Order Hymenoptera—Sawflies And Horntails

Hymenoptera, one of the largest orders of insects, is divided into two suborders. Members of Apocrita, the larger suborder, are largely beneficial, either as parasites or predators of pests or as pollinators of commercial crops. Members of the suborder Symphyta are mostly phytophagous and include the sawfly and horntail borers covered here (Borror and others 1981, USDA FS 1985). Adults are characterized as having four membranous wings; the fore pair is larger and more completely veined than the hind pair. Members of Symphyta are distinguished by having an abdomen that is broadly joined to the thorax (not threadlike as in Apocrita). Also, the adult females have a well-developed ovipositor, either sawlike or hornlike, fitted for making incisions and inserting eggs in plant tissue. Larvae are slightly curved to S-shaped, with three pairs of small thoracic legs and abdominal prolegs often reduced or absent. Members of this group feed in tender shoots, petioles, galls, or solid wood. They seldom cause widespread economically damaging losses, but sometimes are troublesome and cause moderate damage locally to nurseries, young plantations, ornamentals, and weakened timber stands.

Family

Family Tenthredinidae—Gall Sawflies

Members of this family are mostly leaf feeders, but some burrow internally in buds, petioles, twigs, or stems, usually producing galls (Smith 1968b, Smith 1979, USDA FS 1985). Twenty-nine species of *Euura* are listed as forming galls on petioles, twigs, and stems of willow (Smith 1979), but little is known about most species. Therefore, only four species of *Euura* are covered in this manual. Adults are small sawflies with clear wings and short sawlike ovipositors. Larvae vary from white to yellowish, greenish, and purplish, usually slightly curved, have three pairs of legs, and most have abdominal prolegs. Although troublesome on ornamentals, they are of minor importance.

Genus and Species

Caulocampus acericaulis (MacGillivray)

maple petiole borer (figure 227)

Hosts. Maple. Sugar maple is preferred (Britton 1906). Norway maple and planetree maple have also been recorded; other species of maple probably serve as occasional hosts (Johnson and Lyon 1988, Solomon 1982).

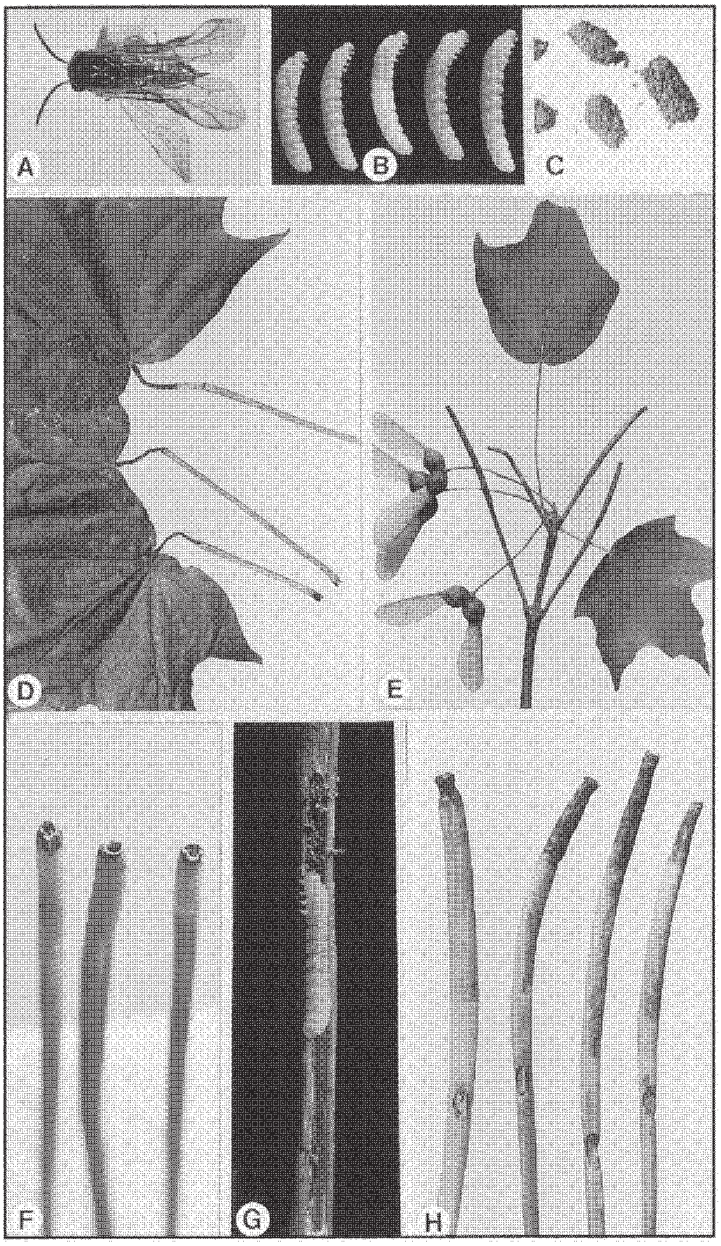

Figure 227—Caulocampus acericaulis, *maple petiole borer: A, adult; B, larvae; C, earthen pupal cells; D, infested petioles limp and darkened; E, petioles with leaf blades detached; F, swollen petioles severed; G, hollowed petiole with larva; H, oval exit holes in petioles (B-H, specimens courtesy C. Pless).*

Range. First reported in 1899 from Danbury, Connecticut (Britton 1906, Johnson and Lyon 1988). Now known from southeastern Canada, Vermont, and New York south through Tennessee and Alabama and west to Kansas, Indiana, and Wisconsin (Solomon 1982, USDA FS 1985).

Description. ***Adult.*** Very small, black and yellow, wasplike sawfly, about 4 mm long, with four transparent wings with wingspan of 10 mm (figure 227A) (Britton 1906, 1912a; Herrick 1935; Smith 1968a). Head and thorax shiny black, except yellowish on underside of thorax; antennae black with first two segments yellowish, and about 2 mm long. Abdomen and legs honey yellow, except tip of abdomen black. ***Egg.*** Colorless, very long, slender, noticeably curved or falcate, nearly uniform in thickness except slightly thicker at one end, 0.98 by 0.19 mm. ***Larva.*** Uniformly buff or straw yellow, head dark yellow to light brown with dark brown to black mandibles, three pair small thoracic prolegs (figure 227B). Full-grown larvae about 8.0 mm long and 1.5 mm in diameter, slightly curved resembling weevil larvae. ***Pupa.*** Pupal case round-to-oval earthen cell, about 5 mm in diameter (figure 227C).

Biology. Adults emerge from pupation cells in the soil in late April and May (Britton 1906, 1912a; Craighead 1950; Herrick 1935). The adults fly to host trees and oviposit mostly during early May. Females deposit eggs singly, primarily in the distal end of the petiole or in the base of the leaf blade where the major veins branch from the petiole. As many as 19 eggs have been found in the abdomen of a female. After a short incubation, the eggs hatch, and the larvae begin feeding and tunneling in the petiole. In about 3 weeks, the leaf blades are severed or break and fall to the ground. The larvae continue to feed inside the portion of petiole still attached to the tree. In 7 to 14 days, the bare petioles containing the larvae abscise and fall to the ground. The larvae vacate their petiole galleries and burrow into the soil 5 to 8 cm. Here, they form tiny earthen cells around themselves where they overwinter as prepupae. Pupation occurs in spring, and adults soon emerge to complete the life cycle. There is one generation a year.

Injury and damage. The first symptoms of wilting, yellowing, and browning leaves appear about mid-May. Injured leaves begin to fall to the ground in late May and early June (Britton 1906, 1912a; Craighead 1950; Johnson and Lyon 1988; USDA FS 1985). Close examination of the affected leaves will reveal that about 6 to 12 mm of the petiole extending from the leaf blade is limp, partially hollowed, and darkening (figure 227D). Inspection of the foliage will show the remainder of the infested petioles to be slightly swollen and still attached to the tree (figure 227E). The severed ends of the petioles appear neatly girdled (figure 227F). Slicing the petiole reveals the hollowed interior, the larva, and loose granular frass (figure 227G). The bare petioles drop to the ground from early to late June. Larvae leave a tiny, irregularly oval hole in each petiole as they enter the soil (figure 227H). The ground under heavily infested sugar

maples may be littered, almost covered with fallen leaves and bare petioles during June and early July. Leaf drop and defoliation of 5 to 20% is common in Ohio, and up to one-third of the leaves are lost on infested trees in Connecticut (Britton 1912a, Solomon 1982). However, leaf drop is seldom serious enough to substantially weaken or threaten the tree. Conversely, early season leaf drop is unsightly and disturbs owners of shade and ornamental maples and sometimes creates unseasonal cleanup problems.

Control. Two hymenopterous parasites—*Bracon montowesi* (Viereck) and an unidentified chalcid—have been reported (Britton 1906, Marsh 1979). Picking and destroying the infested petioles on small trees as soon as they are noticed may help to reduce sawfly populations (Craighead 1950). Raking and burning the infested fallen petioles promptly and daily before the larvae vacate their galleries is recommended (Britton 1906, Herrick 1935). Chemical treatment has been suggested and may provide some protection in problem areas (Britton 1906, Craighead 1950).

Euura atra (Jurine)

[smaller willow shoot sawfly] (figure 228)

Hosts. Willow. Acute leaf, golden leaf, laurel leaf, weeping, crack, and European yellow willows have been recorded as hosts (Ives and Wong 1988, Wong and others 1976). Introduced European willows, especially acute leaf willow, are preferred in Alberta. European aspen and several other willow species have been recorded as hosts in Europe.

Range. An introduced palearctic species first recorded in North America in 1888 in Quebec. It has since been reported from the Maritime Provinces and New Brunswick westward to Alberta (Ives and Wong 1988, MacCall and others 1972, Smith 1979, Wong and others 1976). It seems to be most troublesome across the Canadian prairies.

Description. ***Adult.*** Small, slender, dark black sawfly, shiny, 5 to 8 mm long, with short sheath and saw on abdomen of female (figure 228A). Two pair of clear wings; forewings reach slightly beyond abdomen. Antennae threadlike and slightly less than half body length. ***Egg.*** Pale, whitish, elongate, markedly tapered at one end, about 0.26 by 0.83 mm (figure 228B) (Ives and Wong 1988, Wong and others 1976). ***Larva.*** Pale black head with dark gray shading, greenish white body, three pairs of well-developed thoracic prolegs with claws, caudal abdominal segments usually held in slightly curled position, about 8 mm long when mature (figure 228C) (Ives and Wong 1988, Rose and Lindquist 1982, Wong and others 1976).

Biology. Adults emerge during late May and early June (Ives and Wong 1988, MacCall and others 1972, Rose and Lindquist 1982, Wong and others 1976). After mating, females make a saw-puncture opening in tender succulent shoots, usually near the base of the shoot, and deposit eggs singly next to the shoot pith. Most oviposition occurs during mid-June, and eggs hatch from mid- to late June. Larvae tunnel in or near the pith and undergo five to seven instars. Young larvae produce reddish frass,

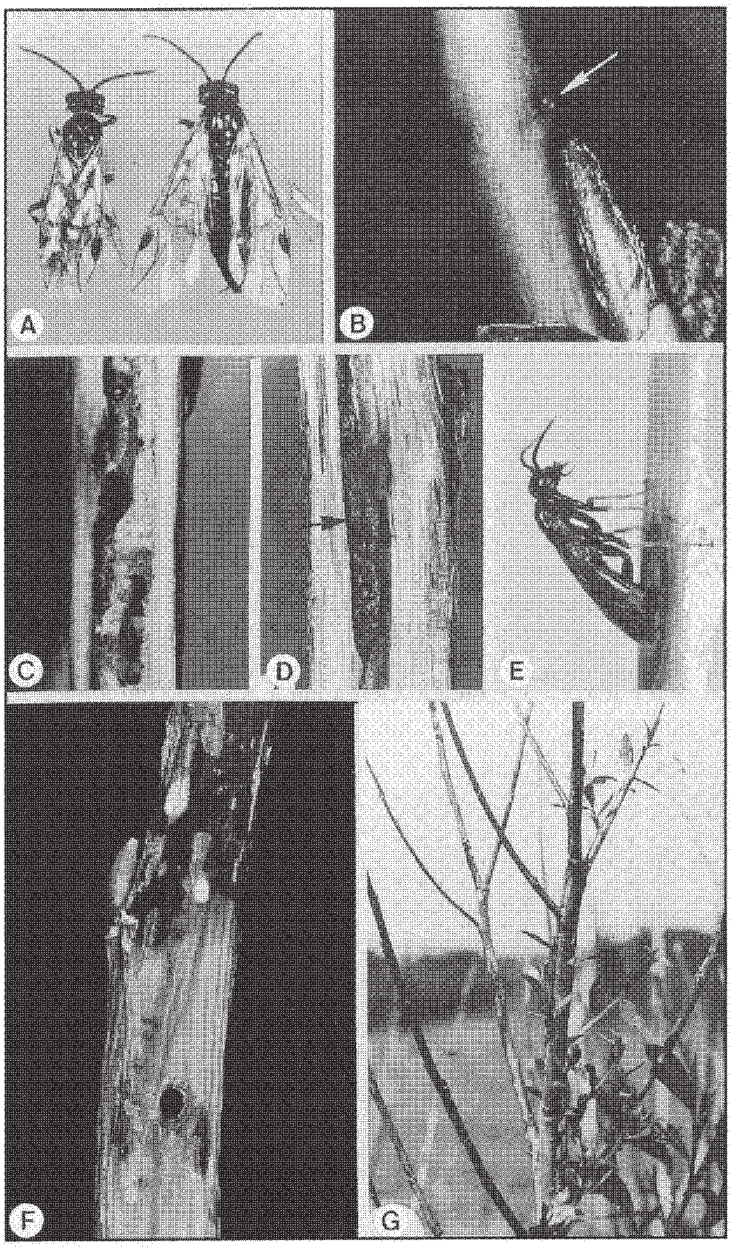

Figure 228—Euura atra, *[smaller willow shoot sawfly]: A, adults; B, egg niche site just above bud; C, larval burrow with frass and larva; D, cocoon within gallery; E, adult emerging from hole in shoot; F, exit hole; G, infested willow shoots failing to leaf out in spring (courtesy H. Wong).*

and older larvae produce whitish frass, which is generally pushed to one end of the tunnel. Stems may contain more than one larva, but each larva has a separate gallery; if not, cannibalism occurs. Larvae may tunnel toward the shoot tip or toward the base of the shoot. When feeding is complete by late September or early October, the larvae gnaw exit holes through the bark at one end of the gallery, then plug them with frass, bits of pith, and silk. The larvae then retreat to the other end of their galleries in late October and early November and spin brownish transparent cocoons in which they overwinter in the larval stage or as prepupae. A few larvae overwinter in the galleries without constructing cocoons. This sawfly has one generation a year.

Injury and damage. New tender shoots 3 to 18 mm in diameter are most susceptible to attack (Ives and Wong 1988, MacCall and others 1972, Rose and Lindquist 1982, Wong and others 1976). Few symptoms are noticeable during the early stages of attack. The trained eye may see the tiny egg scars that occur in succulent shoots near their base (figure 228B). In some cases, infested stems may swell slightly. Tunneling usually kills the infested shoots, but dieback does not occur until late in the growing season or more likely the following spring. The leaves on infested shoots turn yellow and brown, and the stem becomes brown. Dying shoots are commonly infected by a *Cytospora* fungus. Dissection of infested shoots in summer reveals the larvae along with one to three galleries about 12 mm long (ranging from 8 to 21 mm) in the pith. The frass typically is pushed to one end of the gallery (figure 228C). Dissection during winter and spring reveals a brown cocoon containing a prepupa or a pupa in the gallery (figure 228D). Adults emerge from tiny round exit holes usually indicated externally by a slightly depressed, round, discolored area on the shoot (figure 228E and F). This sawfly attacks terminals and branch ends; as many as 30 larvae have been observed in a 2-m-long whip of acute leaf willow. When the trees leaf out in spring, dead shoots are most noticeable (figure 228G). This insect sometimes causes severe damage to willow in nursery stooling beds and occasionally in shelterbelts. Cuttings have to be checked carefully before distribution to avoid dissemination of infested stock. Thus, infestations have the double effect of reducing the number of cuttings produced and increasing production costs because of the extra checking required.

Control. Several insect parasites have been reared from infested shoots including two *Eurytoma* spp., two *Tetrasticus* spp., and an unidentified species in the family Trichogrammatidae (MacCall and others 1972). The downy woodpecker has been observed digging the larvae from their tunnels (Wong and others 1976). In problem areas, growers should select the least susceptible species of willow, such as peach leaf willow, for planting. Pruning and destroying wilted blackened shoots as they appear in fall and spring before adults emerge may help to reduce infestations (Rose and Lindquist 1982). Soil-applied

systemic insecticides have given up to 93% control in nurseries (Wong and others 1976).

Euura exiguae Smith

[sandbar willow gall sawfly] (figure 229)

Host. Willow. Sandbar willow, commonly known as coyote willow, and its subspecies are only known hosts (Smith 1968b).

Range. A western species occurring from the Rocky Mountains to the Pacific Coast and the Columbia River in Oregon to southern California (Price 1989, Smith 1968b). It is the most common willow sawfly below about 2,000 m elevation.

Description. ***Adult.*** Black sawfly with orange to dull yellow markings on legs, ventral edges of tergites, distal edges of sternites of abdomen, and frontal crest and orbits of head (figure 229A) (Smith 1968b, 1970). Abdomen of female equipped with an ovipositor consisting of saw, sheath, and guide; saw averages 1.29 mm long and 0.11 mm wide; sheath from above tapers evenly to a point, not inflated. Front of head glossy or finely striate-punctate. Cerci subcylindrical or slightly clubbed apically. Females 3.6 to 7.0 mm long; males 3.0 to 5.5 mm long. ***Larva.*** Earliest instars pale green from ingested plant material; mid-instars become waxy, cream color; last instar dull, purplish gray, 8 to 10 mm long (figure 229B). Head light brown with pigmented spots on interocular area; antennae plate type and unsegmented; mandibles robust and toothed. Three pairs of thoracic prolegs and six pairs of prominent functional abdominal prolegs. ***Pupa.*** Creamy white, becoming yellowish and finally dark brown to black (figure 229C).

Biology. Adults begin emerging in early March, about the time the first sandbar willow blooms, peaking by late March and ceasing in late April (Smith 1968b, 1970). Adults drink water eagerly upon emerging from the gall and in cages consume small amounts of honey and sugar water. In nature, they are commonly observed on both male and female aments of their hosts eating pollen and drinking nectar; sometimes, they consume whole stamens and parts of capsules. Soon after emerging, mating, and feeding, the females begin ovipositing. Adults are relatively fragile and live only 1 to 2 weeks. Oviposition is accomplished as much through rapid vibration of the abdominal saw as by the more obvious sawing motion. When the oviposition punctures reach the proper depth, the egg and colleterial fluid from the accessory gland are injected through the ovipositor into the meristematic tissue of the tender shoot. Although the eggs are deposited singly, one to four eggs may be deposited in a shoot. The colleterial fluid immediately causes a gall—the expanding gall may become obvious within 48 hours. The galls expand rapidly and generally attain their maximum size before larval eclosion or by the end of the first larval stage. Larvae each make a separate burrow to feed on tissue within the gall. Mature larvae typically cut exit holes in the side of the gall, then plug them with frass, silk, and sawdust before retreating down the mine and entering the prepupal stage. They feed until reaching the prepupal

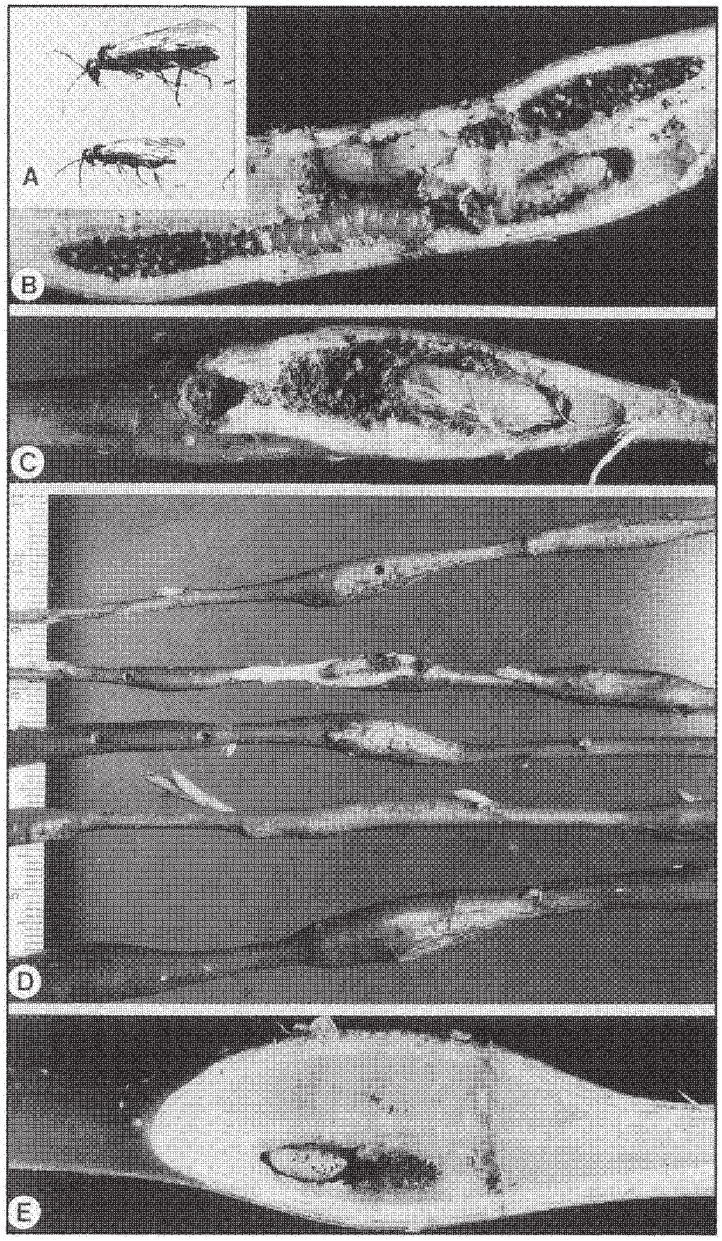

Figure 229—Euura exiguae, *[sandbar willow gall sawfly]: A, adults; B, larvae in gall galleries; C, pupa within gall; D, galls and exit holes on willow shoots; E,* Eurytoma *inquiline kills many sawfly larvae within gall (courtesy E. Smith).*

stage by late September. They overwinter in the prepupal stage within the gall (figure 229C). Pupation occurs during early spring, and the new adults emerge through precut exit holes. There is one generation a year.

Injury and damage. This pest favors sandbar willows growing in sheltered areas overhanging water or humid swales or thickets, with most galls often confined to the lee side of the plants (Price 1989; Smith 1968b, 1970). It is the most common gall sawfly of willow in lowland California and Oregon. Females prefer the most vigorous shoots such as sucker growth or sprouts. Oviposition scars are tiny puncture marks and difficult to detect; however, the galls form quickly and are very noticeable. The galls are thin walled, tapering at both ends, sinuate or linear in outline, and 20 to 70 mm long by 5 to 15 mm wide, with smooth, pubescent, or glabrous surfaces, but never glaucous (figure 229D). Young galls are green when first formed but become uniform brown to russet when mature. Exit holes 1.5 to 2.0 mm are left in the side of the galls. The largest and healthiest galls are characteristically those where the egg never hatched or the larva died early. Galls rarely adversely affect the host other than by distorting the stem. However, they can weaken the branches, causing some breakage. Heavily infested plants may exhibit multiple branching.

Control. Birds prey upon all stages of the insect (Smith 1970). Twelve species of braconid, ichneumonid, and pteromalid parasites kill large numbers of larvae. Also, several inquilines occupy, feed, and develop in the galls and destroy numerous sawfly larvae—a curculionid, *Anthonomus hematopus* (Boheman); three eurytomids, *Eurytoma fossae* Bugbee plus two *Eurytoma* spp.; and a cosmopterygid, *Batrachedra salicipomonella* (Clemens) (figure 229E). Although it is uncommon, some galls are flooded internally by sap, and the larvae drown. Also, excessive heat, caused when galls are exposed for extended periods to direct sunlight, kills some immature larvae.

Euura lasiolepis Smith

[arroyo willow gall sawfly] (figure 230)

Host. Willow. The insect is host species specific, attacking only arroyo willow and its varieties (Price and Clancy 1986, Smith 1968b); considerable variation exists in susceptibility among clones of arroyo willow.

Range. West of the Rocky Mountains to Pacific Coast and from northern California south to Arizona (Price and Craig 1984, Smith 1968b). A different color phase of the insect occurs in the Central Valley of California and in northern Arizona.

Description. ***Adult.*** Small wasplike sawfly, 3 to 8 mm long, with sheath and saw averaging 1.68 mm long and 0.10 mm wide (figure 230A) (Smith 1968b, 1970). Two geographic color phases—a dark, coastal phase that is black with small amber markings and an orange and black Central Valley phase that is slightly larger, translucent, and waxy orange except for brownish black markings. All intergrades occur in interior California. Front of head not polished as in

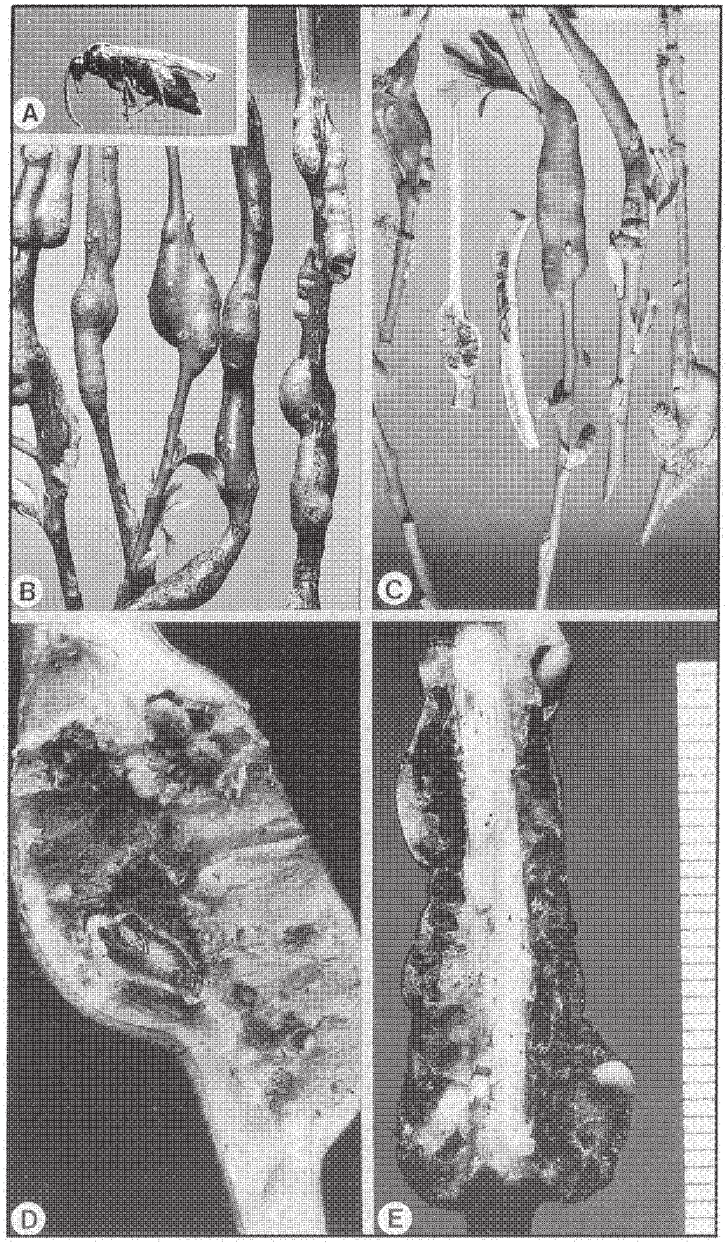

Figure 230—Euura lasiolepis, *[arroyo willow gall sawfly]: A, adult; B, typical galls on willow shoots; C, parasite exit holes and bird excavations in galls; D,* Ichneutes *parasite pupa in gall cell; E,* Dorytomus *inquiline larvae displaced sawfly larvae in gall (courtesy E. Smith).*

E. exiguae. Cerci tapering, distally acuminate, and keeled. ***Egg.*** Newly laid egg is sausage shaped, clear to transparent; anterior end slightly larger than posterior end, 0.55 to 0.60 mm long and 0.20 to 0.25 mm in diameter (Price and Craig 1984). Eggs swell rapidly during embryonic development, becoming more globose and measuring 0.50 to 0.55 mm long and 0.29 to 0.33 mm in diameter. ***Larva.*** Young larva pale green, becoming cream colored and shiny, and finally dull, bluish gray; 8 to 10 mm long (Smith 1970). There are three pairs of thoracic legs and six pairs of prominent abdominal prolegs.

Biology. In California, adult sawflies emerge from late February to early June, with peak emergence during early March (Smith 1968b). In Nevada and at higher elevations in Arizona, adults emerge mostly in May and June (Price and Craig 1984). Emergence generally occurs in the morning, and adults feed on host flowers (Smith 1970). Females lay trails of sex pheromone across the foliage to attract males. After mating, females begin ovipositing within a few minutes, usually on the same plant from which they emerged and then mated on. Females make many short flights between shoots. To oviposit, females search the terminal four or five nodes of shoots, then face down the short petiole toward the shoot and insert their long sawlike ovipositors down the petioles and into the young, succulent stems, laying individual eggs just below the axial bud primordium of each young stem. Two (or rarely 3) eggs, deposited by the same or different females, are in a stem or gall; up to 10 oviposition scars have been found on a shoot. At the time of oviposition, females inject colleterial fluid into the growing tissues, thus immediately inciting gall formation. Larvae feed on the parenchyma cells of galls, tunneling downward toward its base; males pass through five instars, and females pass through six instars. Final instars in October and November do not seem to feed but rasp away at the gall tissue to prevent being crushed by it. Full-grown larvae spin cocoons by matting frass and rasped gall tissues together with silk. Mature larvae overwinter within cocoons inside the galls. Pupation occurs from February through June; the pupal period lasts about 15 days. There is one generation a year.

Injury and damage. This sawfly favors vigorous clonal growths of arroyo willows with many tender shoots that grow in marshy areas along foothill streams, drainage ditches, borrow pits, and around springs and cattle tanks (Price and Clancy 1986; Price and Craig 1984; Smith 1968b, 1970). Oviposition leaves a small scar near the base of the petiole where the ovipositor was inserted; these scars become more noticeable with age as the margins separate and the damaged tissue browns slightly. Growth of galls is rapid through June, then decelerates during July and August; galls reach their greatest diameter by the end of August. The galls are thick walled and tortuous, with smooth, shiny, or corrugated surfaces; yellowish green except purple to red in bright sun; 20 to 70 mm long by 3 to 21 mm in diameter (figure 230B). The

larvae do not make exit holes in the galls for adults as occurs with *E. atra* and *E. exiguae*; instead, the new adults chew their own round exit holes in spring. Galled stems sometimes break, but overall damage to plants is slight.

Control. Natural controls often kill a high proportion of sawfly broods (Price and Craig 1984; Smith 1968b, 1970). Egg mortality caused by galls that fail to develop, or by rapid growth of gall tissue that crushes the eggs, accounts for about 39% of the brood and is the most important mortality factor in Arizona populations. In Arizona, 10% of the brood is killed by the ichneumonid parasite *Lathrostizus euurae* (Ashmead) and another 2% is parasitized by a pteromalid, *Pteromalus* sp. The inquiline *Batrachedra striolata* Zeller sometimes bores into galls, feeds on the gall tissue, and kills the sawfly larvae, but it kills only about 1% of the larvae. Birds, particularly mountain chickadees, peck into the galls and capture about 4% of the larvae from cocoons (figure 230B and C). Ants and grasshoppers destroy a few sawflies. In California, several species of parasites, especially *Ichneutes* sp. (figure 230D) and inquilines, particularly the weevil *Dorytomus luridus* (Mannerheim) (figure 230E), are important natural controls, but losses have not been assessed.

Euura salicis-nodus Walsh

[willow spindle gall sawfly]

Host. Willow. Sandbar willow is only recorded host; both very hairy and less hairy varieties attacked (Judd 1954, Rohwer 1909).

Range. Best known in northeastern North America but widely distributed west to the Rocky Mountains and from Ontario south to Mexico (Rohwer 1909, Smith 1979).

Description. ***Adult.*** Small, wasplike sawfly, black except for reddish brown spot enclosing ocelli on head, 4.1 to 4.6 mm long (Rohwer 1909). Head narrowed toward top; front of head strongly rugose. Wings hyaline, highly iridescent, with pale brown venation. Sheath broad, in lateral view, straight on upper margin, roundly truncate at apex. Cerci not extending beyond sheath. ***Larva.*** Body cylindrical, without setae, white or cream colored to pale; head greenish white, yellowish with dark eye spots and mandibles; body 4 to 9 mm long (Peterson 1962, Rohwer 1909).

Biology. Adult sawflies emerge during April and May, usually peaking in mid-April (Judd 1954). After feeding and mating, females begin ovipositing in tender shoots. One to three eggs are usually deposited in a shoot by the same or different females. The females inject colleterial fluid into the growing shoots during oviposition; galls develop rapidly whether or not eggs were actually deposited. Larvae feed on the gall tissue and usually develop in separate chambers within the galls. Galls become partially filled with frass. Full-grown larvae typically chew a round exit opening in the side, usually near one end of the gall, but some larvae leave a thin membrane cover-

ing the exit burrow. Mature larvae spin a flimsy cocoon surrounded by brown frass within the gall during fall and overwinter with their heads toward the gall openings. They pupate in spring. There is one generation per year.

Injury and damage. Shrubby growths of willow growing along the edges of fields, roadsides, and streams are likely targets for infestation (Judd 1954, Peterson 1962, Rohwer 1909). Spindle-shaped galls on twigs and branches are the most noticeable signs of infestation. Galls begin as gradual enlargements that eventually become spindle shaped, 19 to 38 mm long, and two or three times the stem diameter. Each gall may be perforated by one to three circular openings about 1 mm or more in diameter at either end. Dissection reveals one or two elongated chambers in the gall. Most galls are separate from one another, forming individual swellings along the twig. One or a few galls per stem commonly occur, but up to eight may occur per 30 cm of branch. Damage is generally negligible despite possible breakage or pruning at galled sites.

Control. Three species of hymenopterous parasites—*Habrocytus thyridopterigis* Howard, *Hoptocryptus* sp., and *Ichneutes* sp.—have been recorded, but little is known of their effectiveness (Judd 1954). *Eurytoma* sp., apparently an inquiline in the galls, destroys some sawfly larvae.

Family Siricidae—Horntails

The siricids are commonly known as horntails because of their hornlike projection on the last abdominal segment in adults. Only one species important to hardwoods is covered in this manual. The adults are medium to large, thick-waisted, cylindrical insects with long threadlike antennae and well-developed wings (Furniss and Carolin 1977, USDA FS 1985). Larvae are yellowish white and cylindrical with vestigial thoracic legs and lacking prolegs. Horntails occasionally attack healthy trees, but prefer trees that have been damaged or killed by fire, wind, insects, or diseases. Economic damage to hardwood trees is minor.

Genus and Species

Tremex columba (Linnaeus)

pigeon tremex (figure 231)

Hosts. Beech, elm, hickory, maple, oak, poplar, apple, pear, sycamore, hackberry. Prefers maple and beech, but readily attacks hickory, elm, and oak (Blackman and Ellis 1916, Stillwell 1967). Attacks other species less frequently.

Range. Throughout the United States and southern Canada west to the Rocky Mountains with a few records from Utah, Arizona, and southern California (Doane and others 1936, Ives and Wong 1988, USDA FS 1985). Three geographic races, with race 1 common in southeastern Canada and the northeastern United States, race 2 common in the southeastern United States north to Pennsylvania and west to Utah, and

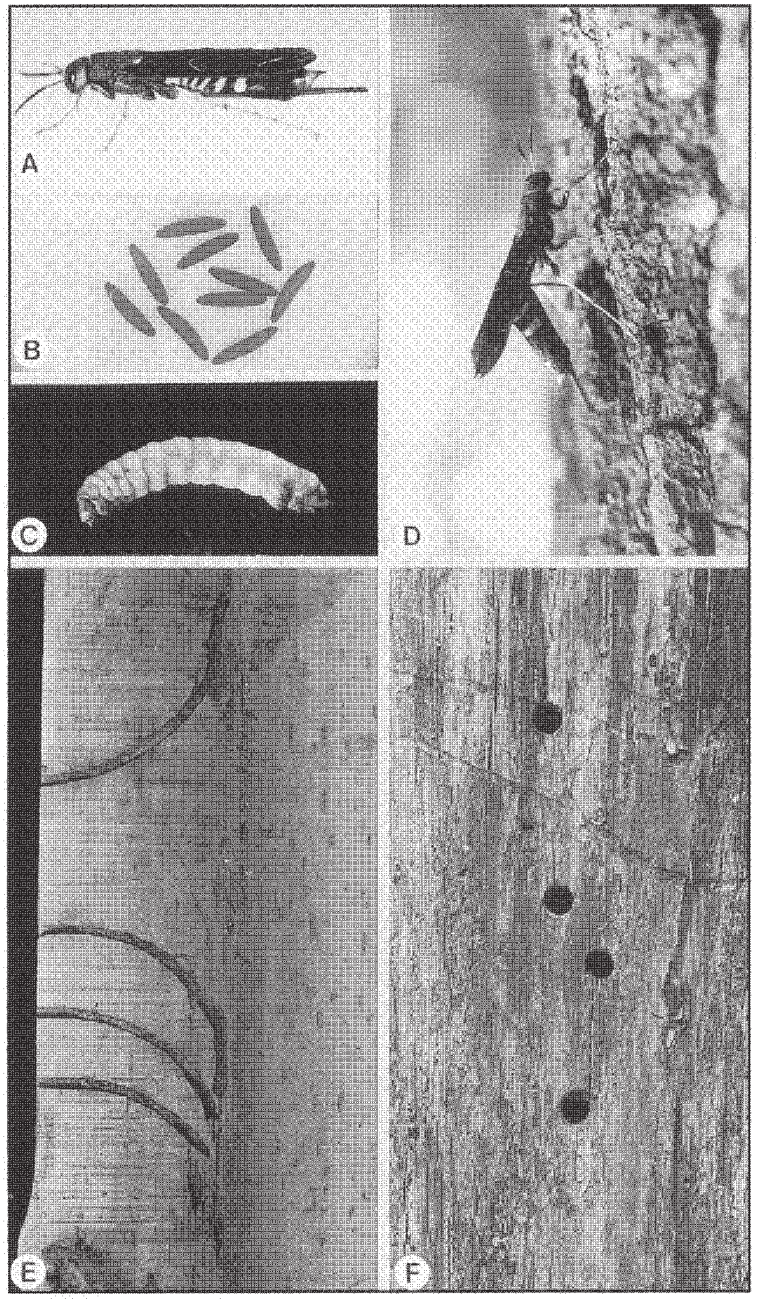

Figure 231—Tremex columba, *pigeon tremex: A, adult; B, eggs; C, larva; D, female ovipositing in tree; E, galleries with curving exits; F, round exit holes.*

race 3 in the Rocky Mountains. Some overlap in range among the three races.

Description. ***Adult.*** Large, cylindrical, heavily bodied, thick-waisted, wasplike horntail with abdomen ending in hornlike projection (figure 231A) (Beal and others 1952, Doane and others 1936, USDA FS 1985). Horny projection of abdomen long and spearlike; encasing ovipositor in females but short and triangular in males. Head large, widened behind eyes. Two pairs of wings transparent to smoky brown. Females 37 to 50 mm long; males 18 to 37 mm long. The three geographic races differ in color: race 1, abdomen black with brownish yellow bands and spots, head and thorax brown; race 2, abdomen yellow with sides of eighth and ninth segments black, head and thorax yellowish brown; race 3, brownish yellow throughout. ***Egg.*** Dark brown to blackish, elongate, slender, straight to slightly curved, narrow at ends, 1.0 to 1.5 mm long and about 0.2 mm in diameter (figure 231B) (Stillwell 1967). ***Larva.*** Cylindrical, straight to lightly curved or slightly S-shaped, white except for amber head, brownish mandibles; 14 to 50 mm long when mature (figure 231C) (Beal and others 1952, McDaniel 1936, Stillwell 1967). Head overhung by prothoracic segment, dome shaped, smooth, and shining. Three pairs small thoracic legs, nonsegmented, clawless. Abdomen ends in brown sclerotized prong.

Biology. In southern range, emergence of adults begins in early June, but in New Brunswick, emergence begins in mid-August, peaks in early September, and continues until early October (Blackman and Ellis 1916, McDaniel 1936, Stillwell 1967, USDA FS 1985). Over most of the range, adults are present from early summer to early fall. When ready to oviposit, females select suitable sites on the bark and drill holes with sawlike movements of the ovipositor (figure 231D). Oviposition channels are 2 to 20 mm deep in the wood and usually at right angles to the bark surface. From two to seven eggs are deposited at intervals, sometimes end to end in the oviposition channel as the ovipositor is withdrawn. Eggs usually hatch in 3 to 4 weeks, but in New Brunswick, some do not hatch until the following May or June. At oviposition, a wood-rotting fungus—*Daedalea unicolor* Buller ex Fries—carried in paired intersegmental sacs near the base of the ovipositor, is deposited in the wood. Larvae feed on the fungus-softened wood and construct long, round galleries that loop and meander through the sapwood and heartwood. Without the fungus, eggs hatch, but larvae cannot develop beyond the first instar. Larvae pack the frass tightly within the gallery and tunnel for 15 cm to 2 m, and occasionally up to 3 m. Female larvae also carry the wood-rotting fungus in a hypopleural fold between the first and second abdominal segments. Pupation occurs in the galleries in the sapwood and lasts 3 to 6 weeks. The new adults tunnel their way to the surface and emerge. In Michigan and New Brunswick, a generation requires 2 years, but in the southern range apparently only 1 year.

Injury and damage. This pest usually attacks trees weakened or dying from disease, other insects, fire, flooding, or other

causes; it occasionally attacks healthy trees, especially injured ones (Beal and others 1952, Blackman and Ellis 1916, Stillwell 1967). In the early stages, infestations present little or no evidence of entrance holes and ejected frass. However, it is common in the summer and fall to observe adult females ovipositing on susceptible tree trunks (figure 231A). Dead females with their ovipositors firmly wedged in the wood can sometimes be found, especially on living trees that have green or sappy wood. Dissecting infested stems can reveal frass-packed, meandering, larval galleries and the empty adult exit tunnels that curve in a sweep to the surface (figure 231E). From the exterior, the exit holes are circular and 7 to 8 mm in diameter (figure 231F). Exit holes are typically clustered in localized parts of stems. Because the insect prefers weakened trees, it is not an important pest. However, it can cause economically damaging losses in dying timber and salvage operations.

Control. Four species of hymenopterous parasites—*Ibalia maculipennis* Haldeman, *Megarhyssa atrata* (Fabricius), *M. greeni* Viereck, and *M. macrurus* (Linneaus)—destroy up to 40% of the larvae and pupae (Burks 1979, Carlson 1979, Stillwell 1967). Woodpeckers, especially the pileated woodpecker and hairy woodpecker, are effective predators, but unfortunately they destroy many of the parasites as well. Infestations can be avoided by keeping trees healthy and vigorous. Tree injuries should be promptly dressed and filled to discourage oviposition.

Family Xiphydriidae—Wood Wasps

Members of this family resemble the siricids in having threadlike antennae, well-developed wings, and a cylindrical body but are distinguished by smaller size and shorter ovipositor sheath (Borror and others 1981, USDA FS 1985). Larvae are smaller than but similar to the siricids. Only one species is covered here. It commonly attacks dying and dead branches of host trees; damage is usually minor.

Genus and Species

Xiphydria maculata Say *600*

Xiphydria maculata Say

[maple wood wasp] (figure 232)

Host. Maple. Silver maple and red maple recorded most frequently, but occasionally reported from sugar maple (Deyrup 1984, Knight 1968). Basswood and apple mentioned as hosts, but their status seems questionable (Smith 1976).

Range. Common in southeastern Canada from New Brunswick to Ontario and in the northeastern United States from Maine to Indiana; isolated records from as far west as Manitoba, Kansas, and eastern Texas; one dubious record from California (Deyrup 1984, Smith 1976, USDA FS 1985).

Description. ***Adult.*** Medium-sized, blackish wasp with yellow and white markings; female 11 to 20 mm long, male 7 to 11 mm long (figure 232A) (Harrington 1884, Rohwer 1918, Smith 1976). Head black with yellow stripes dorsally and laterally; antennae white with two basal segments

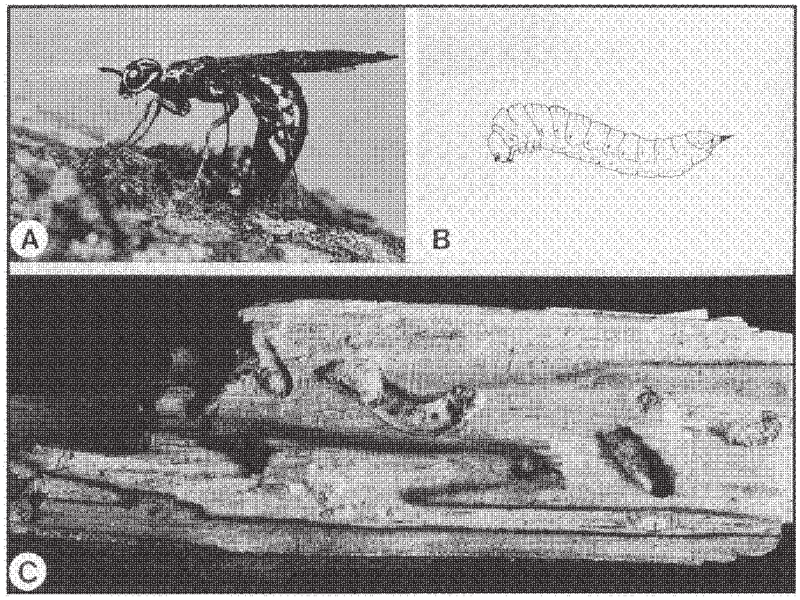

Figure 232—Xiphydria maculata, *[maple wood wasp]: A, adult ovipositing in maple branch; B, larva; C, larval galleries in wood (A, courtesy D. Funk; C, specimen courtesy D. Smith).*

black in female and brownish black throughout in male. Thorax black with broad, yellow band and two yellow spots. Legs orange to red. Abdomen black with yellow to white lateral spots on segments 2 or 3 to 8. Ovipositor contained in sheath projecting slightly beyond tip of abdomen. Wings grayish brown with black veins.

Larva. Yellowish white, cylindrical, except thorax and terminal segments slightly enlarged (figure 232B) (Furniss and Carolin 1977, Smith 1976, USDA FS 1985). Body straight to slightly S-shaped; abdomen ending in a brown, concave, hornlike projection; 18 to 20 mm long. Thoracic legs rudimentary teatlike structures.

Biology. In Ontario, adults emerge from mid-June to late July; in Indiana, adults begin to emerge in late May and finish by early July (Deyrup 1984, Harrington 1884). Adults emerge onto the bark and mate after a brief tapping ritual by both sexes. Females select a suitable host trunk or branch of recently dead or weakened tree and drill through the bark with their ovipositors, depositing one or more eggs at the interface between the bark and wood (figure 232A). Females deposit propagules of symbiotic fungus during oviposition. Upon hatching, the larvae bore immediately into the wood and tunnel mostly longitudinally, packing their galleries tightly with frass. Before pupation, larvae sometimes make bends or loops in the galleries and approach the surface. They overwinter in the larval stage and pupate in spring. New adults chew their way to the surface and emerge. There is one generation a year.

Injury and damage. Wasps attack weakened, dying, and recently dead trees and, less commonly, living trees over a range of sizes (Deyrup 1984, Harrington 1884, Knight 1968, Smith 1976). They mostly attack stems 2.5 to 9.0 cm in diameter, somewhat preferring saplings and branches 4 to 5 cm in diameter. Because the larvae do not eject frass, infestations are difficult to detect until the adults exit. Fallen branches under maple trees sometimes indicate attack; infestations can be confirmed by examining broken ends of branches for frass-filled galleries that weakened them. Dissection of infested stems reveals several galleries densely packed with whitish frass (figure 232C). Recently transplanted young trees with thin bark and branches of shade and ornamental trees have been riddled with galleries in Ontario.

Control. Seven insect parasites—*Aulacus burquei* (Provancher), *A. digitalis* Townes, *Coeloides rossicus betulae* Mason, *Orussus* sp., *Rhyssella nitida* (Cresson), *Spathius elegans* Matthews, and *Xiphydriophagus meyerinckii* (Ratzeburg)—have been recorded (Deyrup 1976, Rohwer 1918). The insect is generally of little economic importance, but in problem areas, wrapping or spraying the trunks of newly transplanted trees during May and June provides protection.

Family Cephidae—Stem Sawflies

The cephids are borers in tender shoots of trees and shrubs. Adults are small- to medium-sized sawflies with slender, compressed bodies and filiform antennae (Borror and others 1981, Craighead 1950). Most are dark colored; some are marked with yellow or red. Larvae are usually yellowish white and most are S-shaped. Their feeding typically causes shoot mortality and dieback. Damage is occasionally serious in localized infestations, but injury is seldom widespread.

Genus and Species

Hartigia cressoni (Kirby)

[raspberry horntail] (figure 233)

Hosts. Raspberry, blackberry, boysenberry, rose. Raspberry appears to be major host; both wild and cultivated varieties are attacked (Middlekauff 1969, Ries 1937).

Range. Western species common in California, with isolated collections from Oregon, Nevada, Montana, and Colorado (Smith 1986).

Description. ***Adult.*** Slender, black or dark brown and yellow, wasplike sawfly (figure 233A) (Essig 1912, Smith 1986). In females, head and eyes black with yellow markings. Antennae black with middle segments yellow orange to amber. Thorax black with small to large yellow spots mostly on sides. Legs black basally and mostly yellowish distally. Abdominal segments 1 and 5 entirely black, segments 6 and 9 entirely yellow, other segments partially yellow. Abdomen laterally compressed and equipped with a sheath; lancet broad and rounded dorsally. Wings hyaline, amber to orange tinged with brownish veins. Females 11 to 17 mm long; males 11 to 15 mm long and mostly black. Females easily distinguished from other members of genus by extensive yellow on abdomen and yellow markings on antennae. ***Egg.*** Glossy, pearly white, oval, somewhat flattened, curved, and sharp pointed at one end, about 1.5 mm long and two-thirds as wide (Essig 1912, Middlekauff 1969, Ries 1937). ***Larva.*** Yellowish green at first, becoming mostly white; cylindrical, somewhat S-shaped, with thoracic region somewhat enlarged dorsally and laterally; 22 to 25 mm long when mature (figure 233B) (Essig 1912, Middlekauff 1969, Middleton 1917). Head pale yellow to light brown with darkened mouthparts. Thorax with three pairs of vestigial, fleshy, teatlike legs without tarsal claws; abdominal prolegs absent. Abdomen ends in short tubular prong.

Biology. Adults begin emerging in early March; populations peak in April, May, and June, decline during July, and are gone by early August (Essig 1912, Middlekauff 1969, Ries 1937, Smith 1986). The adults are

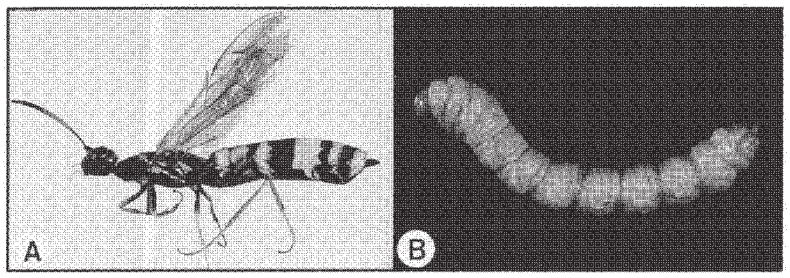

Figure 233—Hartigia cressoni, *[raspberry horntail]: A, adult; B, larva (specimens courtesy D. Smith).*

most active during midday (when temperatures are highest), feeding on nectar. Females oviposit by making a slit in tender shoots usually near the second or third leaf axil of new canes. They force single eggs slightly downward 1.5 to 6.0 mm from the opening and just beneath the epidermis. Areas surrounding the oviposition punctures become discolored and easily visible. Eggs hatch in a few days, and the young larvae feed on surrounding tissues, remaining near the points of hatching until they are about 6 mm long. Then, they begin to travel downward, burrowing in spirals encircling the shoot one to three times in the cambium for 25 to 30 mm. Next, they work into the pith and upward toward the tip of the young shoot, which soon withers and dies. As soon as the shoot tip dies, the larvae turn downward, working through the center of the pith to within 30 to 60 cm of the ground and sometimes into the roots. Larvae mature after about 4 to 6 months, usually in October. Mature larvae overwinter within the burrows. Pupation occurs during spring in a silken cocoon. New adults chew an opening in the cane to exit. There is apparently one generation per year (Middlekauff 1969), although there is some evidence of two (Essig 1912, Ries 1937).

Injury and damage. The earliest indications of infestation are oviposition niches just before and during the early flower stage. The oviposition sites discolor, usually becoming whitish to yellowish brown and slightly swollen (Essig 1912, Middlekauff 1969, Ries 1937, Smith 1986). Soon after young larvae girdle the stems, shoots wilt, droop, wither, and turn brown and black. Dying shoots promptly call attention to the infestations. Infested shoots may die back 15 to 50 cm. Two or more new shoots may issue from canes just below the girdle. Dissection of injured canes reveals the tight spiral galleries and long tunnels in the center of the stems. Some canes may be killed back to the ground. In California, the insect has been economically important in reducing fruit production, particularly at higher altitudes in the central and northern foothill counties of the Sierra Nevada. Shoot mortality rates of 90% or more have been recorded in commercial raspberry plantings in Placer County.

Control. Several unidentified parasites have been reared from the pupae (Essig 1958). In the past, a recommended control practice was to locate egg sites on shoots by the swollen, discolored areas and mash the stem between the thumb and forefinger to crush the eggs (Essig 1912). Some growers cut the infested shoots just below the girdle in spring, whereas others prune out the infested canes during winter. Insecticides may be needed in commercial plantings.

Hartigia trimaculata (Say)

[rose shoot sawfly] (figure 234)

Hosts. Rose, blackberry. Reared from rose and blackberry, and adults collected on raspberry and boysenberry; other *Rubus* species probably serve as hosts (Champlain 1924, Ries 1937, Smith 1986).

Range. Distributed across southern Canada from New Brunswick west; throughout the United States from Vermont south to

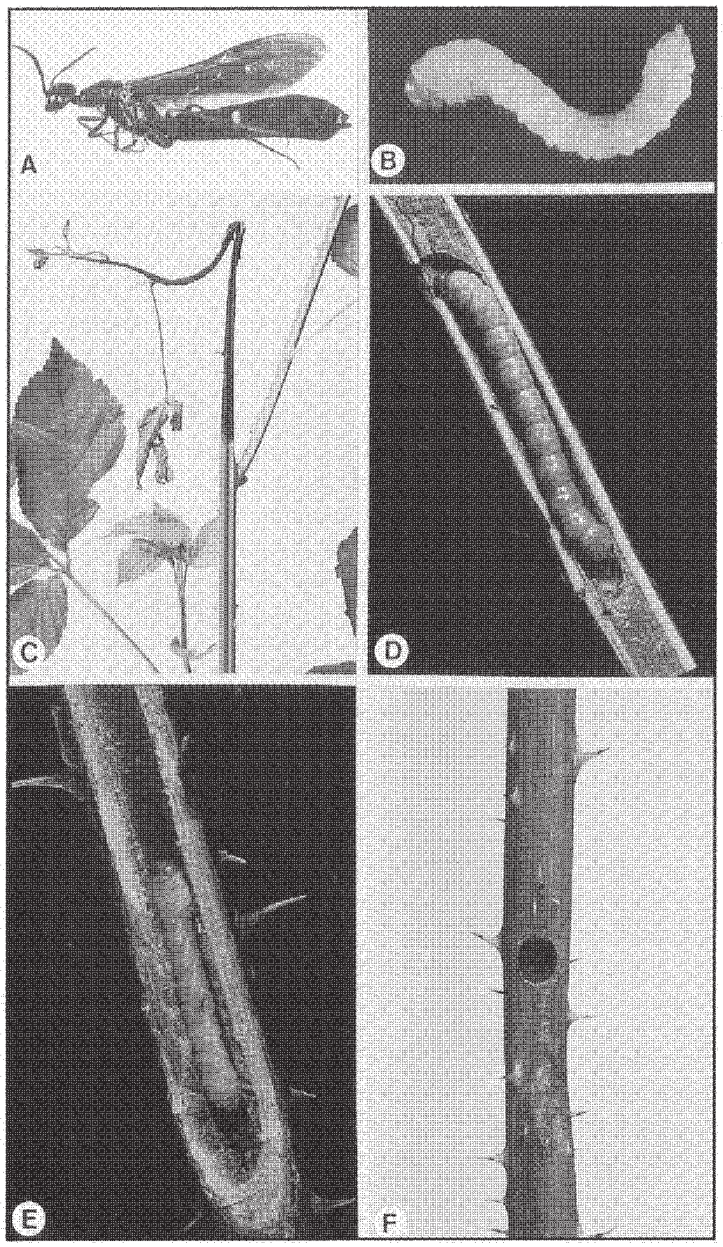

Figure 234—Hartigia trimaculata, *[rose shoot sawfly]: A, adult; B, S-shaped larva; C, infested blackberry shoot dying back; D, gallery with feeding larva in blackberry; E, gallery with frass and larva in rose; F, exit hole in cane (A, specimen courtesy D. Smith).*

Florida and Louisiana and west to the Great Plains; and in a small area in the West around Caldwell and Boise, Idaho (Smith 1986). Appears to be most common along Atlantic Coast and north central United States.

Description. ***Adult.*** Elongate, slender, mostly black, wasplike sawfly (figure 234A) (Ries 1937, Smith 1986). Head black with small, yellow spots around eye, mandible, and molar areas. Mandibles bidentate, translucent, yellowish with black tips and brown palpi. Antennae black and swollen beyond fourth segment. Legs black and lightly marked with yellow on inner surface of foretibia. Wings uniformly dark black infuscated with black veins. Thorax black. Abdomen compressed, elongate, widened dorso-ventrally toward apex, black with large, yellow spot laterally on fourth segment, and occasionally a smaller spot on third or sixth segment. Saw sheath reaches only slightly beyond tip of abdomen. Sheath narrow, not rounded dorsally. Saw not distinctly widened at base. Females range from 12 to 14 mm long; males 10 to 17 mm long. ***Larva.*** Pinkish white, cylindrical, somewhat S-shaped, with slightly enlarged thorax, and abdomen terminating in short, horny projection or prong (figure 234B) (Middleton 1917, Smith 1986). Head pale with mandibles and other mouthparts darkened. Thorax with three pairs of small teatlike, fleshy legs. Full-grown larvae are about 21 mm long.

Biology. Adults begin emerging in late April; numbers peak in May, June, and July, and are all dead by early to mid-August (Champlain 1924, Middlekauff 1969, Ries 1937, Smith 1986). Occasionally, the adult sawflies can be observed flying and alighting on terminals and new shoots. Females crawl downward from terminal tips along the shoot, stopping repeatedly to insert their ovipositors into succulent tender tissue. The punctures are made at short intervals along the stem. Several dozen punctures are often clustered within a small area. To oviposit, females insert the eggs singly deep in the shoot tissue. It seems likely that only one egg is laid in most terminals. When two or more eggs are placed in a shoot, the one that hatches first is the only one to survive. The larvae begin feeding in the succulent terminals, which soon wilt and die; then they feed in the pith, packing frass behind in their tunnels as they move down the stems. At frequent intervals, the larvae girdle the insides of the stems apically to their burrows, often causing the stems to break at that point. Fully grown larvae make a partial opening in the stem to the outside in the fall, then spin cocoons at the basal ends of burrows and overwinter within. Pupation takes place during spring inside the cocoons. This sawfly has one generation a year.

Injury and damage. Although the blackish adults may be seen flying and crawling about the succulent new growth of host plants, the earliest indications of injury are wilting and drooping of tender terminals (Champlain 1924, Middlekauff 1969, Ries 1937, Smith 1986). Close examination reveals ovipositor puncture marks along the shoots. Affected shoots promptly turn brown and black and sometimes break (figure 234C).

When infested shoots fail to break early from the punctures, they frequently break at girdled sites along the stem. Infested shoots may continue to die back as the larvae burrow further downward, repeatedly girdling the stem. Dissection reveals a frass-packed gallery and slightly S-shaped larva (figure 234D and E). Emerging adults leave circular exit holes in the stems (figure 234F). In the past, this borer has been an economically important pest in Pennsylvania. Infested rosebushes produce fewer flowers, and the loss of blackberry canes reduces fruit production.

Control. The infested terminal and shoot tips should be pruned and destroyed as soon as wilting and dying are noticed (Champlain 1924). When pruning is delayed, shoots must be cut lower to ensure that tunneling larvae are removed. Chemical control occasionally may be needed locally when high populations exist.

Janus abbreviatus (Say)

willow shoot sawfly (figure 235)

Hosts. Willow, poplar. Prefers black willow; two clones of the interspecific hybrid *Salix babylonica* x *S. alba* have been mentioned specifically as hosts; poplars, including eastern cottonwood, quaking aspen, bigtooth aspen, and balsam poplar have been recorded (Osgood 1962, Riley 1888, Solomon and Randall 1978).

Range. Southern Canada from New Brunswick west to Alberta and in the eastern and central United States from Maine west to Minnesota and south to Virginia, Arkansas, and Mississippi, and in Oregon (Smith and Solomon 1989, Solomon and Randall 1978).

Description. ***Adult.*** Delicate, brown, wasplike sawfly 7 to 10 mm long, with wingspan of 12 to 16 mm in females and 10 to 12 mm in males (figure 235A and B) (Ries 1937, Smith and Solomon 1989, Solomon and Randall 1978). Head and thorax shiny black with tiny, white to yellow markings. Abdomen black with segments 2 and 3 (and sometimes part of 4) red to reddish brown in females; only venter red in males. Abdomen of females compressed, much deeper than wide; sharp sawlike ovipositor. Abdomen not compressed in males. Wings hyaline, without violaceous reflections; base of radial vein atrophied near base. ***Egg.*** Translucent to whitish, oval to elongate, 0.8 to 1.0 mm long and 0.3 to 0.5 mm in diameter (Solomon and Randall 1978). ***Larva.*** Cylindrical with thorax slightly enlarged dorsally and laterally; typically S-shaped; 8 to 11 mm long at maturity; white, except for pale yellow head, brownish mandibles, and brownish, short, tubular prong at tip of abdomen (figure 235C) (Middleton 1917, Solomon and Randall 1978). Thoracic legs short, fleshy, and without claws; abdominal prolegs absent. ***Pupa.*** White, 8 to 10 mm long, enclosed in partially transparent cocoon (figure 235D).

Biology. Adults from the overwintering brood emerge mid-April to mid-May in Mississippi and May to July in Michigan (Middlekauff 1969, Osgood 1962, Reighard 1985, Ries 1937, Solomon and Randall 1978). Adults are cautious and take flight

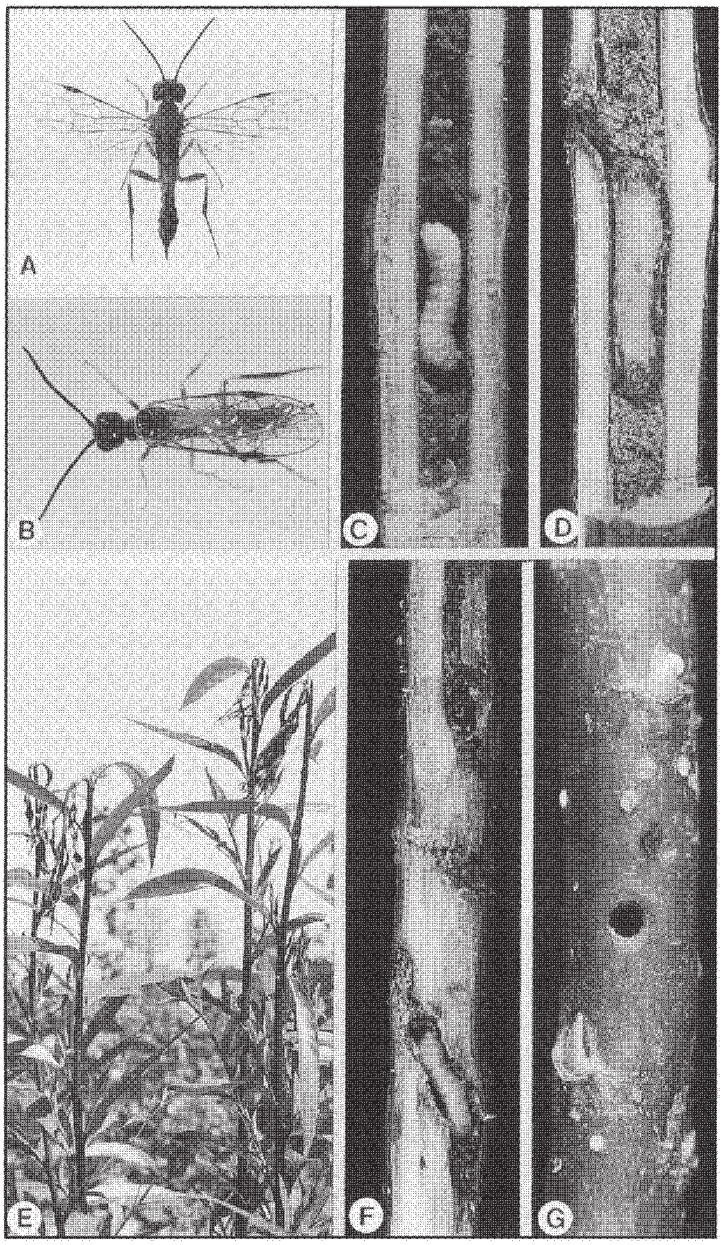

Figure 235—Janus abbreviatus, *willow shoot sawfly: A, adult with wings spread; B, adult with wings folded; C, S-shaped larva in gallery; D, cocoon in gallery; E, wilting and drooping shoots in black willow nursery bed; F, spiral girdling of stem; G, round exit hole in shoot.*

after slight disturbances. Females use their ovipositors to girdle succulent shoots by making a series of punctures encircling the stem and are selective about shoot diameter and distance from stem tip. They girdle willow shoots at an average of 44 mm from the tip; shoot diameter at the point of girdle averages 2.4 mm. Girdle sites on cottonwood average 50.1 mm from the tip and 3.2 mm in diameter. To girdle a shoot, females insert their ovipositors, withdraw them, move slightly around the stem, and puncture again, making 4 to 5 punctures in each of 1 to 3 trips around the stem for a total of 5 to 16 punctures per girdle. Shoot tips begin to wilt in 30 to 60 minutes after punctures are made. Females oviposit in the tender shoots 7 to 26 mm below the girdled site. Single eggs (rarely two) are deposited per shoot and typically are inserted at oblique angles into the pith. Eggs hatch in 7 to 12 days. Initially, young larvae tunnel toward the shoot apex near the girdled site, then turn and tunnel downward for 15 to 36 cm. In nursery stool beds, the entire length of the shoot is often tunneled, and occasionally the side of the rootstock. Larvae pack brownish frass in the gallery as they tunnel; they eject frass from the shoot only at breaks and girdled points along the stem. Before pupation, mature larvae cut a hole almost through the bark surface to permit emergence of the adult. Then they prepare a thin, somewhat transparent, membranous, cocoonlike structure in which to pupate. In its northern range, the insect reportedly requires 1 year to complete a generation; in Mississippi it has three generations per year, with first-generation adults emerging from mid-April to mid-May, second generation adults appearing from mid-June to mid-July, and third generation adults emerging from early August through September. Larvae of the last generation overwinter in cocoons, transforming to pupae and adults the following spring.

Injury and damage. The earliest evidence of injury is wilting and drooping terminals and branch ends (figure 235E) (Solomon and Randall 1978). Injured shoot tips wither and turn brown or black. Infested shoots gradually die back 30 to 60 cm; young shoots sometimes die back to the rootstocks. Peeling the bark off infested shoots reveals numerous spiral girdles made by the tunneling larva (figure 235F). Slicing through the center of infested shoots with a sharp knife reveals galleries filled with brown frass (figure 235C and D). Injured plants often produce many new branches just below the injured part, giving them a bushy appearance. The emerging adults leave behind round exit holes 1.5 to 2.5 mm in diameter (figure 235G). This insect is a major factor in the suppression and mortality of sucker shoots in cutover aspen stands in the Lake States, killing up to 9% of the dominant sucker shoots annually (Osgood 1962). In Mississippi, injury to cottonwood is usually minimal because most attacks occur on lateral branches. However, the pest severely damages nursery-grown willow; 90% of the shoots are sometimes killed by the first-generation sawflies (Solomon and Randall 1978). Damage to willow plantations in Maryland has been so

severe that the trees appeared to have been damaged by frost or fire. Repeated attacks in young plantations sometimes adversely affect tree form.

Control. In Mississippi, two hymenopterous parasites—*Bracon jani* Muesebeck and *Eupelmus* sp.—commonly kill 1 to 12% of the sawfly larvae in willow shoots (Solomon and Randall 1978). In the Lake States, up to 22% of the larvae in aspen shoots are parasitized by five species of hymenopterous parasites—*Bracon* sp., *Eurytoma* sp., *Scambus granulosus* Walley, *S. pterphori* (Ashmead), and *Tetrastichus productus* Riley (Osgood 1962). Three species of hymenopterous parasites—*Eurytoma* sp., *Microbracon* sp., and *Tetrastichus* sp.—have been reared in New Jersey (Middleton 1917). Up to 9% of the sawfly larvae in Mississippi have been killed by an unidentified fungus (Solomon and Randall 1978). Overwintering mortality of larvae in Mississippi has been estimated at 56%; mortality is most prevalent in the smallest, least vigorous shoots (Solomon and Randall 1978). Infestations can be reduced in nurseries by pruning and destroying infested shoots (Riley 1888). In Michigan's poplar nurseries and plantations, planting small blocks of willow (which the insect prefers over poplar) nearby as a trap crop, then annually coppicing the willow to destroy overwintering larvae and create a crop of succulent sprouts for next year's sawflies, has been recommended for control (Reighard 1985). Insecticides have reduced girdled shoots by 75 to 90%, but repeated applications are necessary (Reighard 1985).

Janus bimaculatus (Norton)

[viburnum stem sawfly] (figure 236)

Host. Viburnum. Blackhaw and nannyberry mentioned specifically as hosts, and other viburnum species are undoubtedly susceptible (Middlekauff 1969, Solomon 1982).

Range. Eastern North America from Quebec and Ontario south through Maine and New York to Maryland and Virginia and west to Illinois and Minnesota (Middlekauff 1969, Ries 1937, Smith and Solomon 1989).

Description. ***Adult.*** Small, mostly black, wasplike sawfly, 6 to 10 mm long (Ries 1937, Smith and Solomon 1989) (figure 236A). Head and pronotum black except lateral margin of pronotum translucent and whitish. Abdomen of females noticeably compressed, much deeper than wide; basal segments, venter, and legs reddish yellow to orange; ends in short, stout, amber-colored, sawtoothed ovipositor. Wings mostly hyaline and iridescent except for two, round, black, fuscous apical spots on each forewing. Males slightly smaller than females and radial vein of forewing atrophied at base. ***Larva.*** White with light amber head and mandibles, cylindrical, S-shaped, 7 to 10 mm long (figure 236B).

Biology. Adults are observed as early as May 9 in Illinois and as late as July 10 in Maine (Ries 1937). Adult activity seems greatest during early June across its range, when females are busy girdling and ovipositing in young viburnum stems. Females deposit eggs in tender shoots 15 to 40 mm from the apices. Larvae tunnel basally within

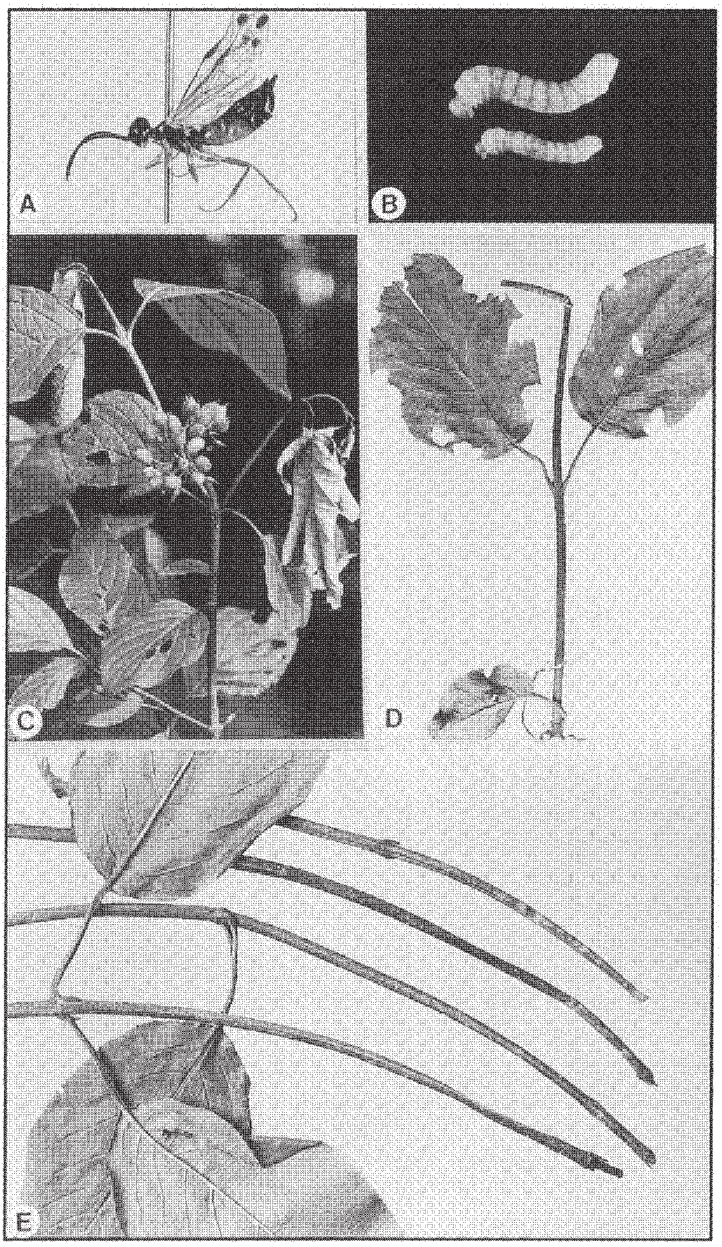

Figure 236—Janus bimaculatus, *[viburnum stem sawfly]: A, adult; B, larvae; C, wilting and drooping viburnum shoots; D, terminal leaves and shoot tip breaking away; E, dead, blackened, leafless shoots typical of infestation (A, specimen courtesy D. Smith).*

the shoots. Mature larvae prepare thin cocoons in the galleries where they overwinter. This stem sawfly has one generation a year.

Injury and damage. Wilting and drooping tender terminals and branch ends are the earliest evidence of infestation (figure 236C). Closely examining affected shoots reveals the girdle, the sawfly punctures, and the oviposition site. Leaves and shoot ends turn brown, then black, and soon begin breaking away (figure 236D). Dissection of infested shoots exposes hollowed stems with brown frass and sometimes the white, S-shaped larvae. Shoots gradually turn brown and black and die back 3 to 9 cm. Leaves die and shed along the affected stems as they die further back, typically leaving darkened, dead, leafless shoots projecting from infested plants (figure 236E). The insect has been reported as a nursery pest in Ohio and has killed up to 6% of the twig growth of blackhaw in Pennsylvania (Solomon 1982).

Control. Birds have been reported as predators in Wisconsin (Solomon 1982). Nothing else is known of natural controls, and direct controls have not been needed.

Janus integer (Norton)

currant stem girdler (figure 237)

Host. Currant. Both wild and cultivated currants are attacked; however, wild currant is the original host and appears to be favored over cultivated varieties (Marlatt 1895).

Range. Canada from Newfoundland and Quebec to British Columbia, across the northern United States from New Hampshire and New York west to Washington and Oregon and south to Virginia and Iowa (Middlekauff 1969, Smith and Solomon 1989). Seems most prevalent in the Northeast.

Description. ***Adult.*** Delicate, shiny, black and reddish, wasplike sawfly; female averages about 12 mm long with wingspan of 20 mm; male averages about 9 mm long with wingspan of 12 mm (figure 237A) (Ries 1937, Slingerland 1897, Smith and Solomon 1989). Head and pronotum black with yellowish mandibles and similar markings at base of wings on thorax. Abdomen noticeably compressed, being deeper than wide, and equipped with a stout, sharp, sawtoothed ovipositor at apex in females; basal three to four segments red to reddish orange with remaining segments black. Abdomen of male brownish yellow and not compressed. Legs brownish yellow in both sexes. Wings hyaline, without violaceous reflections, with one fuscous black spot below stigma on forewing. ***Egg.*** Elongate to oval, rounded at both ends; white to yellowish white when first laid, becoming transparent before hatching; delicate structure without surface sculpturing; 1.0 to 1.1 mm long (Marlatt 1895, Slingerland 1897). ***Larva.*** Cylindrical, slightly S-shaped with somewhat enlarged thorax; white to creamy white with pale yellow, rounded head, brown mandibles; short tubular prong at tip of abdomen; three pairs fleshy, unjointed, teatlike legs on thorax; abdominal prolegs absent; 10.0 to 12.7 mm long when mature (figure 237B) (Marlatt 1894, 1895; Middleton 1917).

Biology. The adults emerge during May and June and begin ovipositing soon after

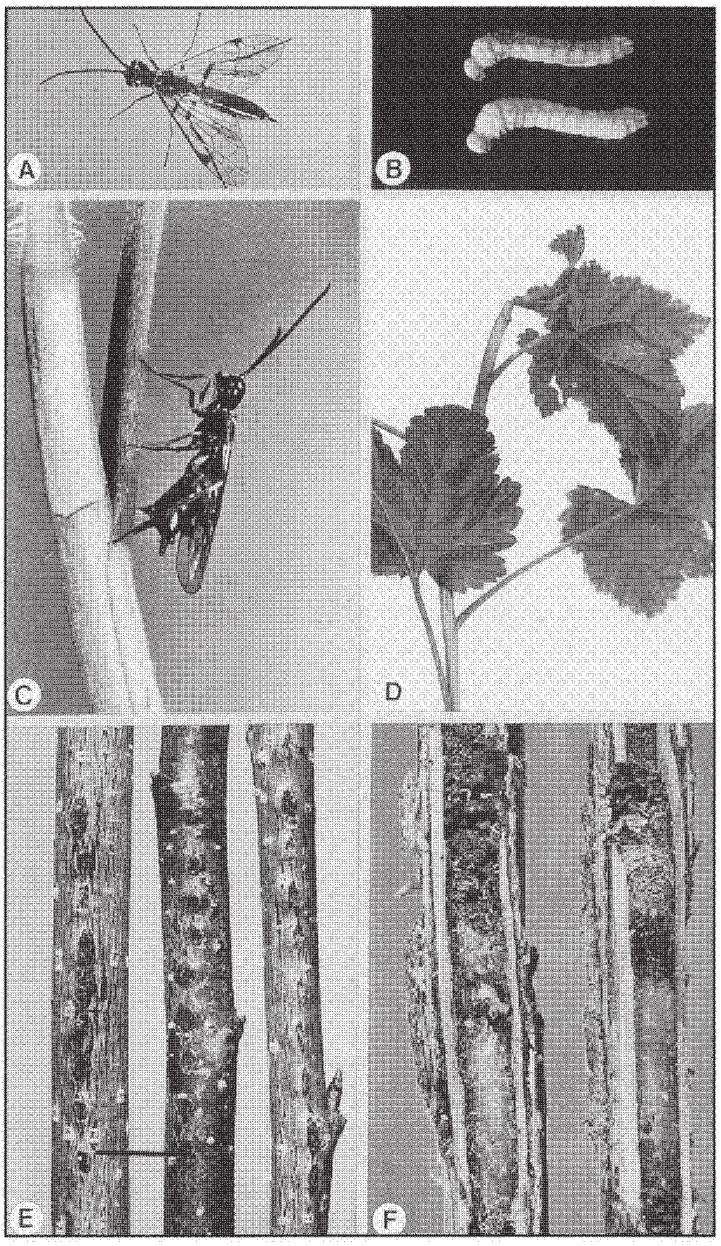

Figure 237—Janus integer, *currant stem girdler: A, adult; B, larvae; C, female ovipositing in shoot; D, currant shoot broken at girdled site; E, scars from probing punctures by female ovipositor; F, cocoons in frass-packed galleries (courtesy NY Agricultural Experiment Station).*

(Marlatt 1894, Slingerland 1897). Females may visit several plants before selecting terminals for oviposition and may begin depositing eggs within 2 hours of emergence. To oviposit, the females take a position with heads upward a few centimeters below the shoot tips (figure 237C). They quickly push the full length of their ovipositors into the tender shoots and deposit single eggs in the pith. They quickly withdraw their ovipositors, accomplishing the whole operation of laying an egg in about 1 minute. The slits cut by their ovipositor saws are so small that they can scarcely be found even with a hand lens until a few days later, when the sides of the shoots swell slightly. Immediately after ovipositing, females move up the shoots for 3 to 25 mm and girdle them by forcing their ovipositors in the shoots and withdrawing them in a twisting or sawing motion. They move around the stems and repeat the puncture-sawing action four to six times or until girdles are nearly complete, which takes about 4 minutes. Female can lay up to 30 eggs and girdle the same number of shoots. Eggs hatch in about 11 days. The young larvae feed and tunnel downward mostly in the pith, leaving enough of the woody stem to hold it upright. Larvae continue to feed for 75 to 150 mm, packing the dark brown frass behind them in the galleries. During fall, larvae prepare cells for overwintering and eventually pupate at the lower ends of the galleries. They chew round passageways nearly through the stem for later exit, then spin thin, glistening, silken cocoons around themselves to overwinter. Beginning in April, larvae pupate within the silken cocoons and emerge as adults after about 2 weeks. There is one generation a year (Middlekauff 1969, Ries 1937).

Injury and damage. The earliest symptoms of damage are sudden wilting and drooping of terminal shoots during spring and early summer after new growth is several centimeters long (Marlatt 1894, 1895; Middlekauff 1969; Slingerland 1897). Wilted shoots typically wither rapidly and die. Some shoots are so thoroughly girdled that, instead of wilting and drooping, they drop over immediately and hang suspended or fall to the ground (figure 237D). Careful examination of the wilted or broken terminals reveals that they were deftly girdled with several sharp, somewhat curved cuts encircling the stem and extending through or nearly through 5 to 10 cm below the tip. Sometimes when the terminal is quite large, the puncture cuts do not extend deep enough to sever the stem. Partially girdled terminals are slow to wilt and may or may not die and break off later. The girdled or severed terminals are the principal kind of injury, but another 15 mm of the infested shoot may die back from tunneling by the larva. Also, stems may have scars resulting from probing punctures made by the female (figure 237E). Dissecting infested stems reveals galleries densely packed with brown frass, except for the bottom portion, which is occupied by the larva or cocoon (figure 237F). Injuries stop the growth and disfigure or stunt the plant for the rest of the season. The insect has been particularly troublesome to currant growers in New

York and is especially objectionable in nursery cuttings.

Control. Six species of insect parasites have been recorded; up to a third of the sawfly larvae have been destroyed by parasites, largely by a braconid parasite—*Bracon apicatus* Provancher (Marsh 1979, Slingerland 1897). The greatest natural mortality rates (up to 85%) occur when eggs fail to hatch and newly hatched larvae die. Populations can be reduced by pruning and destroying the flagged (infested) shoots. Early pruning in May and June requires removal of only the top 5 to 8 cm of the shoot; late pruning from July to April requires removing the top 20 cm of the shoot to ensure getting all the larvae. Insecticides applied during the oviposition period should be effective against adults.

Janus quercusae Smith

[oak shoot sawfly] (figure 238)

Host. Oak. Found only in two species, Nuttall oak and water oak, which are in the red oak group (Smith and Solomon 1989). However, because this pest also occurs outside the range of Nuttall and water oaks, it likely infests other species in the red oak group.

Range. Newly discovered species known only from Mississippi, Maryland, and Virginia (Smith and Solomon 1989). It undoubtedly occurs elsewhere in the East, particularly between Mississippi and Maryland.

Description. ***Adult.*** Female delicate, black and red, wasplike sawfly, 6.5 to 8.0 mm long, with wingspan of 11 to 13 mm; male unknown (figure 238A) (Smith and Solomon 1989). Head, antennae, and thorax black with yellow mandibles, palpi, and indistinct markings on pronotum. Abdomen compressed, noticeably deeper than wide; black with at least segments 3 to 6 red; ends with a sharp, sawlike ovipositor. Forelegs and midlegs yellow; hindlegs black, yellow, and orange. Wings hyaline with indistinct, ochre markings and brownish veins; radial vein complete in forewing. ***Larva.*** Nearly cylindrical, thorax somewhat enlarged, slightly S-shaped with head and thorax most noticeably curved downward; white with yellowish head and light brown mandibles (figure 238B).

Biology. Adults emerge from mid-April in Mississippi to mid-May in Virginia (Smith and Solomon 1989). Females lay eggs in the tender terminals and branch ends during spring when shoots elongate. The shoots are girdled by a series of ovipositor punctures apically to the oviposition sites and 3 to 8 cm from the shoot tips. Larvae tunnel basally in the stem pith for 4 to 10 cm, eventually hollowing the shoots and packing frass behind them within the galleries (figure 238C). The larvae girdle the shoots from within one or more times in their travel down the shoots. Larvae are fully grown by mid- to late June and construct thin, white to light brown, partially transparent, cellophane-like cocoons around themselves near the basal ends of the galleries (figure 238D). They spend the rest of the summer, fall, and winter in the cocoons, and pupate in early spring. Adults emerge through round holes in the sides of the shoots. The oak shoot sawfly has one generation a year.

Injury and damage. Flagging shoots

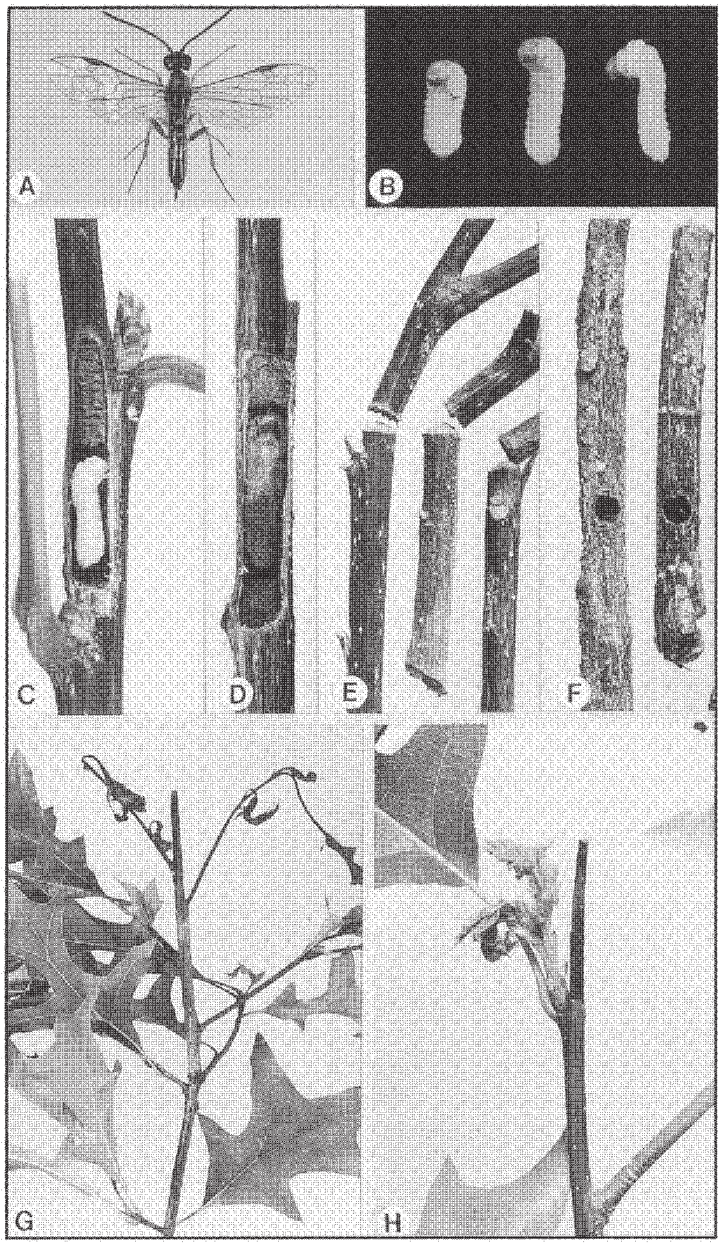

Figure 238—Janus quercusae, *[oak shoot sawfly]: A, adult; B, larvae; C, frass-packed gallery with S-shaped larva; D, cocoon in gallery; E, shoots with dome-shaped breaks at girdled sites; F, exit holes in shoots; G, flagging dying shoot; H, infested shoot with tip detached and new lateral shoot emerging.*

from mid-April to mid-July provide the earliest evidence of attack (figure 238G). New expanding leaves and succulent new growth of terminals and branch ends begin wilting and drooping soon after attack. Affected shoots turn yellowish brown then black, flagging the injured shoots. Most shoots break at girdled sites 3 to 8 cm from the apices and drop to the ground, leaving only blunt stubs (figure 238G and H). As the larvae tunnel down the stems, the shoot stubs gradually turn dark brown or black, and any succulent side shoots also wither, droop, and darken (figure 238G). By midsummer, new lateral shoots often issue from bud sites just below the blackened stubs (figure 238H). The tunneled portion of the shoot is easily broken at one or more sites that are girdled from the inside by the larva (figure 238E). The girdled site is always nearly perfectly round, with the tightly packed frass protruding from the branch stub in a dome shape; the site is concave in the end of the detached portion. The emerging adults leave round exit holes 1.2 to 1.6 mm in diameter in infested shoots (figure 238F).

Control. Parasitic larvae in sawfly cocoons and very small exit holes in the bark directly over sawfly cocoons have been observed, but no adult parasites have been obtained, and none have been identified. Direct controls will probably be needed for ornamental trees, but none have been investigated.

Janus rufiventris (Cresson)

[white oak shoot sawfly] (figure 239)

Host. Oak. Oregon white oak is only known host, but this pest probably attacks other oaks in the white oak group within its range (Hanson 1986).

Range. A western species known only from California and Oregon (Hanson 1986, Middlekauff 1969, Ries 1937).

Description. ***Adult.*** Small, delicate, black and red, wasplike sawfly, 7 to 8 mm long (figure 239A) (Ries 1937, Smith and Solomon 1989). Head and thorax shiny black with yellowish mandibles and whitish thoracic membranes laterally. Abdomen compressed, being deeper than wide, uniform brick red with brownish yellow cerci and amber saw and terminating with short, sawlike ovipositor. Legs blackish brown. Wings hyaline, slightly infuscated along margins and veins. Distinguished by only one preapical spur on hind tibia, entirely red abdomen, and wings infuscated toward tips and along veins. ***Larva.*** Cylindrical with slightly enlarged thorax, slightly S-shaped, head and thorax curved somewhat downward, whitish with slightly darker head and mandibles (figure 239B).

Biology. In California, adult emergence has been recorded from mid-March to early June (Middlekauff 1969, Ries 1937), whereas in Oregon emergence occurs from mid-April to mid-May (Hanson 1986). Females select current year's growth for oviposition (figure 239C), preferring succulent, vigorous shoots. They oviposit from late April to early June in the Willamette Valley of Oregon. Females insert one egg into the outer pith. Immediately after oviposition, the females girdle the stems with their ovipositors by making a series of deep punctures around the circumference 4 to

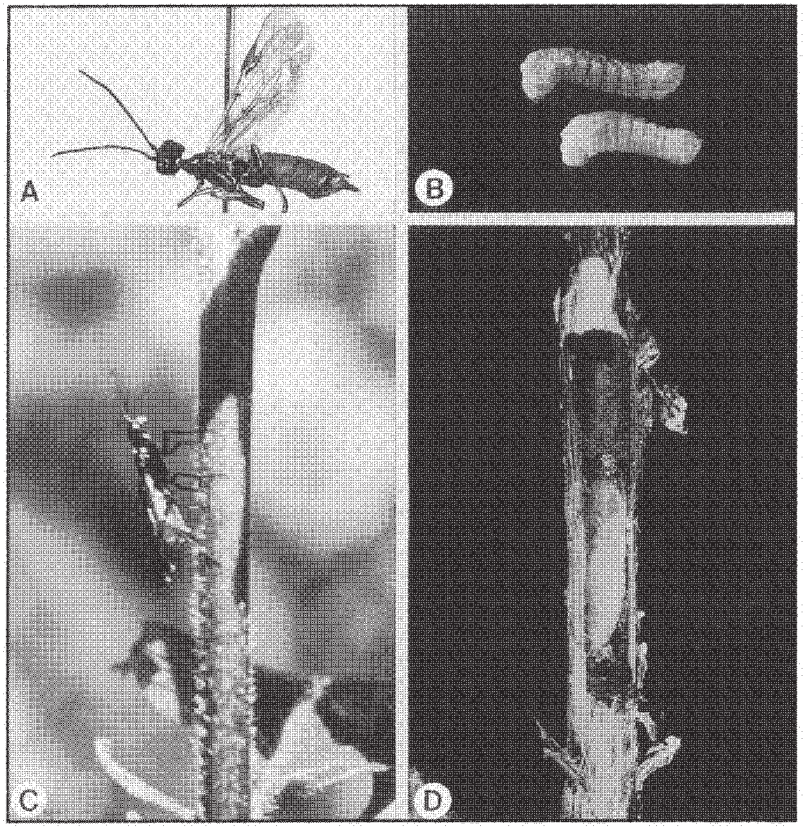

Figure 239—Janus rufiventris, *[white oak shoot sawfly]: A, adult; B, larvae; C, female ovipositing in Oregon white oak shoot; D, infested shoot with gallery containing cocoon (A, specimen courtesy D. Smith; B-D specimens courtesy P. Hanson).*

10 mm distal to the eggs. Girdling requires 4 to 7 minutes. These cuts almost totally sever the stem. Upon hatching, the larvae initially tunnel toward the apex (point of girdling); in subsequent instars, they turn and burrow toward the base of the stem. Feeding larvae consume almost all the interior of the shoot, packing the frass tightly in the vacated gallery. In late July and early August, fully grown larvae begin lining a chamber near the base of the shoot with silk, which is spread flat rather than spun into threads, resulting in a translucent, parchment-like cocoon (figure 239D). This insect overwinters as a postfeeding, last-instar larva or as a pharate pupa. Adults emerge in spring. There is one generation a year.

Injury and damage. Wilting and drooping shoots of terminals and branch ends during spring and early summer mark the beginning of injury (Hanson 1986). Most affected shoots, nearly severed by a ring of deep punctures 6 to 17 cm from the apex, quickly darken and usually detach within 1 week. Buds, leaves, and the shoot tissue die sequentially as larval tunneling and girdling proceed basally. Dissection of infested shoots reveals galleries tightly packed with brown frass, extending 4 to 9 cm, and containing one larva or a thin glazed cocoon with the mature larva or pupa inside. New adults cut emergence holes directly over the pupation chambers to exit. Tender, thick, stem shoots on vigorously growing young trees and especially stump sprouts are most susceptible to infestation. Damage has been negligible to date.

Control. Natural controls cause larval mortality rates estimated at about 34%, a third of which is by two hymenopterous parasites—*Eurytoma* sp. and *Pteromalus* sp. (Hanson 1986). Some mortality occurs in the egg and first-instar stages associated with cracking of the stem near the girdle, causing desiccation. Infested stems with irregular holes and peeled edges suggest some bird predation. Direct controls have not been needed.