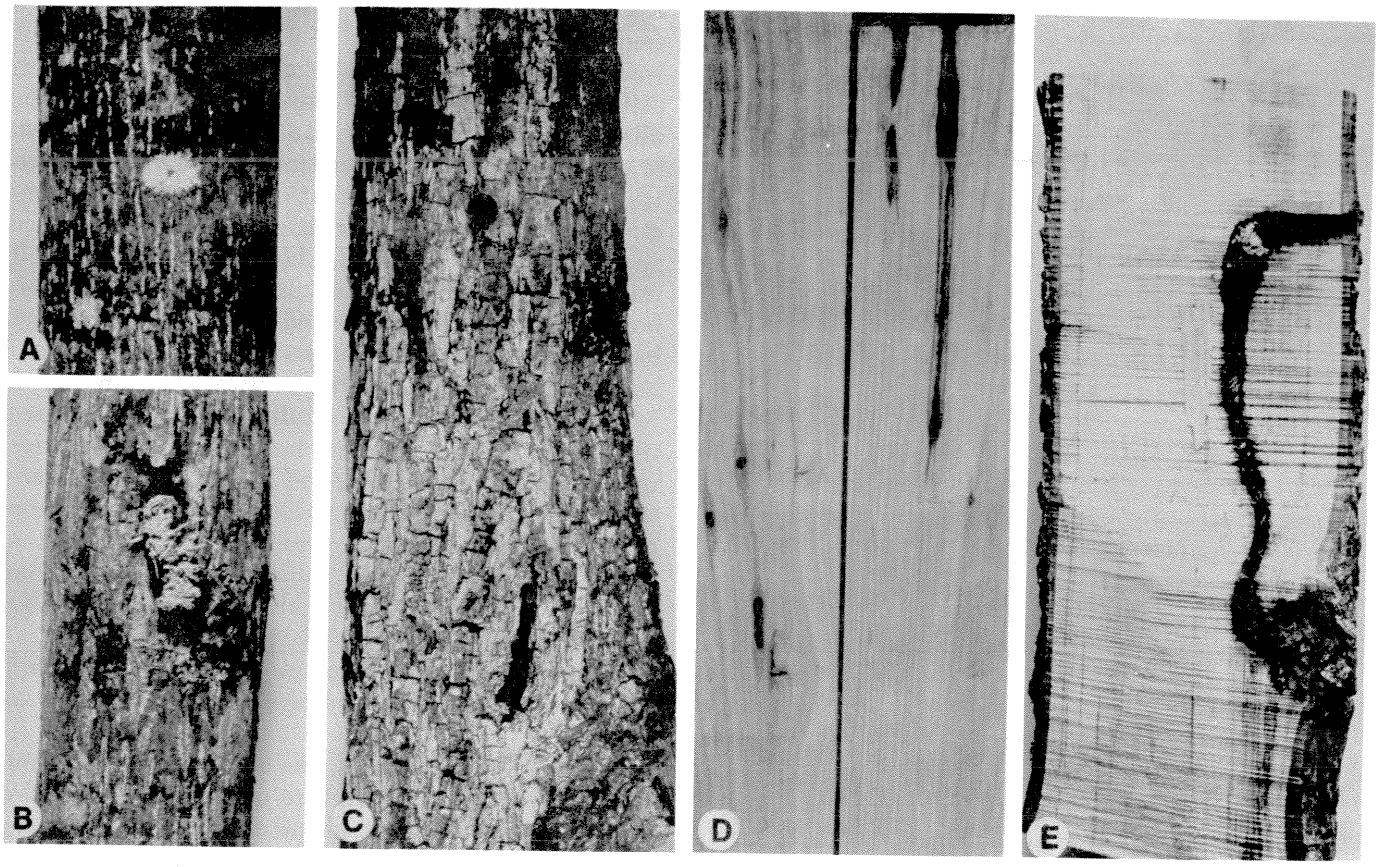


Figure 13.—*Habits and signs of infestation by* Goes pulcher *in hickory: (A) egg niche cut in bark by female beetle; (B) ribbon of frass being extruded from gallery entrance indicating active attack; (C) elongate entrance hole made by larva below and round exit hole made by adult above; (D) defects in sawn lumber; (E) sectioned stem showing typical larval gallery.*

mechanical damage, or soil conditions are most susceptible to attack, but young, vigorous trees can also be attacked and are occasionally cut off at the groundline. Severe root damage results in reduced growth, a poor nut crop, and eventual death of the tree. In southwest Georgia, pecan growers estimated that 3 to 10 percent of the trees showed signs of attack (Payne and others 1970).

Description.—The adults are robust, broad, somewhat flattened, and blackish brown to reddish brown (fig. 14A) (Linsley 1962). They have antennae about half as long as the body, and there are broad spines on each side of the prothorax. Adults of *P. laticollis* measure up to 45 mm long and adults of *P. imbricornis* measure up to 37 mm long. The eggs are irregularly punctate and glossy yellow, but later darken and lose their glossiness (Farrar and Kerr 1968). One end of the egg is slightly larger than the other. Eggs average 3.5 mm long and 1.4 mm wide. The large root-boring larvae are fleshy, elongate-cylindrical, and creamy white to yellowish; they have three pairs of small legs and small heads armed with strong mandibles adapted for boring in wood (fig. 14B) (Payne and others 1970). Mature larvae attain lengths of 9 cm or more and weigh up to 15 g. Pupation takes place inside earthen cells, and pupae are white initially, but their eyes, mandibles, and appendages darken as adult transformation approaches.

Evidence of Infestation.—Since injury to the roots occurs below ground level, correct diagnosis is often difficult (fig. 14C) (Payne and others 1970). Only by excavating the tree and examining the roots can one confirm the infestation (fig. 15A, 15B). The aboveground syndrome is a gradual decline, characteristic of any tree under severe, prolonged stress (fig. 16). Symptoms often resemble a nutrient deficiency—leaves may be sparse, reduced in size, and have a light-green to yellowish tinge. Nut yields from infested trees may be three to seven times less than from healthy trees. As an infestation progresses over a period of several years, 70 to 90 percent of the root system may be destroyed, resulting in a limb-by-limb death of the tree (Sparks and others 1974).

Biology—Adults emerge from the soil in late spring and early summer (Baker 1972, Benham and Farrar 1976). The beetles are normally nocturnal or crepuscular in habit and during the day remain hidden beneath debris or loose bark at the base of the tree. The females are short-lived—about 1 week—but deposit 300 to 500 eggs either singly or in groups in the soil

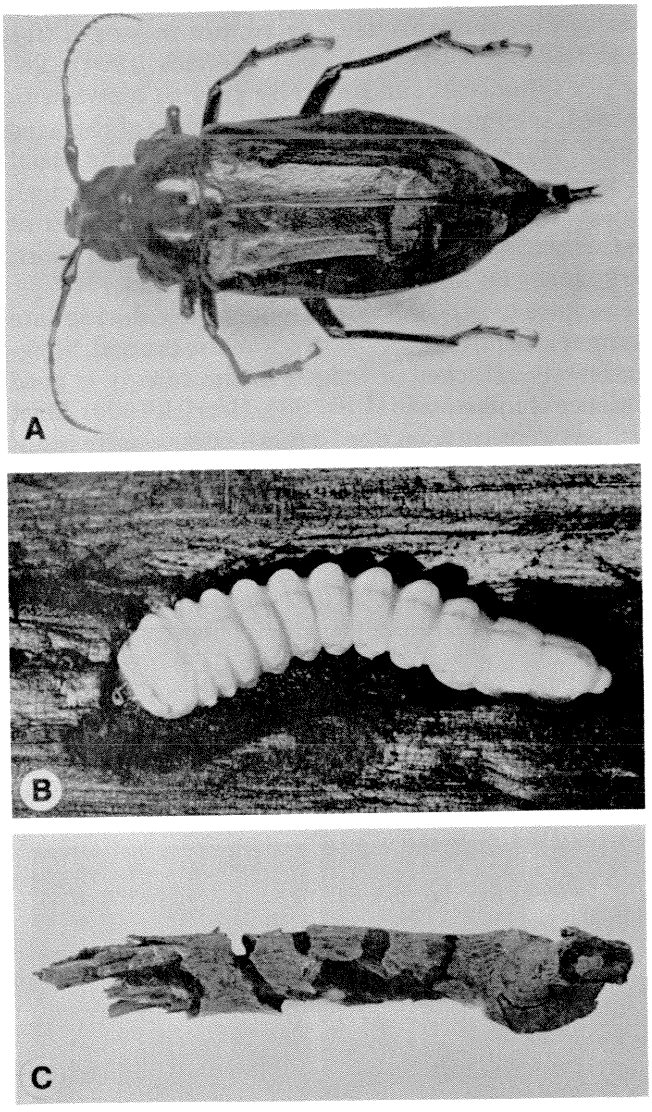


Figure 14.—*Life stages of and injury from* Prionus *spp: (A) adult beetle; (B) mature larva; (C) pecan root girdled and hollowed by larvae.*

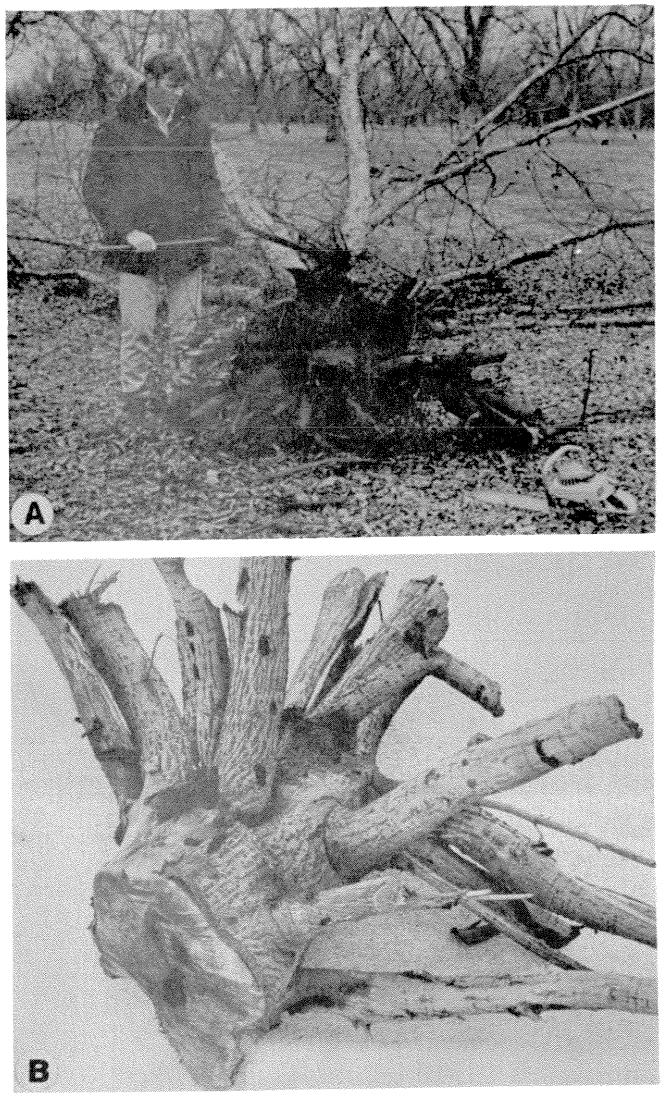


Figure 15.—*Diagnosing for* Prionus *spp. in pecan: (A) excavating roots to confirm* Prionus *infestation; (B) closeup of root system showing holes and girdling—most of smaller roots have been consumed by the larvae.*

near the base of host trees. When the eggs hatch in 2 to 3 weeks, the young larvae dig down to the roots and begin feeding on the bark. They move from root to root through the soil feeding on the surfaces of smaller roots as they go and causing many injuries and wounds. They enter the wood of larger roots and hollow, girdle, or sever them. In the summer, the larvae feed on roots in the upper 15 to 45 cm of the soil, but in winter they are often found at depths down to 80 cm. The feeding period lasts 3 to 5 years. In early spring, mature larvae come to within 6 to 12 cm of the soil surface and prepare large, oval earthen cells in which they pupate and transform to the adult stage.

Control.—Root borers usually attack trees weakened by other factors such as disease, drought, mechanical damage, or soil conditions (Sparks and others 1974). Therefore, cultural practices should be followed to keep trees thrifty and vigorous. Since these root borers are also pests of other tree species, it is advisable to establish new plantings some distance away from orchards and tracts of woodland that are already infested. Although little is known about natural enemies, they undoubtedly play a role in regulating root borer populations. A tachnid parasite (near *Dexilla)* has been reared from *P. laticollis* (Benham and Farrar 1976), and several bacteria and fungi have been isolated from dead larvae and pupae of *P. laticollis*. It may be necessary to use insecticides occasionally if root borer populations threaten high-value trees (Payne and others 1976).

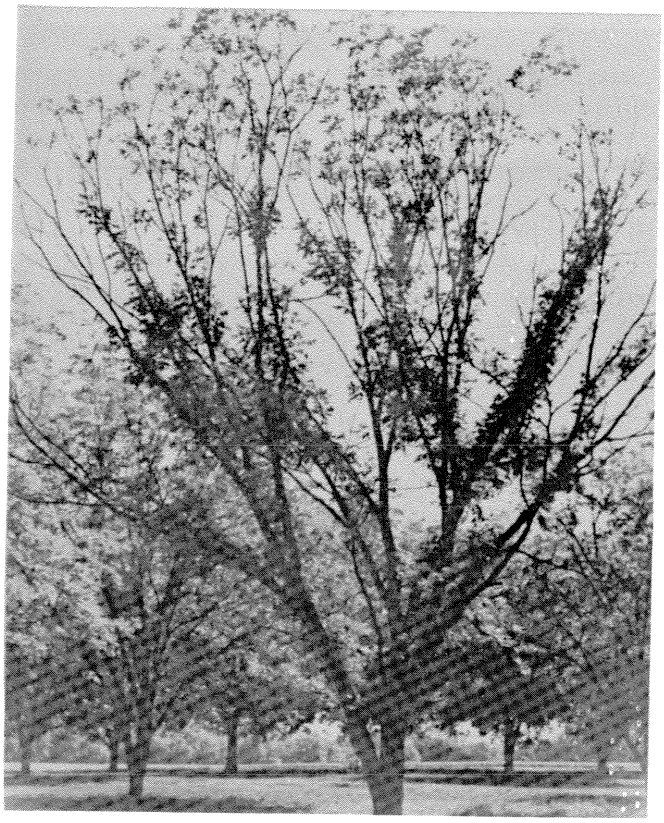


Figure 16.— *Pecan tree in declining condition—symptoms of root injury by* Prionus *spp.*

TWIG GIRDLER
Oncideres cingulata (Say)

Importance.—The twig girdler, *Oncideres cingulata* (Say), a pest of pecan and hickory, and to a lesser extent several other hardwood species, is found most commonly in the Southern States but is known as far north as New England and westward to Arizona (Gill 1924, Herrick 1904, Beal and Massey 1942). The adult beetles girdle twigs and small branches causing the injured portions to break away or hang loosely on the tree. It is not uncommon to see the ground under infested trees almost covered with twigs that have been cut off. This affects the beauty and aesthetic quality of ornamental plantings. The fruiting area of heavily infested trees is often greatly reduced, resulting in low nut yields the following year and sometimes longer. This type of injury causes the development of many offshoots that adversely affect the symmetry of the tree. Pecan nurseries located close to heavily infested woodlots occasionally suffer considerable loss from girdled seedlings. Repeated girdling of terminals causes forks, crooks, and other stem deformities in young timber plantations as well as in natural reproduction (Kennedy and others 1981).

Description.—The adults are typical long-horned beetles that range from 12 to 16 mm in length (fig. 17A) (Bilsing 1916, Gill 1924, Herrick 1904). The body is cylindrical and generally grayish brown with a broad, ashy-gray band across the middle of the wing covers. The eggs are white, elongate oval, and about 2.5 mm in length. The larvae are whitish, cylindrical, legless grubs that reach 16 to 25 mm in length at maturity (fig. 17B). The pupae are white with short, dark spines on the dorsal sides of segments.

Evidence of Infestation.—The presence during late summer and fall of severed twigs on the ground, hanging loosely attached or lodged in the canopy is good evidence of infestation (Gill 1924, Herrick 1904). Most girdled twigs are from 6 to 12 mm—occasionally ranging up to 18 mm—in diameter, and 30 to 60 cm in length. The nature of the girdle itself distinguishes the twig girdler from other branch pruners. The cut by the twig girdler is the only one made from the outside by the adult beetle and has been described as a uniform V-shaped cut (fig. 17A). The cut is seldom

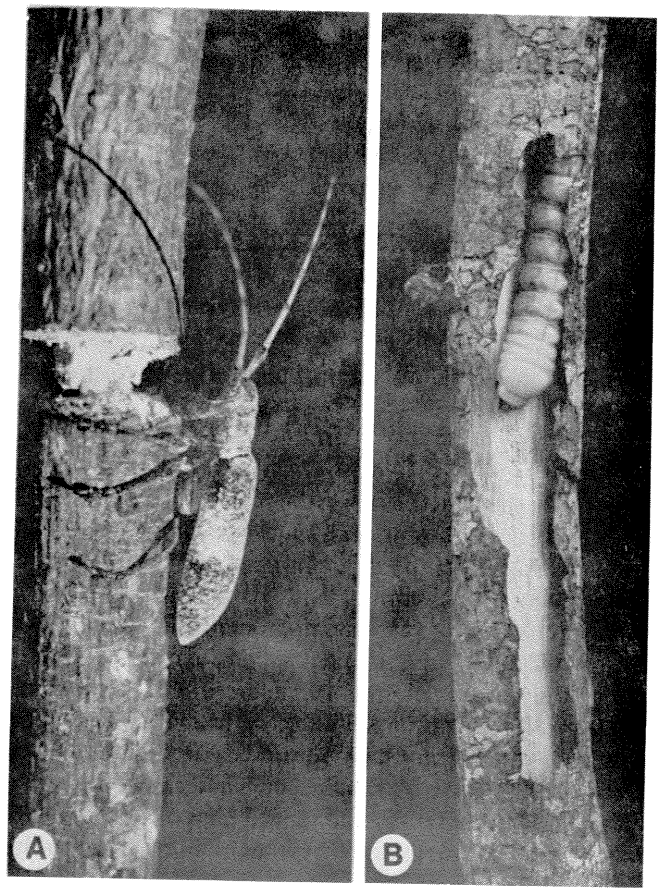


Figure 17.—*Life stages of* Oncideres cingulata: *(A) adult beetle girdling pecan stem; (B) mature larva in gallery.*

complete, leaving a small center with a jagged surface caused by the break. Since the twigs are girdled while the leaves are present, the severed twigs retain the brown leaves for some time (fig. 18). Severed twigs lodged in the tree canopy or on the ground often retain leaves even after the tree sheds its leaves in the autumn. Close inspection of the severed twigs will reveal tiny egg niches and many mandible marks or grooves made in the bark by the female beetles. Large trees usually sustain the most girdling, but young plantation trees are sometimes heavily damaged (fig. 19).

Biology—The adults emerge from late August to early October (Bilsing 1916, Gill 1924, Herrick 1904). They feed on the tender bark near branch ends and mate before ovipositing and girdling the twigs. The branches are apparently girdled by the female so that congenial conditions will be provided for the development of the larvae, which are unable to survive in living twigs. The girdling extends through the bark and well into the wood in a complete circle around the stem and leaves only a thin column of the center wood attached, which breaks easily (fig. 17A). Eggs are laid during or after the cutting process, but never before the beetle makes part of the cut. They are inserted singly beneath the bark or slightly into the wood, usually near a bud scar or adjacent to a side shoot. The number of eggs per twig varies from 3 to 8 but may range up to 40. Adults live 6 to 10 weeks. Females deposit 50 to 200 eggs each, which hatch in about 3 weeks. After overwintering, the larvae grow rapidly in the spring and tunnel toward the severed end of the twig by feeding only on the woody portion and leaving the bark intact. A few small circular holes are made in the bark to eject pellets of frass and excrement. The mature larvae close off the gallery with shredded fibers to form a pupation chamber. Pupation occurs during August and September and lasts 12 to 14 days. The adult chews a circular hole in the bark to emerge. There is one generation per year.

Control.—In orchards, nurseries, and ornamental plantings, the severed twigs on the ground as well as those lodged in the trees should be gathered and burned during the fall, winter, and spring when the eggs and grubs are in the twigs (Gill 1924, Moznette and others 1931). The same practice should be followed in nearby woodlots when plantings in the vicinity have a history of serious damage from this insect pest. Insecticides may be necessary to prevent damage from heavy infestations, although they are probably

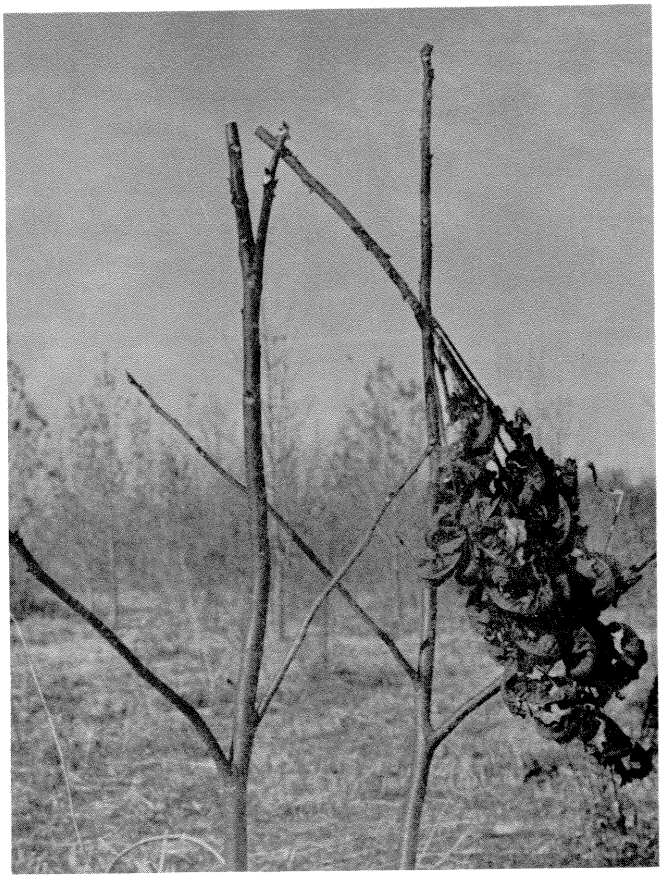


Figure 18.—*Main stem of young tree girdled by* Oncideres cingulata.

Figure 19.—*Young plantation tree with terminal and most of branches girdled by* Oncideres cingulata.

unnecessary in natural forest stands. Natural controls are important in keeping twig girdler populations low; desiccation of the eggs is apparently the greatest single decimating factor. Three parasites: an eurytomid, *Eurytoma magdalidis* Ashm., one ichneumonid, *Iphiaulax agrili* (Ashm.), and one eulophid, *Horismenus* sp., help to reduce the girdler population (Beal and Massey 1942). A clerid predator, *Cymatodera undulata* Say, has also been reared.

TWIG PRUNER
Elaphidionoides villosus (F.)

OAK TWIG PRUNER
Elaphidionoides parallelus Newman

Importance.—The twig pruner, *Elaphidionoides villosus* (F.) and oak twig pruner, *E. parallelus* Newman, are found throughout the Eastern United States northward to Canada and westward to Texas, reaching greatest importance in their northern range (Chittenden 1910, Linsley 1963, Moznette and others 1931). They attack pecan and hickory as well as other forest, shade, and fruit trees but show a marked preference for the oaks. The larvae, boring in the stems, cut off or prune twigs and small branches. Pruned twigs drop to the ground or hang loosely from partially severed branches. The ground under heavily infested trees may be littered with fallen twigs and branches. Such pruning and littering adversely affect the aesthetic quality of ornamental plantings and cause clean up problems; heavy twig losses reduce the fruiting area and, in turn, the nut crop; and young trees may be deformed. Injuries to trees in natural stands are seldom serious.

Description.—The adult beetles are elongate, slender, and parallel-sided (fig. 20A) (Chittenden 1910, Linsley 1963). The bodies are light to dark brown and clothed with irregular patches of fine gray hairs giving them a mottled appearance. There are spines on the first few joints of the antennae and the tips of the wing covers are notched and bispinose. They range from 12 to 18 mm in length. *Elaphidionoides villosus* resembles *E. parallelus* very closely, but *E. parallelus* is usually slightly smaller and somewhat more slender. The larvae are elongate, cylindrical, and creamy white; they have short rudimentary thoracic prolegs and measure about 14 to 22 mm in length at maturity (fig. 20B).

Evidence of Infestation.—During the summer, fall, and winter pruned twigs from 8 to 20 mm in diameter and from 20 to 90 cm in length litter the ground under infested trees (Gill 1924, Moznette and others 1931). Pruned twigs may also hang from the crown. The nature of the girdle itself distinguishes the twig pruners from the twig girdler and branch pruner. The cut by twig pruners is made from inside by the larva, which gnaws a circular groove in the wood, leaving only the bark intact. The severed end of the twig presents a smoothly cut surface, near the center of which is an oval 2-mm gallery opening often plugged lightly with frass (fig. 21). A smaller side-twig is usually hollowed out and may be broken in its fall to the ground. There are no egg niches or mandible marks on the bark surface as seen with the twig girdler. Moreover, splitting the freshly pruned twig reveals the nearly grown twig pruner larva inside, while the twig girdler either has not hatched or the larva is too small to be noticed until the following spring and summer.

Biology.—The adults emerge from early spring to early summer (Chittenden 1910, Gosling 1978). The female deposits her eggs in slits in the bark at leaf axils near the tips of very small green twigs that arise from a larger twig 8 to 20 mm in diameter. The young larva burrows down the center of the twig toward its base, hollowing it out more or less completely. When the larva reaches the larger limb, it bores into the branch and burrows a short distance down the center of the stem. In late summer or fall the larva severs the branch by making concentric circular cuts from the

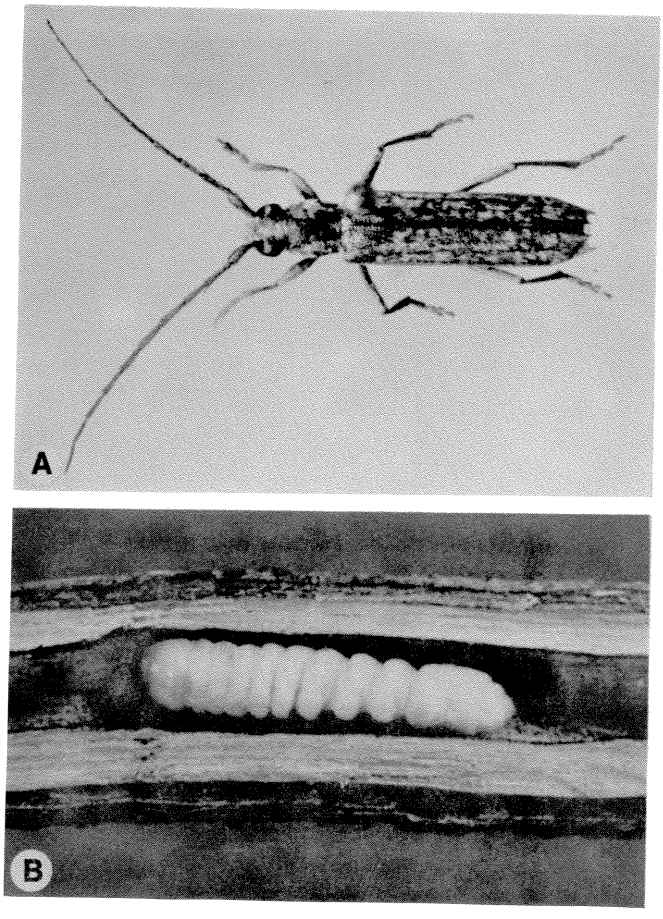


Figure 20.—*Life stages of* Elaphidionoides *sp: (A) adult beetle; (B) mature larva.*

center outward to, but not including, the thin bark. Severed branches later break and fall to the ground with the larvae in them. The larva retreats back into its burrow and plugs the oval gallery at the severed end with small fibrous frass and pupates within the burrow the following spring. There is usually one generation per year, but a 2-year generation life cycle has been reported for *E. parallelus* in its northern range (Gosling 1978).

Control.—Control of twig pruners in orchards, nurseries, and ornamental plantings is similar to that for the twig girdler (Chittenden 1910, Gill 1924). That is, all severed twigs on the ground or lodged in the tree should be collected during fall and winter and destroyed while the grubs are still in the twigs. To be most effective, the severed twigs should be collected over the entire orchard, woodlot, or neighborhood. Insecticides are rarely needed; natural controls help to keep infestations in check. Two braconid parasites, *Bracon eurygaster* Brulle and *Odontobracon elaphivorus* Rohwer, have been recovered from the twig pruner (Linsley 1963), while two braconids, *Meteorus tibialis* Muesebeck and *Iphiaulax eurygaster* Brulle, one ichneumonid, *Agonocryptus discoidaloides* Viereck, and one tachinid, *Minthozelia ruficauda* Reinhard, were reared from the oak twig pruner (Gosling 1978). The downy woodpecker, *Dryobates pubescens* L., blue jay, *Cyanocitta cristata* L., and black-capped chickadee, *Parus atricapillus* L., have been reported to destroy large numbers of the twig pruner (Chittenden 1910). A spider, *Theridium tepidariorum* C. Koch, has also been observed preying upon the twig pruner. Rodents, such as squirrels, have destroyed up to 31 percent of the oak twig pruner population in Michigan studies (Gosling 1978).

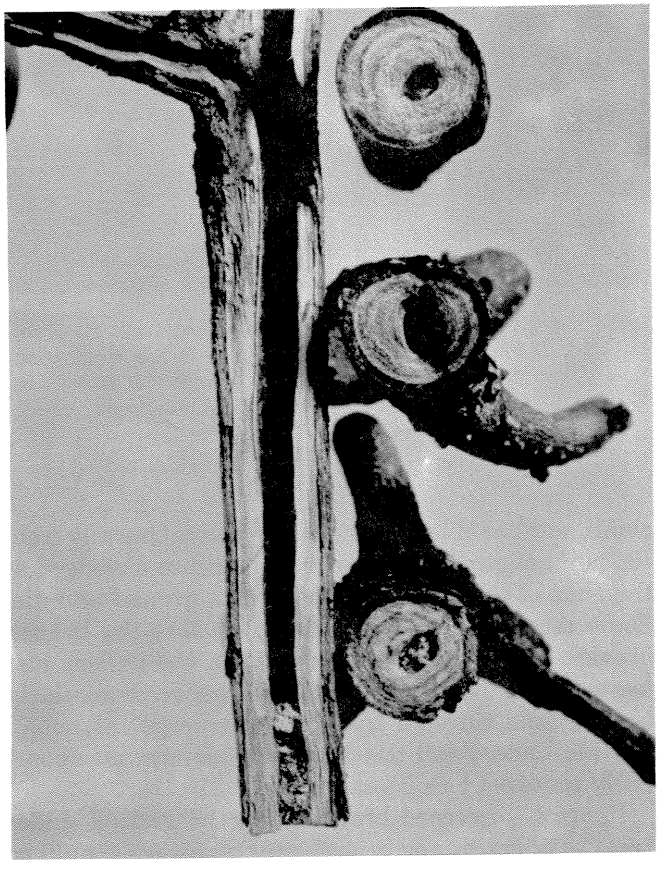


Figure 21.—*Larval gallery and ends of twigs severed by* Elaphidionoides *sp. Note oval holes with frass plugs in ends of severed twigs.*

BRANCH PRUNER

Psyrassa unicolor (Randall)

Importance.—The branch pruner, *Psyrassa unicolor* (Randall), attacks pecan and hickory, and to a lesser extent the oaks and a few other species throughout the Eastern United States from Minnesota south to Alabama and west to Texas (Linsley 1963). The larvae tunneling in the stems cut off or prune large branches. Pruned branches, due to their size and weight, usually drop to the ground; they seldom hang loosely from partially severed branches as seen with the twig girdler and the twig pruner. Although individually pruned branches are generally larger than those girdled by the twig girdler or the twig pruner, the number of pruned branches is usually less. Although individual shade and ornamental trees and occasionally orchard trees may be seriously pruned, entire stands or groves seldom sustain economic damage.

Description.—The narrow, elongate adults are colored light to reddish brown, have short and inconspicuous pubescence, and are coarsely punctured (fig. 22A) (Linsley 1963). The antennae are about as long as the body in the female and slightly longer in the male. In length, females range from 9 to 13 mm and males 7 to 11 mm. In width, females average 2.2 mm and males 1.8 mm. The larvae (fig. 22B) are slender, elongate, cylindrical, and whitish with dark-brown mandibles; they have yellowish thoracic shields, very short rudimentary thoracic prolegs, and measure about 12 to 18 mm long at maturity.

Evidence of Infestation.—Branches are pruned and fall to the ground during spring as opposed to summer, fall, and winter for those cut off by the twig pruners and twig girdler. Pruned branches are often much larger than those cut off by other pruners and girdlers, ranging from 10 to 50 mm in diameter and 0.6 to 3.6 m long. Pruned branches generally fall free to the ground, seldom hanging from the tree by the severed end as is true for the other pruners and girdlers (fig. 23A). The cut made by the branch pruner is similar to that of the twig pruner in that is is made from the inside by the larva, which chews a uniformly smooth, circular cut in the wood, leaving only the

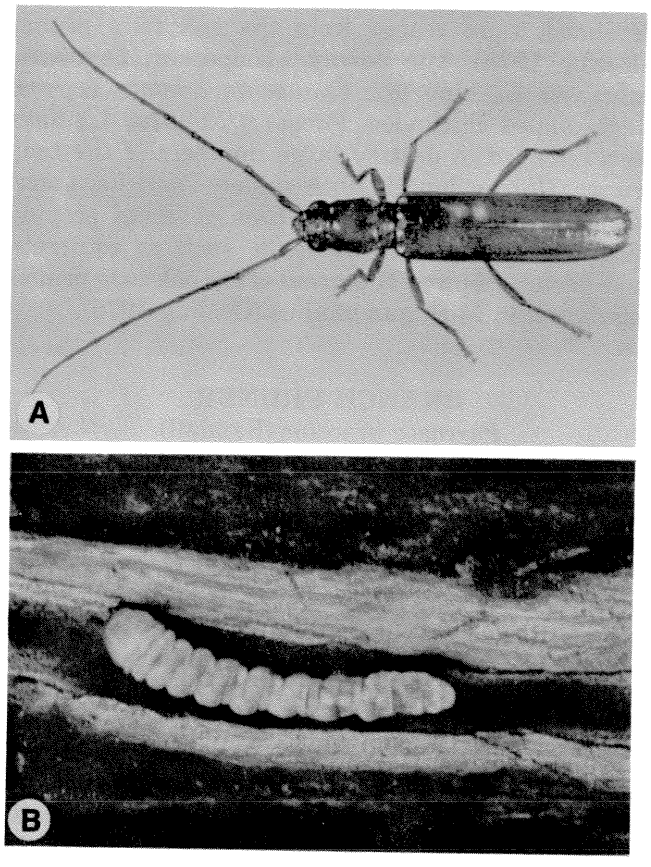


Figure 22.—*Life stages of* Psyrassa unicolor: *(A) adult beetle; (B) matura larva.*

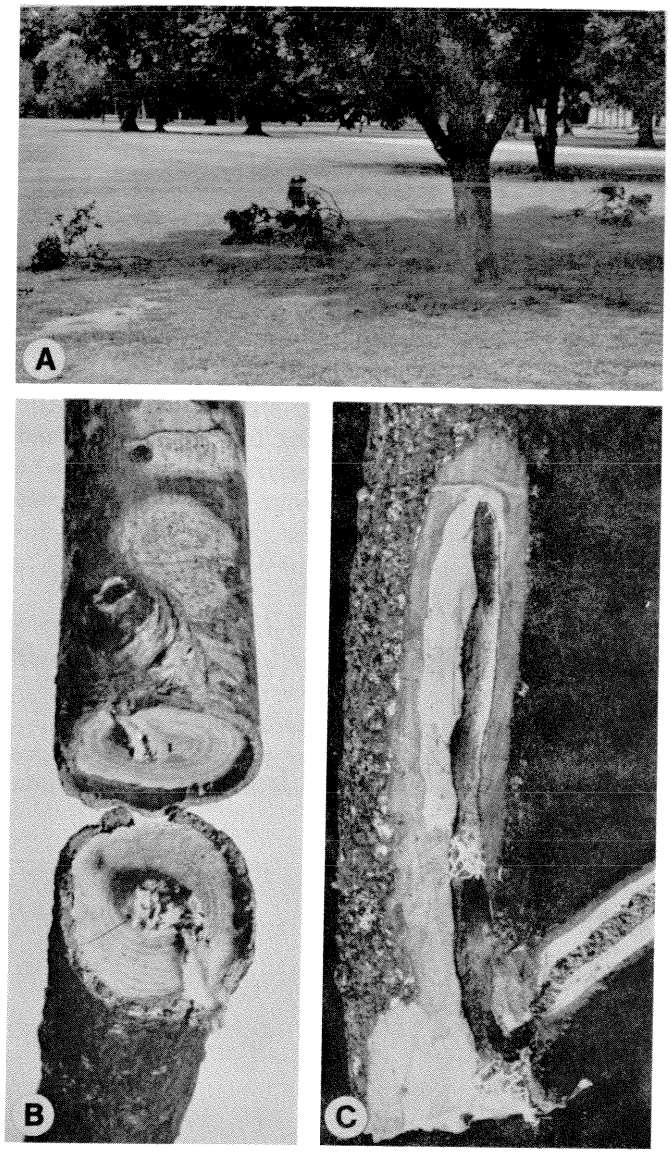


Figure 23.—*Evidence of infestation by* Psyrassa unicolor *in pecan: (A) large severed branches have fallen to ground; (B) severed branch illustrating nature of larval cut; (C) larval gallery extending from small side branch into severed main branch.*

bark intact (fig. 23B). It differs from the twig pruner in that the larval hole is not at the center of the twig, but instead is near one side, usually just below the bark near a small side-twig, and the hole is often plugged with frass. Although the larva usually tunnels in the pruned branch, it will sometimes tunnel in the pruned stub still on the tree.

Biology.—Adults emerge from late April to early June. Eggs are deposited on small twigs that arise from a larger branch 10 to 50 mm in diameter. The young larva tunnels down the center of the twig toward its base, but it does not hollow out the small twig as completely as *Elaphidionoides* spp. Upon reaching the larger branch, it bores into the branch and begins to girdle it. The girdle is completed during late winter and spring when the larva makes a smooth, uniform concentric circular cut, often completely severing the wood, but leaving the bark intact (fig. 23B). Severed branches may break at any time, but breakage occurs mostly during spring windstorms. If breakage does not occur immediately, the larva usually tunnels into the severed portion of the branch just beneath the bark near the junction of the small twig. Here it tunnels toward the center of the stem for 15 to 30 mm then back toward the surface, and finally tunnels distally just under the bark for 30 to 80 mm (fig. 23C). A small number of larvae, however, tunnel basally from the point of girdle. Larvae are sometimes dislodged at the time of the break and fall to the ground and die. Some retreat into the small twig before the branch breaks. Pupation takes place within the gallery just beneath the bark. The adult chews an irregularly shaped hole through the bark to emerge. Although the life history is little known, a generation apparently requires 1 to 2 years.

Control.—Severed branches on the ground under trees in orchards and ornamental plantings should be picked up in the spring and destroyed before the adults emerge in late spring and early summer. To be most effective, the pick-up and destroy practice should

be done for the entire orchard, woodlot, or neighborbood. Direct control in natural forest stands is rarely needed. Two icheumonid parasites of *P. unicolor*, *Labena grallator* Say and *Agronocryptus discoidaloides* Viereck, help to reduce infestations (Linsley 1963).

HICKORY SPIRAL BORER
Agrilus arcuatus Say

Importance.—The hickory spiral borer, *Agrilus arcuatus* Say, is primarily a pest of pecan and hickory but occasionally attacks other deciduous species throughout the eastern half of the United States (Beal and Massey 1942, Brooks 1926). Twigs, branches, and terminals up to 40 mm in diameter on trees of all sizes may be severed. Many of the severed branches break and drop to the ground. Serious damage to large trees results in reduced nut production, ragged appearance, and poor tree symmetry. Repeated attacks on young reproduction may cause stunted, misshapened, crooked, and forked stems. Although individual trees may be seriously damaged, entire stands, groves, nurseries, and other plantings are seldom badly damaged. Serious damage is most likely to be found in plantings adjacent or close to forested tracts containing many heavily infested hickories.

Description.—The adults are dark, slender buprestid beetles (fig. 24A) (Brooks 1926). The head and thorax of the male are greenish bronze, the wing covers are purplish black, and the underparts are brassy; the female is bronze in color throughout. The average length of males is 8 mm and that of females about 10 mm. Eggs are flat, disklike in shape, 0.8 to 1.1 mm in diameter, and glued firmly to the smooth bark of the twigs. They resemble the shield of a small scale insect. Initially the eggs are smooth and pale yellowish green, but before hatching they become slightly wrinkled and almost black. The larva is a slender, flat, legless grub, with full-grown specimens reaching 15 to 20 mm long and 2 mm wide (fig. 24B). They are yellowish white except for dark brown or black mouth parts and tail forceps.

Evidence of Infestation.—Branches and terminals are severed during the winter and spring (fig. 25) (Baker 1972, Brooks 1926). The portion above the girdle usually dies in the spring before the foliage appears, the injury becoming apparent as the rest of the tree puts forth leaves. Severed branches may break and fall to the ground either before or after bud-break in the spring. Stems 8 to 40 mm in diameter and 0.5 to 2.5 m long may be severed; although many of these stems are larger than those girdled by twig girdlers and twig pruners, on the average they are slightly smaller than those pruned by the branch pruner. The spiral cut made by the larva is a characteristic winding, concentric cut from the inner bark to the heart of the branch or stem, the coils of the thin burrow joining and completely severing the wood except for the bark and sometimes a slender fiber of wood at the center (fig. 26A).

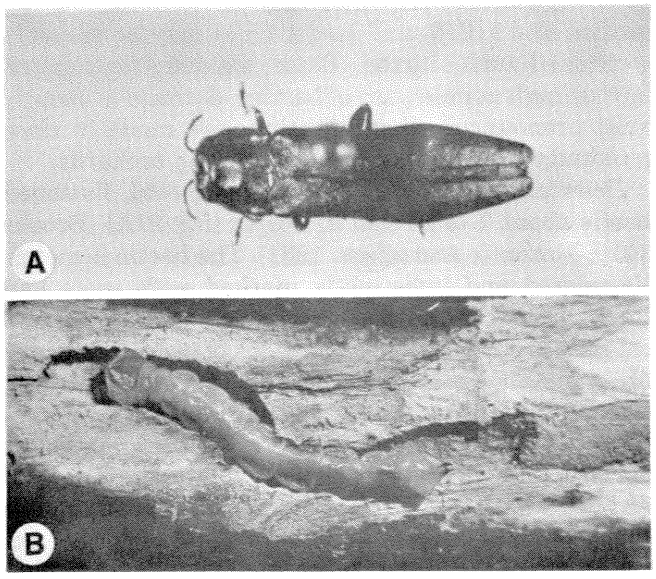


Figure 24.—*Life stages of* Agrilus arcuatus: *(A) adult beetle; (B) nearly mature larva.*

Figure 25.—*Young hickory with main stem severed by* Agrilus arcuatus.

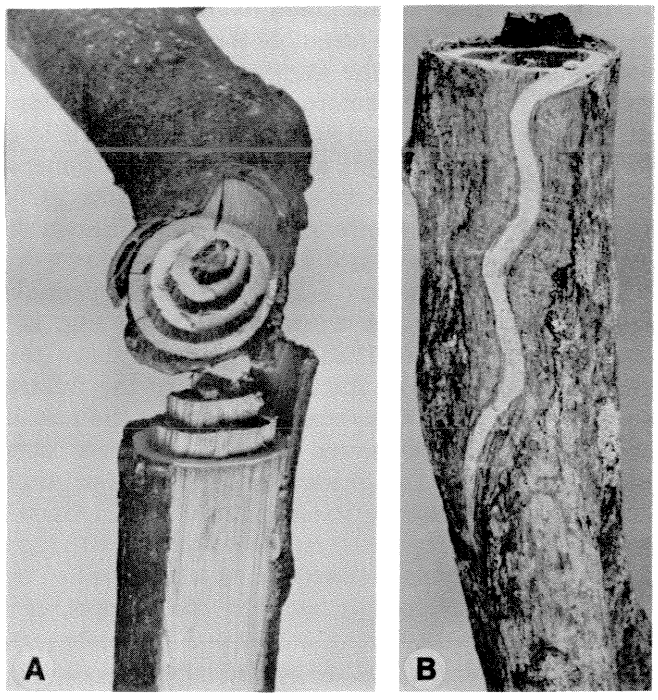


Figure 26.—*Characteristics of injury by* Agrilus arcuatus *in hickory: (A) severed branch illustrating spiral cut made by the larva; (B) bark removed to expose larval mine leading to the spiral cut.*

Biology.—Adults emerge from late April to late June, depending on location, and feed on the foliage, making elongate notches and slits in the edges of the leaves (Brooks 1926, Ruggles 1918). Females begin oviposition 10 to 14 days after emergence. A single egg is deposited on the bark surface of terminal or lateral twigs, usually near the base of a small shoot of the current season's growth, and is covered with a transparent secretion that glues the egg to the bark. Each female lays from 2 to 55 eggs over a period of 1.5 to 2 months. The eggs hatch in 3 to 4 weeks. The larva hatches by chewing its way through the bottom of the egg chorion and directly into the twig. In the twig it makes an elongate threadlike burrow under the bark. Late in autumn it begins a spiral burrow, partially severing the twig by spring. The mining larva packs the gallery behind itself with fine wood dust. During the second summer it mines basally under the bark along the stem for 20 to 60 cm leaving a shallow but relatively wide burrow packed with brown-colored frass (fig. 26B). During late fall it changes its course abruptly and cuts a thin symmetrical ring around the stem. When the first circuit is completed, it bores spirally inward, encircling the stem until the stem center is reached. The larva then turns upward toward the bark where it mines under the bark for 25 to 76 mm where it forms a crescent-shaped pupal chamber. The ends of the chamber extend to the bark, and the bottom curves toward the stem center. Both ends of the pupal chamber are plugged with frass. Pupation occurs during May and June and lasts about 3 weeks. The adult gnaws a D-shaped hole in the bark 25 to 76 mm above its spiral burrow to emerge from the pupal chamber. A generation requires 2 years.

Control.—Young trees in heavily infested nurseries and orchards should be pruned to remove the killed branches and terminals as soon as leaves develop in the spring in order to collect and destroy the larvae (Beal and Massey 1942, Brooks 1926, Ruggles 1918). Special care should be taken to remove the small dead twigs that have been severed by the first-winter larvae. Such twigs should be clipped several centimeters below the dead part in order to make sure of getting the borer. Also, any severed branches or terminals should be picked up and destroyed promptly before adult emergence begins. Three parasites: an ichneumonid, *Labena apicalis* Cress., a braconid, *Monogonogastra agrili* Ashm., and pteromalid, *Zatropus* sp. (near *nigroaeneus* Ashm.), help reduce populations (Brooks 1926).

FLATHEADED APPLETREE BORER
Chrysobothris femorata (Olivier)

Importance.—The flatheaded appletree borer, *Chrysobothris femorata* (Olivier), is a pest of pecan and hickory as well as many other deciduous trees, extending from Mexico throughout the United States into Canada (Baker 1972, Brooks 1919). It generally attacks trees that have recently been transplanted, stressed from various causes, or have bark that has been damaged by tools, disease, rodents, sun scald, or other insects. Injury results from the larvae tunneling in the bark and cambium area. Trees of all sizes may be attacked; those 5 cm or less in diameter may by girdled and killed, and larger trees may be severely weakened and scarred. Since wooded tracts often harbor high populations of beetles, damage is usually most pronounced when plantings are made in close proximity to woodland or old declining orchards.

Description.—The adult is a broad, oval, flattened beetle about 7 to 16 mm in length (fig. 27A) (Brooks 1919, Moznette and others 1931). The beetle is metallic colored and indistinctly marked with spots and irregular bands of dull gray. The underside is a coppery-bronze color and the sides beneath the wings are a metallic greenish blue. The egg is pale yellow, flattened, disklike, wrinkled, and about 1.5 mm in diameter. It is firmly attached to the bark by its flat surface. The larva is yellowish white, legless, and about 25 mm long when fully grown (fig. 27B). The three thoracic segments are much broadened and compressed, giving the larva the appearance of having a large flattened head, which accounts for the name "flathead." The larvae within their galleries

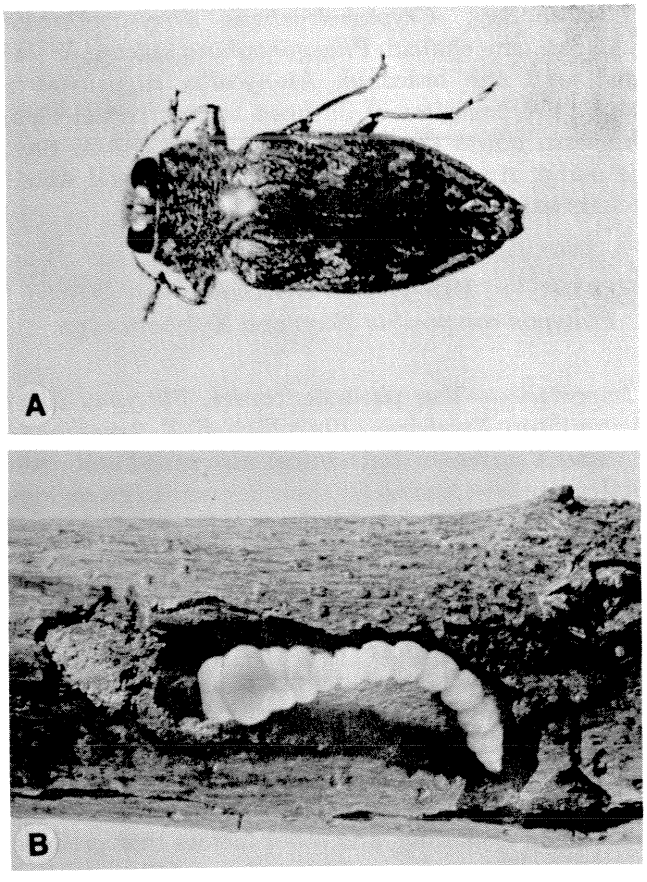


Figure 27.—*Life stages of* Chrysobothris femorata: *(A) adult beetle; (B) nearly mature larva.*

Figure 28.—*Signs of infestation by* Chrysobothris femorata: *(A) frothy sap oozing from bark is early symptom of infestation; (B) bark depressions, loosened bark, and oval exit hole provide evidence of infestation.*

nearly always assume the curved shape of a horseshoe. The pupa is somewhat more yellow than the larva and resembles the adult in structure.

Evidence of Infestation.—Points of infestation can usually be detected by white, frothy sap oozing from cracks in the bark (fig. 28A) (Fenton 1942, Brooks 1919, Moznette and others 1931). The bark gradually assumes a darkened, wet or greasy appearance. Little or no frass is ejected except at cracks in the bark. Injured areas usually become depressions, and later the bark may split at the injured sites (fig. 28B). Attacks occur most often on the sunny aspect of the tree. The burrows under the bark are broad and irregular and filled tightly with fine, sawdustlike frass. In young trees with thin bark, the tunnels are usually long and winding, sometimes encircling the tree. In older trees with thick bark, the burrows are confined to a circular area under the bark. Wounds may be enlarged year after year by succeeding generations. As mentioned previously, attacks are often associated with injuries. Trunks may be attacked at any point above ground level; branches may also be attacked.

Biology.—Adults appear from March to November, but they are most abundant during May and mid-August to mid-September (Fenton 1942, Moznette and others 1931). Beetles are active, run rapidly, and take flight quickly when disturbed. On hot, clear days, they may be found on the sunny side of trunks and larger branches. The female spends much time running over the surface, probing the bark with her ovipositor for places to oviposit. Females mate and begin ovipositing in 4 to 8 days; they live about 1 month after emergence. Each female lays about 100 eggs, depositing them singly in cracks or crevices of the bark, under bark scales, and at bark injuries. Eggs hatch in 8 to 16 days. The newly hatched larva chews through the bark and feeds in the phloem and surface of the sapwood. In trees sufficiently weakened, the larvae produce long tortuous burrows and develop rapidly. In more vigorous trees, larval development is slow and many larvae die, probably due to heavy sap ooze. As soon as the larva is fully developed, it tunnels from the cambium area radially into the sapwood where a pupal chamber is prepared by plugging the burrow tightly with frass. Here it overwinters as a larva. The larva pupates during the following spring or summer. The pupal stage lasts about 8 to 14 days. Adults emerge by cutting small oval emergence holes through the bark (fig. 28B). Nor-

mally there is one generation per year, but some generations require 2 to 3 years.

Control.—Because flatheaded borers rarely injure healthy, vigorous trees, cultural methods should be selected that keep trees vigorous, such as proper transplanting, cultivation, fertilization, spraying, pruning, thinning, and irrigation (Baker 1972, Brooks 1919, Fenton 1942, Moznette and others 1931). Since young transplanted trees are under stress and particularly susceptible, additional measures may be warranted such as wrapping the trunks with a double thickness of newspaper, burlap, or crepe paper from the ground to the lower limbs to prevent oviposition (fig. 29), or by shading the trunks from sunlight to deter the ovipositing females. Painting the trunks white to reduce injuries from sun scald may also help. Injuries by equipment, storm, frost, and other causes should be minimized and any fresh wounds promptly painted with pruning compound. Borers may be removed from individual trees with a knife, being careful to avoid unnecessary cutting and damage. All dead and dying trees and all pruned branches should be removed from ornamental and orchard plantings to reduce breeding sites for the beetles. Natural enemies also help to reduce flatheaded borer populations. Two ichneumonids, *Labena grallator* Say, *Cryptohelcostizus chrysobothridis* Cushman, one chalcid, *Phasgonophora sulcata* Westwood, and one braconid, *Atanycolus rugosiventris* Ashm., are parasites of flathead borers; two clerids, *Chariessa pilosa* (Foster) and *C. pilosa onusta* Say, one asilid, *Andrenosoma fulvicauda* Say, and woodpeckers are predators.

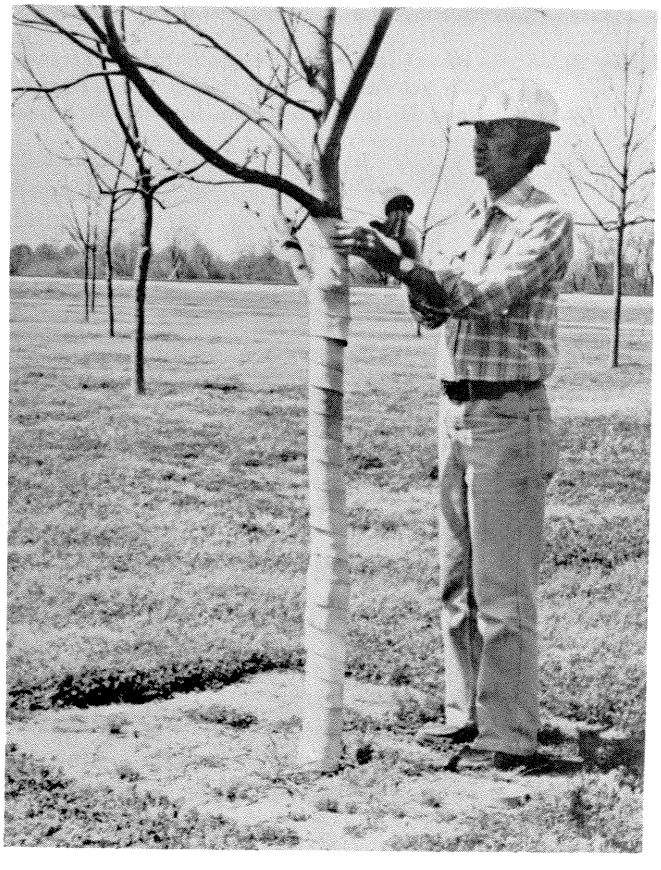


Figure 29.—*Wrapping trunk of young transplanted pecan tree with crepe paper for protection from* Chrysobothris femorata.

PIN-HOLE BORERS

Platypus compositus (Say) and *Xyleborus* spp.

Importance—The pin-hole borers, *Platypus compositus* (Say), *Xyleborus affinis* Eichoff, *X. ferrugineus* (F.), and *X. saxeseni* (Ratzeburg), also called ambrosia beetles, are best known for their damage to green logs and unseasoned lumber. They inhabit the trunks and branches of pecan and hickory as well as many other deciduous trees (Baker 1972, Bright 1968). The *Xyleborus* spp. are widely distributed from Canada throughout the eastern half of the United States. *Platypus compositus* is found from Mexico throughout the Southern United States northward to West Virginia. Ambrosia beetles seldom attack healthy, vigorous trees; their attacks are largely limited to stressed trees weakened from drought, disease, old age, insect defoliation, wounding, and other factors that produce tree stress. Thus, when trees are successfully attacked by ambrosia beetles, one can be sure that the trees have been under stress of some sort. The beetles tunnel through the bark directly into the sapwood and sometimes even into the heartwood, especially *P. compositus*. Although ambrosia beetles are not tree killers, the physical wounds produced by large numbers of beetles provide ports of entry for disease agents that may cause tree death. The pinholes and associated stain quickly degrade the wood for lumber and other wood products.

Description.—Adults of the *Xyleborus* spp. are small, brown, reddish-brown, or black elongate beetles with compact cylindrical bodies that vary from 1.5 to 3.0 mm in length (Bright 1968, Chamberlin 1939, Blackman 1922). The adults of *P. compositus* can be distinguished by having longer and more slender bodies and wide heads flattened in front (fig. 30A). The first segment of the tarsus is as long as all the other tarsal segments combined and about 4.5 mm in length. The eggs are elongate oval and pearly white. The larvae of *Xyleborus* spp. are C-shaped, legless, white to cream colored, and reach 3 to 4 mm in length; larvae of *P. compositus* (fig. 30B) are straight to only slightly C-shaped, legless, white to cream colored, and reach 5 to 6 mm in length.

Evidence of Infestation.—Infested trees are usually attacked by numerous beetles that bore many uniform, round (0.8- to 1.7-mm diameter) holes directly

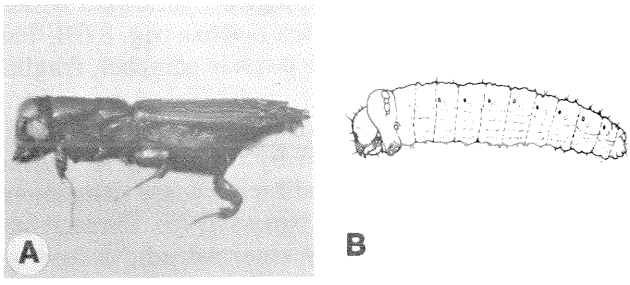


Figure 30.—*Life stages of* Platypus compositus: *(A) adult beetle; (B) nearly mature larva.*

through the bark into the wood (Chamberlin 1939). As the beetles construct their galleries, they push the fibrous (*P. compositus*) or granular (*Xyleborus* spp.) boring dust to the outside through the entrance holes (fig. 31A). The boring dust is usually in evidence on the bark just below the entrance holes or in loose piles at the base of the tree; during humid weather it may stick together as it is pushed out to form string-like masses. Sap frequently oozes from many of the entrance holes, staining the bark around and below the entrances. Active galleries are kept free of boring dust and are light colored; vacated galleries are stained black by fungi. The galleries extend directly into the sapwood and then branch several times—the branching pattern depending on the species (fig. 31B). These galleries cause dark-stained pinholes that will show up as defects in sawn lumber (fig. 31C).

Biology.—In the deep South the beetles are active most of the year, but further north they hibernate in brood galleries in the host tree (Chamberlin 1939). In the spring the adults emerge and initiate new attacks on the same tree or on different trees. Both adults and larvae feed on moldlike fungi that they culture in the galleries. The insects carry the specific inoculum from one tree to another and grow the fungi in pure culture on the walls of the tunnels. Galleries 0.8 to 1.6 mm in diameter are bored horizontally into the sapwood, then branch several times for a distance of 10 to 40 cm. Galleries of *P. compositus* are much more extensive and extend deeper into sapwood and heartwood than those of *Xyleborus* spp. Females deposit eggs in loose clusters in the galleries and may lay up to 200 eggs each. The eggs hatch in 6 to 10 days, and the young larvae wander freely about the mines and feed on the ambrosia fungus. Several adults may occupy each gallery. Both adults and larvae help to excavate and extend the galleries. When full-grown, the larvae of *P. compositus* excavate cells along the main gallery in which they transform to pupae and adults; those of *Xyleborus* spp. pupate freely in the galleries without making cells. Development from egg to adult during the summer requires 5 to 8 weeks. There are several generations per year in the Gulf Coast States. Successive broods may continue to attack a tree as long as it remains suitable. Infested trees that die

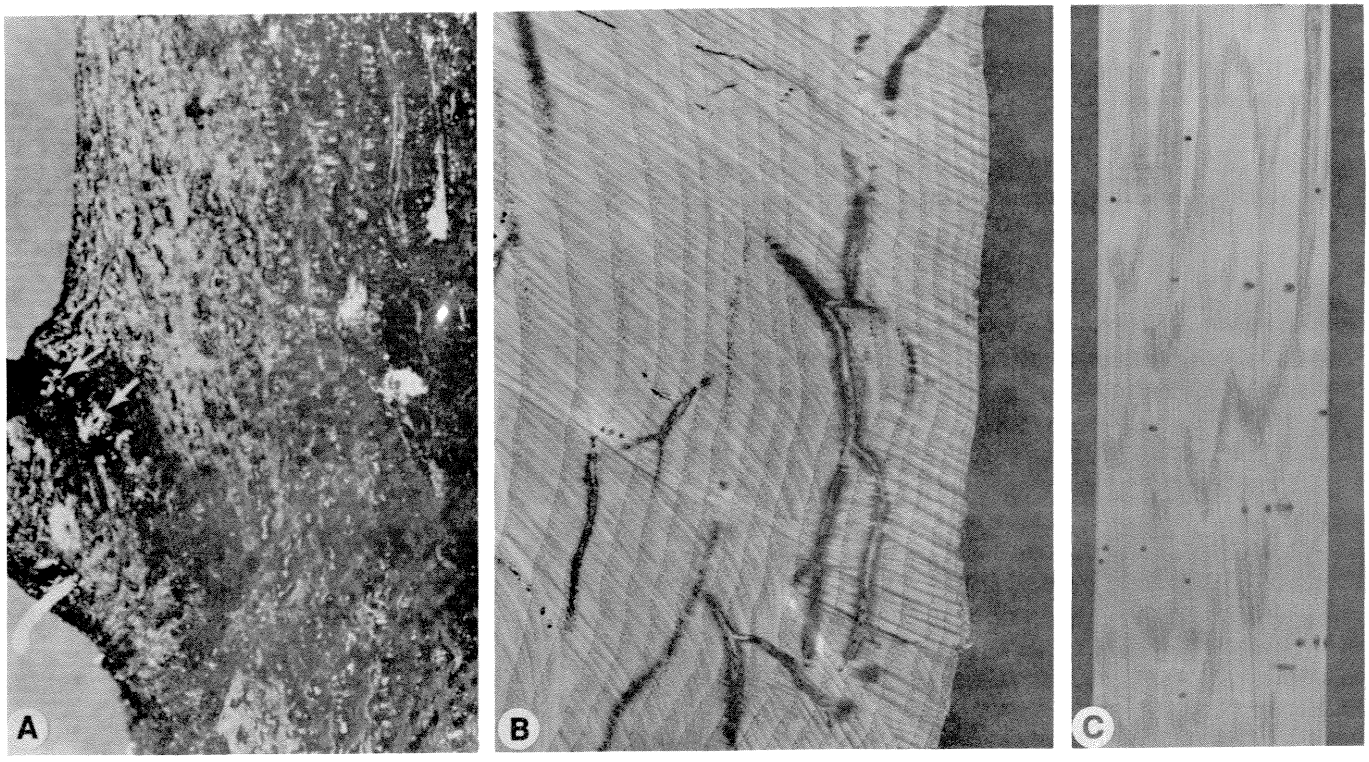


Figure 31.—*Evidence of infestation by* Xyleborus *and* Platypus *spp. in pecan: (A) fresh white frass at pinhole entrances in trunk; (B) black-stained branching galleries in sapwood; (C) pinhole defects in sawn lumber.*

become unsuitable for brood development as soon as the moisture content drops below about 48 percent.

Control.—Since ambrosia beetles rarely attack healthy vigorous trees, good cultural practices should be followed to promote and maintain tree vigor (Baker 1972, Payne and others 1979). Trees that are weakened or stressed apparently emit fermenting-like odors that attract ambrosia beetles. Because healthy trees do not emit these odors, they remain unattractive. Insecticides may be needed occasionally.

HICKORY BARK BEETLE
Scolytus quadrispinosus Say

Importance.—The hickory bark beetle, *Scolytus quadrispinosus* Say, is a pest of pecan and hickory and reportedly butternut and black walnut (McDaniel 1933, Goeden and Norris 1964). However, it shows a strong preference for the hickories and is reported to be the most important pest of this group of trees (McDaniel 1933). It is found from Quebec southward throughout the eastern half of the United States to the Gulf Coast States and westward to Texas. Both adults and larvae produce galleries between the bark and wood of trunks and branches. When attacks are numerous, the galleries soon girdle the tree. Trees stressed and weakened from drought, fire, storm, disease, or other cause are most susceptible to attack. Vigorous trees are seldom attacked except when large beetle populations are produced from nearby brood material. Although heavy infestations usually kill the tree, light infestations may only girdle branches or a portion of the trunk, causing top dieback.

Description.—The adult is a short, 4- to 5-mm long, stout, thickly cylindrical, black to reddish-brown, almost hairless beetle (fig. 32A) (Goeden and Norris 1964, McDaniel 1933). There is a short curved spine or hook on the front tibia. The venter of the male is deeply excavated; the third abdominal segment is armed with three spines, the fourth with one large median spine. The venter of the female is without spines. The egg is ellipsoidal, cream colored, and barely visible to the naked eye. The larva is short, curved or slightly C-shaped, legless, yellowish white, and 5 to 8 mm in length when mature (fig. 32B). The body appears wrinkled. The pupa is compact, fragile, and white.

Evidence of Infestation.—Damage occurs from feeding in terminal growth and by tunneling in trunks and large branches for breeding purposes (Blackman and Ellis 1915, Goeden and Norris 1965). Throughout the summer months, newly emerged adults feed on twigs in the tree crown. Their short food tunnels are mainly confined to axillary buds and leaf bases in the current year's growth and the junctions of current and 1-year-old growth. Heavy twig feeding may cause yellowing and premature dropping of leaves and broken twigs scattered throughout the crown, but this seldom seriously weakens the tree.

The most serious damage results from tunneling and reproducing in the trunks (fig. 33). In the fall and winter after initial attack, the presence of numerous round, 3-mm diameter entrance holes in the bark are often the only signs of attack. During winter and spring, woodpecker holes in the bark are good indicators of infestation; in spring, sparse or yellowed foliage are signs of beetle attack. Dead or dying trees with bark perforated by numerous 3-mm holes from which beetles have emerged also indicate the beetles' presence along with galleries beneath and within the bark of such trees. The inner bark and wood surfaces are engraved with peculiar centipede-shaped designs consisting of broad vertical galleries with narrow bur-

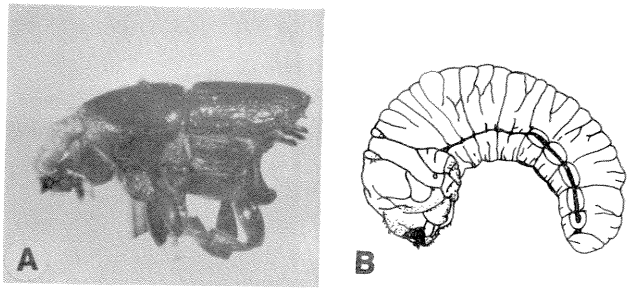


Figure 32.—*Life stages of* Scolytus quadrispinosus: *(A) adult beetle; (B) mature larva.*

Figure 33.—*Galleries of* Scolytus quadrispinosus *beneath bark of hickory. Note vertical egg gallery with larval galleries radiating outward.*

rows radiating outward like centipede legs from either side of them. The foliage of heavily infested trees turns red within a few weeks after attack and finally turns brown as the tree succumbs (fig. 34).

Biology.—The beetles overwinter as larvae in various developmental instars (Goeden and Norris 1964, 1965, McDaniel 1933). During spring the oldest larvae transform to pupae in elliptical chambers terminating each larval tunnel just beneath the bark surface. Beetles emerge from May through late August. The beetle population and seasonal activity reach a maximum during July and early August. The newly emerged beetles fly to the crowns of host trees and feed mainly in terminal and twig growth for 10 to 15 days. Sexually mature beetles are then attracted to low-vigor trees where they bore into the trunks and branches for breeding purposes. Here the females excavate short (12 to 50-mm) vertical egg galleries between the bark and wood. Mating and egg laying continue throughout the summer, with each female depositing 20 to 60 eggs singly in small niches along either side of the egg gallery. Each egg is covered with a plug of macerated frass. The eggs hatch in 10 to 12 days. The larvae mine at right angles to the main gallery and parallel to each other, but as the larvae become larger their galleries diverge more and more, resembling an engraving of "centipede legs." Larval mines extend 76 mm or more away from the egg gallery, severing the trees' food and water conducting tissues. Mature larvae leave the cambium and bore into the outer bark where they construct pupation cells. There is one generation per year in the northern range and two per year in the southern distribution.

Control.—Since hickory bark beetles rarely attack healthy trees, good cultural practices such as thinning, pruning, fertilization, and irrigation are important for promoting and maintaining good tree vigor (Goedon and Norris 1964, Hopkins 1912). The most effective means of controlling a hickory bark beetle infestation is by destroying trees in which larvae are overwintering. Infested trees should be cut and burned or submerged in water, have the bark peeled, or be sprayed with an insecticide before beetle emergence begins in May or June. To protect high-value trees, thoroughly spraying the trunks and large branches with an insecticide during early July will curtail most breeding attacks.

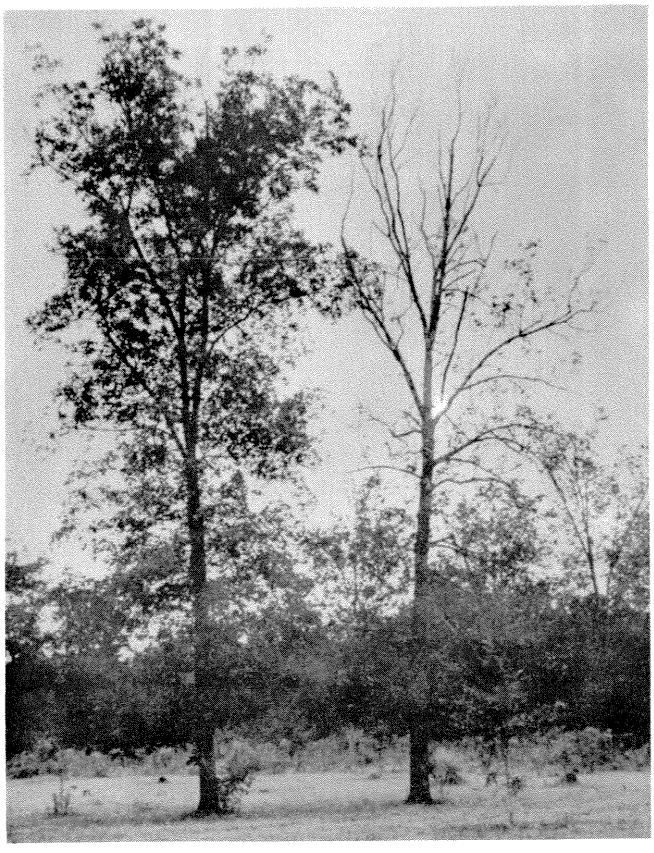


Figure 34.—*Hickory (right) dying from* Scolytus quadrispinosus *attack.*

RED-SHOULDERED SHOTHOLE BORER
Xylobiops basilaris (Say)

APPLE TWIG BORER
Amphiceris bicaudatus (Say)

Importance.—The red-shouldered shothole borer, *Xylobiops basilaris* (Say), and apple twig borer, *Amphiceris bicaudatus* (Say), are found throughout the United States east of the Rocky Mountains and in southern Canada (Baker 1972, Gill 1924, Moznette and others 1931). Pecan and hickory are among their favored hosts, but they also attack several other deciduous hosts. They generally attack severely stressed and dying or recently dead trees. Trunks of healthy trees growing in close proximity to heavily infested trees are occasionally attacked but seldom with success; however, *A. bicaudatus* may tunnel the twigs and small branches causing them to wither and die back. Although these borers may cause some twig dieback and possibly hasten the death of trees already stressed or dying from other causes, the threat to healthy living trees is minimal.

Description.—The adults of *X. basilaris* are 3 to 5 mm long, black, and bullet-shaped, with many small punctures over the body. The basal part of the elytra is dull reddish or yellow—hence the name "red-shouldered." The wing covers end in an oblique angle at the posterior end, the edges of which are armed with three conspicuous teeth on each side. The adults of *A. bicaudatus* (fig. 35A) are similar to *X. basilaris* except they are larger, range from 6 to 11 mm long, are dark brown, and lack the reddish marking on the wing covers. The larvae of both species are white and

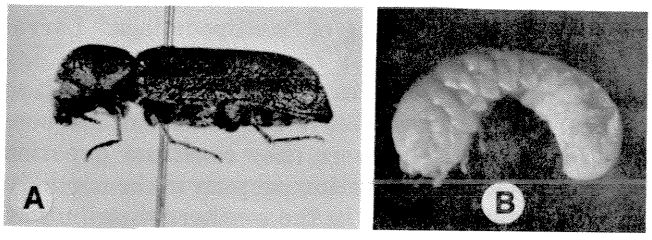


Figure 35.—*Life stages of* Amphiceris bicaudatus: *(A) adult beetle; (B) mature C-shaped larva.*

C-shaped; when full-grown, *X. basilaris* is about 5 to 6 mm long and *A. bicaudatus* is 6 to 12 mm long (fig. 35B). The head of the larva is globular and greatly enlarged into the prothorax, the mouthparts extend forward, and there are three pairs of thoracic prolegs.

Evidence of Infestation.—The adults of *X. basilaris* make small round exit holes 2 to 3 mm in diameter; the holes of *A. bicaudatus* are 3 to 4 mm in diameter and generally much less numerous (Payne and others 1979, Baker 1972, Gill 1924). The holes give a tree trunk the appearance of having been hit by birdshot, hence these borers are often referred to as "shothole" borers (fig. 36A). Light sawdust particles may be observed coming from the holes. The borings or frass of the larvae are very fine and powderlike in appearance; they are firmly packed or compressed within the galleries, which run parallel with the grain of the wood (fig. 36B). Trees cut back so severely that the trunk becomes saturated with sap are susceptible to infestation by *X. basilaris*. Twigs that have withered and brown leaves usually contain single, round entrance holes 2 to 4 mm in diameter adjacent to a bud or leaf base (fig. 36C). Dissection of the twigs usually reveals a hollow twig that is often occupied by a single adult beetle from late fall to late spring.

Biology.—Adults emerge during the summer and fly in search of suitable host trees where they bore through the bark and into the sapwood (Gill 1924, Lugger 1899, Baker 1972, Dean 1920). Tunnels are constructed across the grain just under the wood surface in the sapwood. These tunnels may completely girdle small-diameter limbs and trunks (fig. 36D). Eggs are deposited at intervals along the sides of the tunnel. The larvae feed mostly in the sapwood and to some extent in the heartwood. Larval mines run parallel with the grain and are packed with fine, white, powderlike dust. Feeding may continue until the wood is quite dry. The winter is spent mostly as ma-

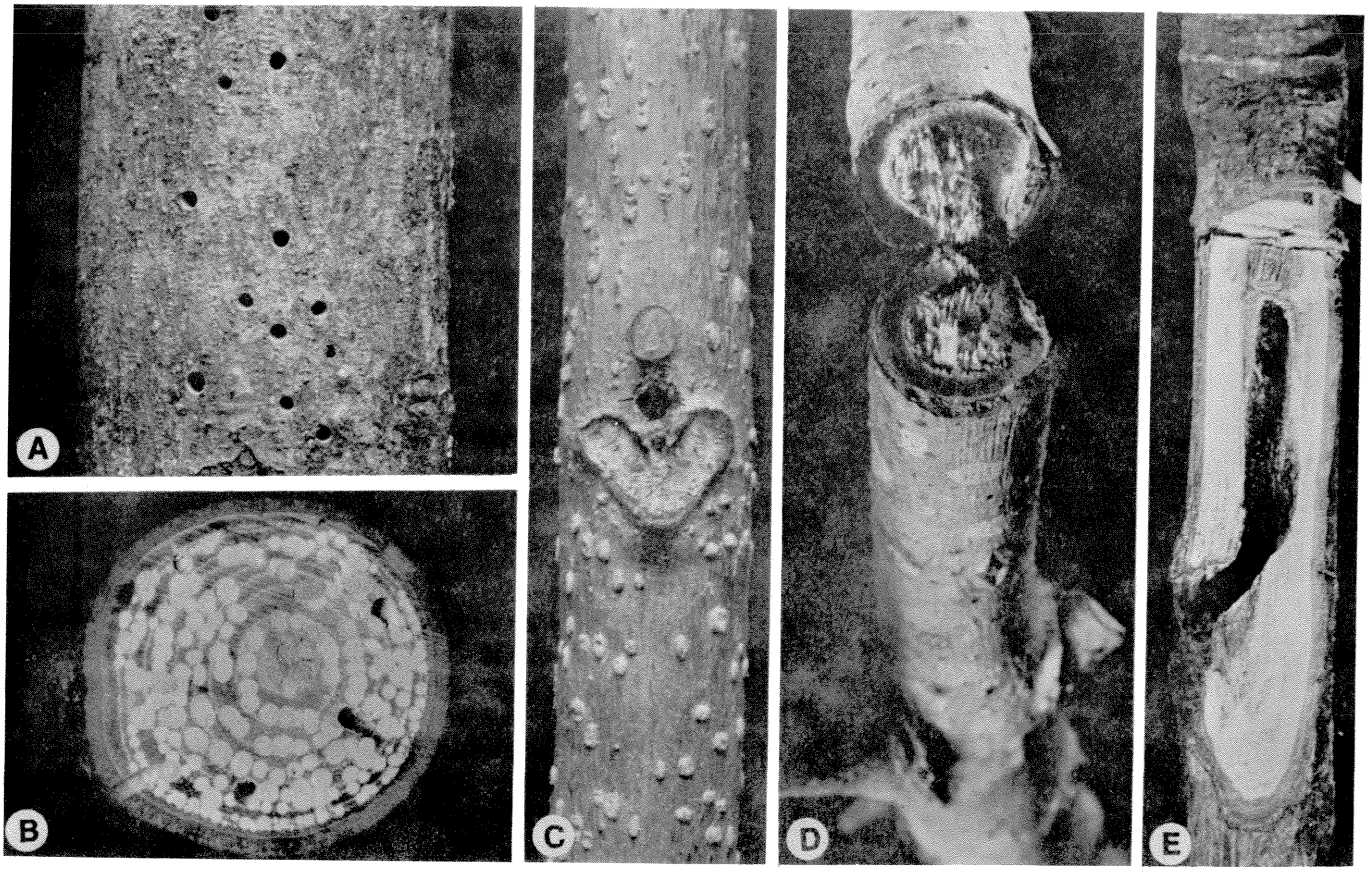


Figure 36.—*Habits and signs of attack by* Xylobiops basilaris *and* Amphiceris bicaudatus *in pecan: (A) exit holes (shotholes) in bark; (B) cross-section of stem showing ends of frass-packed larval galleries; (C) adult entrance hole between leaf scar and bud; (D) girdling tunnel made just beneath bark by adult beetle; (E) overwintering gallery made by adult of* Amphiceris bicaudatus.

ture larvae in mines; larvae pupate and emerge as adults the following spring and summer through circular holes cut in the bark. Adults of *A. bicaudatus* often bore into twigs for food and shelter and commonly spend the fall, winter, and spring in galleries within the twigs (fig. 36E). A generation can develop from egg to adult in 1 year under optimum conditions, but longer periods of time are sometimes required.

Control.—These borers present little threat to healthy well-kept trees; therefore, good cultural practices should be followed to maintain tree vigor (Dean 1920, Moznette and others 1931). Sources of infestation can be eliminated by promptly removing and destroying all dead and dying twigs and branches, prunings, and dead trees.

YELLOW-BELLIED SAPSUCKER
Sphyrapicus varius L.

Importance.—The yellow-bellied sapsucker, *Sphyrapicus varius* L., pecks small holes in tree bark, causing injuries that are often mistaken for insect borers—hence its coverage in this paper. This pest is found over most of the United States and southern Canada, but its damage is best known in the Eastern United States. It attacks pecan and hickory as well as over 250 other trees and shrubs (Beal and McAtee 1922). As portions of the bark and cambium are removed by numerous pecked holes, the vitality of the tree is lowered. When the injury is extensive, individual branches or the entire tree may be completely ringed or girdled and killed. Sapsucker pecking disfigures ornamental trees and gives rise to holes, to sap spots, and subsequently to gnarled bark deformities that ruin the aesthetic appearance of the trees. Disease and wood-boring insects often become established at sapsucker wounds. The greatest damage done by sapsuckers, however, is to cause defects in the wood of trees cut for lumber, veneer, and handle stock. Economic losses to the lumber industry in hickory alone have been estimated at 1.2 million dollars annually (Dale and Krefting 1966).

Description.—The yellow-bellied sapsucker is a member of the woodpecker family (Picidae) and resembles the woodpeckers in appearance (fig. 37A). However, its habits are detrimental as opposed to the generally beneficial habits of woodpeckers. The identifying field markings of adult birds are a black crescent on the breast, pale yellow belly, longitudinal white stripe on the mostly black wings, and crimson

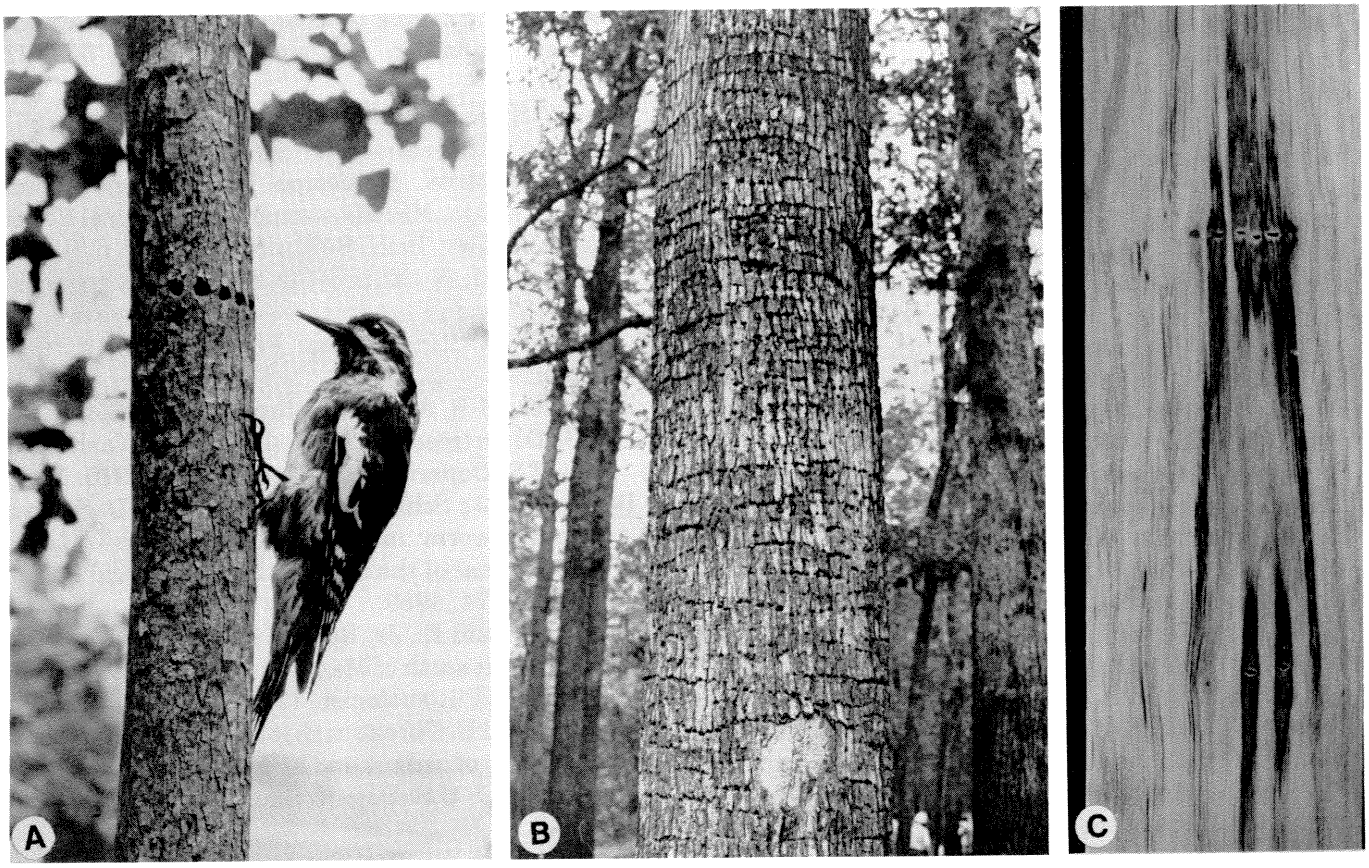


Figure 37.—*Characteristics of injury by* Sphyrapicus varius *in pecan: (A) bird pecking trunk of young tree; (B) heavy bird-peck injury to trunk of large tree; (C) bird-peck defects in sawn lumber.*

red crown (Peterson 1947, Ostry and Nicholls 1976). Although it most closely resembles the hairy and downy woodpeckers and is between the two in size, it is the only woodpecker with a red forehead in combination with a black patch on the breast. In addition, the male has a crimson chin and throat that distinguish him from the female whose chin and throat are white.

Evidence of Infestation.—The yellow-bellied sapsucker pecks a series of small holes about 5 mm in diameter in the bark (Beal and McAtee 1952). Generally, the holes are made in horizontal rings (full or partial) around the trunk or branches (fig. 37B). The holes extend through the bark to the cambium, sometimes penetrating the sapwood to a depth of 3 mm. Occasionally the holes in a series are gradually enlarged until they girdle or partially girdle the stem. Dissections of trees that have suffered from repeated yearly attacks reveal characteristic symptoms of previous damage by sapsuckers. The evidence consists of uniformly spaced peck-marks surrounded by dark vertical stains, often with small pockets of ingrown bark and decay. These defects degrade the lumber sawn from damaged trees (fig. 37C). Attacks may be seen at any point on the trunk and branches but are perhaps most common on the bole area just below the lower branches. Small trees are particularly susceptible to attack.

Biology.—Although the yellow-bellied sapsucker is a member of the woodpecker family, it has a short brush tongue in contrast to that of true woodpeckers, which have long tongues equipped with barbed tips for preying upon wood-boring grubs. The sapsucker's staple diet is the living cambium layer, inner bark, and sap that flows from the pecked wounds (Dale and Krefting 1966). After settling in a locality, each bird pecks many trees but then selects a few trees for most of its feeding. Pecked holes are revisited several times daily to drink sap oozing from the wounds and to eat small insects attracted to the sap. On favored trees, holes are often enlarged as the sapsucker feeds on the cambium to freshen the wound and to stimulate sap flow. The yellow-bellied sapsucker is a migratory bird that spends its summers and nests primarily in the Northern States and southern Canada (Peterson 1947). In the fall it migrates southward, sometimes as far as the Gulf Coast.

Control.—Control is difficult, but several remedies have been used with some success on high-value trees (Ostry and Nicholls 1976, Beal and McAtee 1922). Trunks of individual trees may be wrapped with burlap or some other material to prevent attacks. Painting damaged trees with tree-wound paint will sometimes discourage the birds. Commercially available repellents have been used successfully in repelling sapsuckers. Spraying the trunk periodically with a soap solution has also helped to discourage attacks. Often only a single bird is responsible for damage to a shade or ornamental tree; thus, if it can be discouraged or eliminated, the problem is solved.

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Appendix—Common and Scientific Names

CLASS: INSECTA

Lepidoptera
- Cossidae
  - Pecan carpenterworm, *Cossula magnifica* (Strecker)
- Sesiidae
  - Dogwood borer, *Synanthedon scitula* (Harris)
- Pyralidae
  - American plum borer, *Euzophera semifuneralis* (Walker)
  - Acrobasis shoot borers, *Acrobasis* spp.

Coleoptera
- Curculionidae
  - Hickory shoot curculio, *Conotrachelus aratus* (Germar)
- Cerambycidae
  - Hickory borer, *Goes pulcher* (Haldeman)
  - Broadnecked root borer, *Prionus laticollis* (L.)
  - Tilehorned prionus, *Prionus imbricornis* (Drury)
  - Twig girdler, *Oncideres cingulata* (Say)
  - Twig pruner, *Elaphidionoides villosus* (F.)
  - Oak twig pruner, *Elaphidionoides parallelus* Newman
  - Branch pruner, *Psyrassa unicolor* (Randall)
- Buprestidae
  - Hickory spiral borer, *Agrilus arcuatus* Say
  - Flatheaded appletree borer, *Chrysobothris femorata* (Olivier)
- Platypodidae
  - Pin-hole borer, *Platypus compositus* (Say)
- Scolytidae
  - Pin-hole borers, *Xyleborus* spp.
  - Hickory bark beetle, *Scolytus quadrispinosus* Say
- Bostrichidae
  - Red-shouldered shothole borer, *Xylobiops basilaris* (Say)
  - Apple twig borer, *Amphiceris bicaudatus* (Say)

CLASS: AVES

Piciformis
- Picidae
  - Yellow-bellied sapsucker, *Sphyrapicus varius* L.

Solomon, J. D.; Payne, J. A. A guide to the insect borers, pruners, and girdlers of pecan and hickory. Gen. Tech. Rep. SO-64. New Orleans, LA: U.S. Department of Agriculture, Forest Service. Southern Forest Experiment Station; 1986. 31 p.

The importance, identification, biology and indirect control of insects attacking shoots, branches, trunks, and roots of trees are presented. Damage due to and control of the yellow-bellied sapsucker is discussed.

Additional keywords: *Carya*, impact, identification, pests, control, bird damage, yellow-bellied sapsucker.