TURF, FOREST AND ORNAMENTAL PESTS

8-5. TURF PESTS.

a. Introduction/Importance. Establishing and maintaining extensive grassy regions on military installations provide numerous benefits for personnel. For example, land preservation through erosion prevention, wildlife preservation through the maintenance of natural habitat, recreation (i.e., golf courses, parks) and aesthetics all which improve the quality of life.

Many of these areas, however, are adversely affected by a variety of vertebrate and invertebrate pests and plant diseases. For example, grubs (beetle larvae) live in the soil, feeding on grass roots. Chinch bugs and leafhoppers feed on plant juices. Vertebrate pests such as moles, voles and skunks, destroy turf while searching for grubs. Finally, fungi such as brown patch or dollar spot weakens turf making it more susceptible to arthropod attack or harsh environmental conditions (drought, excessive rain).

Protecting these regions from turf pests requires developing site-specific programs, based on the following guidelines: 1) regular surveillance, 2) proper identification of turf pests and damage, 3) integrating a variety of chemical and non-chemical management techniques and 4) monitoring and re-evaluating of program components.

b. Pest Identification/General Principles. Early recognition and identification of a problem is essential to successful maintenance of turf. Early symptoms of a turf problem, while rarely attract attention, must be correctly identified. For example, a subtle change in color or growth rate, wilting or footprinting earlier in the day than normal, cottony growth on the grass in the early morning, birds or other animals actively feeding in the turf or a combination of these symptoms may be an early indication of a serious turf problem. After the turf thins out or brown patches appear in the turf, the opportunities for effective control are greatly reduced (See Appendix A : Turfgrass Identification).

Regular inspections of the turf must be made to establish a reference by which abnormalities can be readily recognized. For example, difference in soil conditions may cause the grass in one area to wilt sooner than in another. Also, changes in the color or growth rate of a turf may indicate a nutrient deficiency and require frequent observation to detect. The height of grass before mowing, the number of baskets of clippings removed or the frequency of mowing all provide a reference to detect growth rate. Color changes require even closer observations, but they can be an early warning to a serious turf problem. A subtle change in color may signal a nutrient deficiency, a disease or insect infestation.

Maintaining a daily log in enough detail to show what, when, why and how with respect to management practices performed is helpful. Fertilization records can help explain changes in turf color or growth rate. Cultural practices such as mowing, watering, aeration, vertical mowing and topdressing should also be included in the daily records. Insect, disease and weed control treatments must be recorded along with the response obtained. The turf manager trying to identify a problem without these records is probably not going to be successful in determining problems.

(1) Classifying Problems as to Origin. Turf problems should first be identified as to their source: cultural (man-made), environmental or pest related (See Appendices B and C, Key to Turf Pest Damage: Key to Identify Turf Insect Pests). Often two or more of these factors contribute to the problem. For example, a grass that has limited shade tolerance (environmental) should not be mowed to close (cultural). Likewise, a nitrogen deficiency (cultural) can be a contributing factor to an outbreak of dollar spot (pest)(See Appendix D, Key to Identification of

Common Turfgrass Diseases). When two or more factors contribute to the problem, all factors must be identified before the problem can be effectively corrected.

Too often, only one factor is identified as contributing to a turfgrass problem, when, in fact, several factors contribute to the problem. For example, many pest problems are the result of environmental conditions and cultural practices. In fact, pest related problems such as dollar spot may be controlled most effectively by changing the cultural practices that contributed to the problem. Pest management programs must consist of more than the shotgun application of pesticides to the turf. Accurate identification of the factors contributing to the problem and timely application of pesticides are better alternatives. The following provides a description of commonly encountered invertebrate and vertebrate pests and diseases of turfgrass.

c. Turfgrass Pests-Identification

(1) Invertebrates

(a) Soil and root infesting

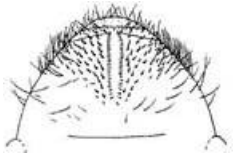
1. **White Grub Complex (Scarabaeidae, Coleoptera).** White grubs are the larvae of many beetle species, most of which belong to the family Scarabaeidae. Although the adults differ in appearance and life cycles, the grub (larval) stage of all species are similar in appearance. For example, fully grown, larvae are about 1/2" to 3/4" (13-19 mm) long, white to grayish, with brown heads and six legs. They generally assume a C-shaped position while in the soil. Grubs can be identified to species on the basis of the raster setal hair pattern found on the underside of the last abdominal segment (Figure 1).

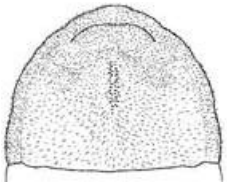
Although numerous species of grubs cause turf damage, only the most commonly occurring are described here in detail including: May/June beetle, Japanese beetle, Green June beetle, Northern/Southern masked chafer, rose chafer, Asiatic garden beetle, and white-fringed beetle (Figure 2).

Figure 1. White Grub Larval Identification Key (Adopted from the Ohio State University Extension Service, Publication HYG-2510-94)

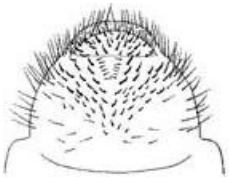
Correct identification of white grub species is important in determining management strategies and timing of controls. The raster pattern is the arrangement of bristles and hairs on the underside of the tip of the abdomen. A 10x hand lens is needed to see this pattern on most mature white grubs. A microscope may be necessary to view smaller grubs.

Raster Location

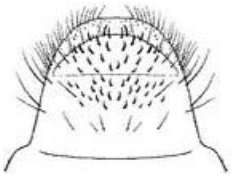




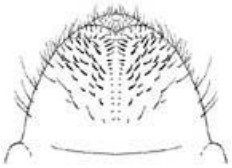
May/June Beetle Raster: *Phyllophaga* sp.



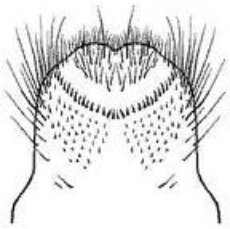
Green June Beetle Raster: *Cotinus* sp.



Japanese Beetle Raster: *Popillia japonica*



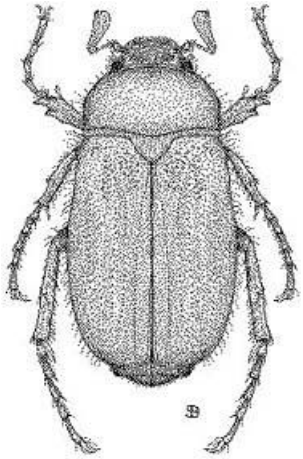
Masked Chafer Raster: *Cyclocephala* sp.



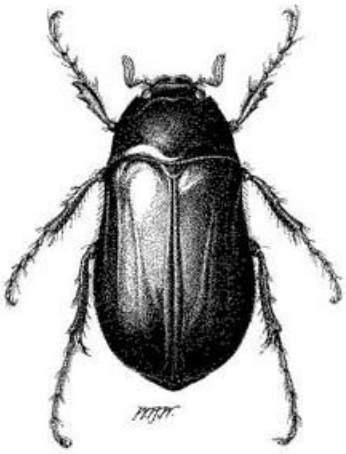
European Chafer Raster: *Rhizotrogus majalis*

Asiatic Garden Beetle Raster: *Maldera castanea*

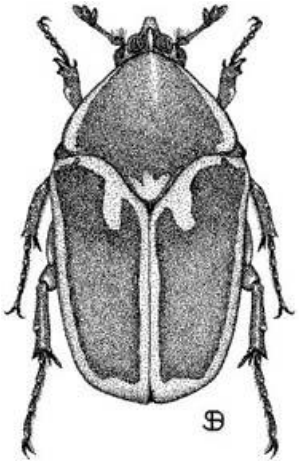
Figure 2. Adult Beetle (White Grub Complex) Identification



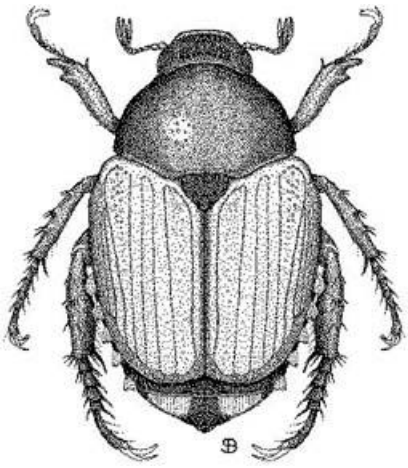
Green June Beetle (*Cotinus nitida*):
Metallic green with tan highlights



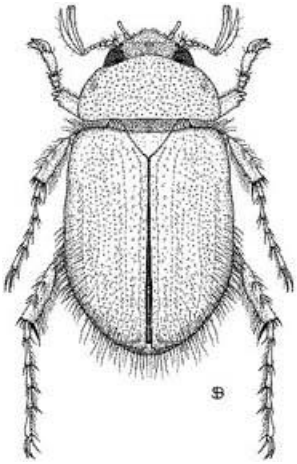
May/June Beetle (*Phyllophaga fusca*):
Tan to chestnut brown



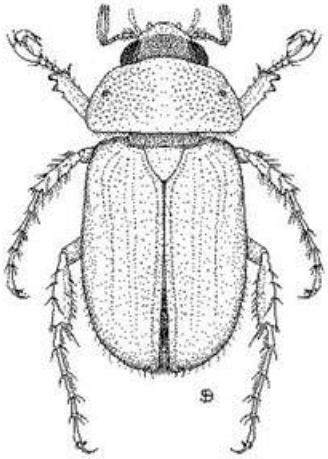
European Chafer (*Rhizotrogus majalis*)
Chestnut brown



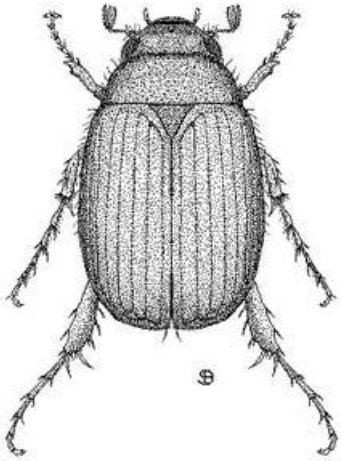
Japanese Beetle (*Popillia japonica*)
Metallic green with copper wing covers



North Masked Chafer (*Cyclocephala borealis*)
Yellowish brown



Southern Masked Chafer (*C. lurida*)
Yellowish brown

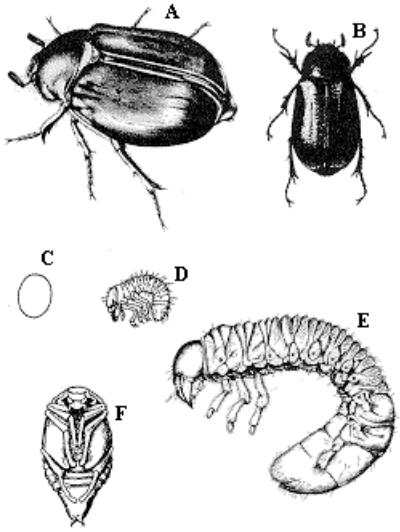


Asiatic Garden Beetle (*Maladera castanea*)
Iridescent, chestnut brown

May/June Beetle, *Phyllophaga* spp., Scarabaeidae, Coleoptera

Description

Adult--Many species of May/June beetles may occur in any given area. They are shiny, robust, reddish-brown to black in color. Oblong in shape, they reach a length of 3/4- 1 3/8" (20-25 mm). The antennae have three plate-like segments forming a club-like structure at a right angle to the other segments. The head, pro-thorax, and wing covers usually have no distinguishing markings or grooves.



White grubs. A & B, Adults. C, Egg. D, E, Grubs. F, Pupa.

Egg-- The eggs are pearly white and oblong. Each one is initially about 2.5 mm long an 1.5 mm wide, becoming slightly larger as the larva grows.

Larva-- Larvae are white and C-shaped, with a distinct brown head. Early instar larvae are about 5 mm long, but may grow to about 25 mm and possess large mandibles. Two parallel rows of hairs on the underside (ventral) of the last abdominal segment (raster) oriented front to rear on the segment are useful for identification.

Pupa-- The oval, brownish pupae are present within earthen cases.

Biology

Distribution-- More than 200 species of May/June beetles occur throughout North America. A single species distribution is seldom found.

Host Plants-- Although live oaks are the favorite food source, adult May/June beetles also feed on the foliage of many other trees. Larvae prefer lespedeza, sod and corn, but they too have additional host foods which include lawn grasses and nursery plantings.

Damage-- Both larvae and adults are destructive. The adults are defoliators, chewing the leaves of various hardwood trees. The grubs feed on and injure the root systems of grasses and other plants. Heavily infested turf can often be rolled up like a carpet, exposing the white grubs.

Life History-- May/June beetles have a 2-3 year life cycle, depending on the species. Eggs are deposited 1-8" (25-150 mm) deep in the soil during late spring. Eggs hatch in about three weeks and young larvae begin feeding on roots and decaying vegetation. In the fall, larvae migrate down into the soil, where they overwinter. The three-year cycle species resume root feeding in the following spring. After a summer of feeding, they hibernate deep in the soil over their second winter, and then migrate near to the surface to feed again until May or June. Pupation will then occur in a hollowed cavity in the soil. The new adults remain in the hollow cavities through the following winter and only emerge the following May or June, when feeding, mating and egg-laying occur.

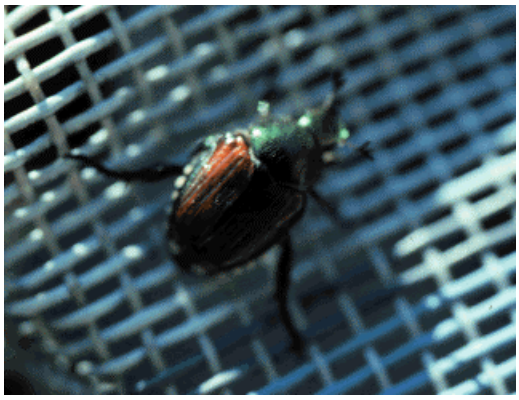
Adults fly and feed during the night but hide in the soil or sod during the day. Trees with new tender spring growth are most susceptible to adult defoliation. Although named May/June beetles, some species emerge in April.

Larval damage to turf is similar to that caused by Japanese beetle grubs. No thresholds are available in the literature. Limited studies indicate that five to seven grubs per square foot may damage turf under drought stress conditions.

Japanese Beetle, *Popillia japonica*, Scarabaeidae, Coleoptera

Description

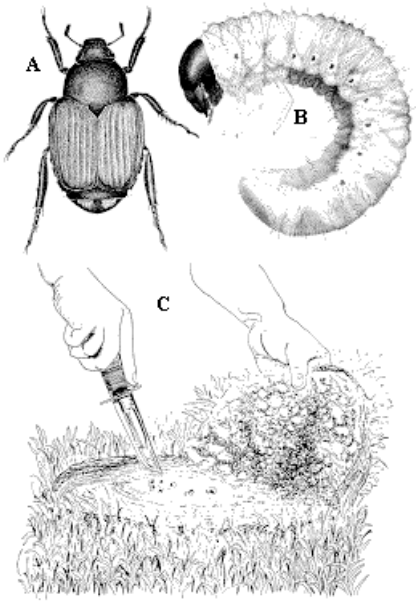
Adult-- The adult male beetle is about 3/8" (1 mm) long, the female is slightly larger. The body is oval in outline, the head and pro-thorax are greenish bronze. The wing covers are brownish bronze with green along the sides and center. Japanese beetles have twelve white tufts of hair along the sides of the abdomen and at the tips of the wing covers and plate-like antennae. The legs are long with large claws.



Egg-- The translucent white to cream-colored eggs are round when first laid, becoming oval after absorption of soil moisture measuring. By the time eggs are ready to hatch, they become more spherical in shape and double in size.

Larva-- The grayish-white, slightly curled grub has a yellowish-brown head and measures about 1.5" (26 mm) long when mature. The head is brown with large brown-black mandibles. It can be distinguished from other white grubs by two rows of spines which form a "V" on the ventral portion of the last abdominal segment.

Pupa-- The cream-colored pupa, approximately 0.5 " (13 mm) long and 0.25" (6 mm) wide, gradually turns light brown and finally develops a metallic green cast.



Japanese beetle. A, Adult. B, Larva (grub). C, Turf infested with Japanese beetle grubs.

Biology

Distribution-- The Japanese beetle is an Asian native that was first reported in the United States at Riverton, New Jersey in 1916. It is common in all states east of the Mississippi River except Florida, Mississippi, and Wisconsin. It has also been found in Missouri, Minnesota, and California. Because of the ease of shipping grubs with nursery stock and soil, this species could potentially be found anywhere in the United States including Hawaii and Puerto Rico.

Host Plants-- The grubs are serious pests of lawns, other grasses and nursery stock. Tender grasses are preferred to tougher varieties. The adult beetles infest over 300 different plants, including many shade and fruit trees, ornamental shrubs, small fruits, garden crops and weeds.

Damage-- Japanese beetle grubs may be abundant in well-kept lawns, pastures and golf courses. They burrow through soil, severing and consuming roots. Large areas of dead brown grass often appear in infested lawns when large numbers of grubs (10 per sq. foot) are present or during drought. Such dead areas are usually noticeable by September or early October. Unlike the grubs, adults eat foliage (leaving a lacy network of leaf veins) and fruit.

Life History--Grubs overwinter in cells within 5" (13 cm) of the soil surface. In spring, they move upward, almost to ground level, where they complete feeding and pupate. About 140 days are required for development from egg to last instar larva.

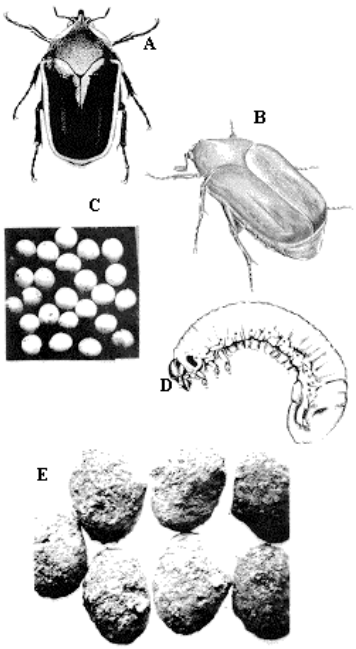
Adults emerge as early as mid-May in the south and as late as July in New England. However, even in the beetles' southern most range, peak emergence occurs in July. Throughout summer, the beetles feed on fruit and foliage of many plants. Soon after emerging, females deposit 40-60 eggs in small batches 2-4" (5-8 cm) deep in the ground. Females prefer to lay eggs in warm, moist soil where the turf is exposed to full sunlight. Under drought conditions, many eggs and larvae perish. However, during warm, wet summers, populations thrive and eggs hatch about two weeks after deposition. The newly emerged larvae feed until cold weather forces them into hibernation. One generation is produced each year.

Green June Beetle, *Cotinis nitida*, Scarabaeidae, Coleoptera

Description

Adult-- The green June beetle adult is usually 0.75 to 1" (2-2.5 cm) long and 0.5" (13 mm) wide. The dorsal side is forest green, with or without lengthwise tan stripes on velvety wings. The ventral side is a metallic bright green or gold, bearing legs with stout spines to assist in digging. The sides are brownish-yellow. In the mid-Atlantic region the names "June bug" and "June beetle" are commonly used for this insect, while they are called "fig eater" in the southern part of their range. They should not be confused with the familiar brown May/June beetles that are seen flying to lights on summer nights. The adult green June beetle flies only during the day.

Egg-- When the egg is first laid, it is pearly white and elliptical, measuring about 0.06" (1.5 mm) wide and 0.125" (2.1) mm long. It gradually becomes more spherical as the larva develops.



Green June beetle. A and B, Adults. C, Eggs. D, Larva. E, Pupa chambers.

Larva-- Larvae are white grubs often called "richworms" because they prefer high levels of organic matter for food. Newly hatched, they measure about 0.375" (8 mm) long and grow to a

length of about 1.75" (40 mm). Whitish with a brownish-black head, they have well defined brown spiracles along the margins of the body, stiff abdominal bristles, short stubby legs and wide bodies. One unique characteristic of this species is the larvae crawl on their backs by undulating and utilizing their dorsal bristles to gain traction.

Pupa- The brown pupa, approximately the same shape as the adult, becomes metallic green just before the adult emerges. It is about 0.625" (15 mm) long and 0.625" (15 mm) wide.

Biology

Distribution-- This species is native to the eastern half of the United States and overlaps with *Cotinis texana* ("Fig-eater") in Texas and the southwestern United States.

Host Plants-- Green June beetle adults prefer to feed on ripened fruits of many plants. Any thin-skinned fruit such as fig, peach, plum, blackberry, grape and apricot may be eaten. The main attraction is probably the moisture and the fermenting sugars. They occasionally feed on plant sap. Larvae feed on decaying organic matter in the thatch and root zone of many grasses, as well as on the underground portions of other plants such as sweet potatoes and carrots. This species is commonly associated with both agriculture crop and livestock production areas as well as urban landscapes. Field-stored hay bales, manure piles, grass clipping piles, bark mulches and other sources of plant material that come in contact with moist soil provide prime microhabitats preferred by both the female for egg laying and the migrating third instar grub.

Damage-- Adult and larval feeding on economic crops causes some financial loss, however, the larvae tunneling and the adult burrowing into the soil cause more serious destruction. The tunneling uproots young plants. Many exit holes of the adults and larvae resemble ant hills and damage lawns and golf course greens.

Life History-- Unlike the May/June beetles, only one year is required for these beetles to complete their life cycle. They overwinter as larvae, often becoming active on warm winter days. Increased activity occurs in the spring, and in late June larvae pupate in earthen cells several centimeters underground and emerge. The pupal stage lasts about 18 days; adults appear in July and August. On warm sunny days, adults may swarm over open grassy areas. Their flight behavior and sounds resembles that of a bumble bee. At night they rest in trees or beneath the thatch. Adults will fly sporadically into September.

After emerging, adult females fly to the lower limbs of trees and shrubs and release a pheromone that attracts large numbers of males. Frequently, males repeatedly fly low and erratically over the turf trying to locate emerging females. After mating, females burrow 2-8" (5-20 cm) into the soil and lay about 20 eggs at a time, up to a total of 60-80 in two weeks.

Most eggs hatch in late July and August. The first two grub stages feed at the soil thatch interface. By the end of September, most are third instar larvae and these large grubs tunnel into the thatch layer, constructing a deep vertical burrow. Grubs may remain active into November in the mid-Atlantic region. In the more southern states, grubs may become active on warm nights throughout the winter. In colder areas they overwinter in burrows 8-30" (20-75 cm) deep. The grubs resume feeding once the ground warms in the spring and then pupate in late May or early June. The adults begin emerging about three weeks later.

Northern and Southern Masked Chafer, *Cyclocephala dorealis*, *C.lurida*, Scarabaeidae, Coleoptera

Description

Adult-- Small, yellow- or reddish-brown beetles are about 1/2" (13 mm) long with black to chocolate brown areas (masks) between the eyes. The masks become lighter in color toward the mouthparts and helps separate these two species from numerous other similar appearing May/June beetles. Additionally, northern and southern masked chafers can be separated based on the amount of hair on the front wing or elytra. Northern masked chafers will have hair on their front wings while southern masked chafers will not.

Egg-- When first laid, the egg is pearly white and elliptical, measuring about 0.062" (1.5 mm) wide and 0.125" (2.1 mm) long. It gradually becomes more spherical as the larva develops.

Larva-- Larvae will be C-shaped, white with a reddish brown head and six legs. The grubs lack a distinctive rastral pattern. Larvae will range in size from about 0.125" (3 mm) (1st instar) to about 1" (25 mm)(3rd instar).

Pupa-- The oval, brownish pupae occur within earthen cases.

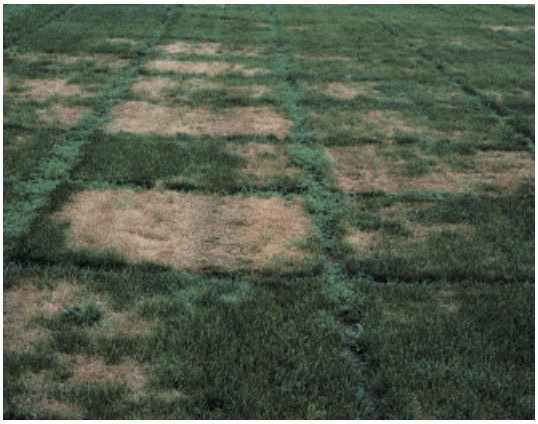
Biology

Distribution-- The Northern masked chafer is found from Connecticut south to Alabama and west to California. The southern masked chafer is a common turf pest in southeastern states. A broad overlapping distribution occurs between both species in the mid-Atlantic states. Because grub feeding damage and life histories are similar both species are frequently referred to as masked

chafer grubs. A grub species shift is occurring in many mid-Atlantic areas where they overlap with the Japanese beetle. For reasons not fully understood, urban neighborhoods that were previously infested by Japanese beetle populations are now reversing to a predominantly masked chafer population. Selective control by milky disease and other Japanese beetle specific pathogens may be a part of the explanation for the shift.

Host Plants-- All cool and warm season turf grasses may be affected. Difference in damage levels are observed with respect to the size and depth of the root system. Turf grasses with extensive root systems tolerate higher levels of grub infestation than shallow systems.

Damage-- Adults do not feed, and grub damage is identical to Japanese beetle. Populations of 10-15 grubs per square foot can severely damage turf. Southern masked chafers fly just after sundown and activity stops around midnight. Northern masked chafers start their flight activity at about 0200 and continue until about sunrise. Both are highly attracted to irrigated lawns during dry weather and both flight and egg laying activities will increase significantly after rain.



Life History-- Life cycle is similar to the Japanese beetle except the adults fly at night and do not feed. Both species have one generation per year and will overwinter as a third instar grub below the frost line. Eggs are laid in the upper 2" (5 cm) of soil during July and grubs begin to develop by early to mid-August. Larval feeding damage can be observed by late August and through October. Larvae will move deeper into the soil by late October and November and overwinter in earthen cells. Adults do not feed.

Larval feeding activity will continue in the spring, April-May period, with pupation occurring in late May to early June.

Eastern and Western Rose Chafer, *Macrodactylus subspinosus, M. uniformis*, Scarabaeidae, Coleoptera

There are two species of rose chafers in the genus *Macrodactylus* in North America; Eastern rose chafer and Western rose chafer. Both species are very similar in size, body shape and habits.

Description

Adult-- The eastern rose chafer is a long-legged, slender beetle from 0.5" (8-12 mm) long, tan to reddish-brown with bodies densely covered by dull yellow scales or hairs. The Western rose chafer is about 1/2" (10 mm) long with a slender body, long-legged and yellowish-brown in color.

Egg-- Eggs are pearly white and oblong. Each one is initially 0.125" (2 mm) long and about 0.625" (1.5 mm) wide, becoming slightly larger as the larva grows.

Larva--The full grown grub measures about 0.75 (18 mm) long and slender, white in color with a dark head capsule.

Biology

Distribution-- Most common in the eastern United States is the eastern rose chafer, *Macrodactylus subspinosus* and is found from eastern Canada south to Colorado. The western rose chafer, *Macrodactylus uniformis*, occurs in Arizona, New Mexico, Texas and south into central Mexico.

Host Plants-- Adult rose chafer was first reported as a grape pest as early as 1810, later extending its host range to include a wide assortment of plants, including many types of flowers, deciduous trees, shrubs peonies, and roses. Grape remains among the most severely injured crops. The larvae will feed on the roots of many grasses and weeds.

Damage-- The larvae will destroy grasses by feeding on the roots throughout a single growing season. The adults damage plants by feeding on the flowers, newly set fruit and foliage. On roses it skeletonizes the leaves in the same way as other scarab beetles like the Japanese and Chinese rose beetles.

Life History-- Adult beetles emerge from the soil in late May through early June and live for about a month. Mating occurs soon after emergence and the female lays her eggs (24-36) continuously for about two weeks in the soil of grassy sandy areas. Upon hatching the larvae burrow in the soil and feed on the roots of grasses and weeds. They overwinter as a larvae, continuing development in the spring. From late May through July, foliage should be monitored for skeletonized leaves and the presence of adult beetles on the leaves and flowers. The rose chafer has only one generation per year. Birds may sometimes die from eating adult rose chafers. The beetles apparently produce a chemical that affects the hearts of small, warm blooded animals if consumed in quantities.

Asiatic Garden Beetle, *Maladera castanea*, Scarabeaidae, Coleoptera

Description

Adult-- The adult is a small, 0.43" (1 cm), chestnut-brown, velvety, sometimes iridescent beetle. The wing covers (elytra) do not entirely cover the abdomen.

The Asiatic garden beetle.

Egg-- White eggs (about 0.06", 2 mm oblong) are laid in clusters of up to 20, held together by a gelatinous material.

Larva-- The larva is white with a brown head capsule, has a V-shaped anal opening and there is a single transverse row of curved spines on the underside of the last segment. Mature larvae are about 0.75" (2 mm) long.

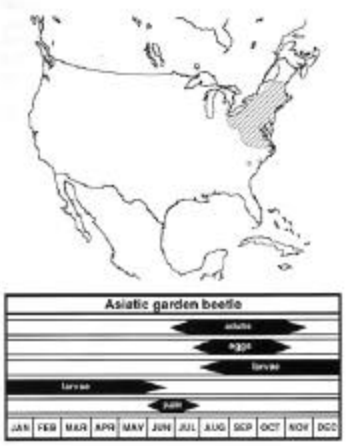
Pupa-- The oval, brownish pupae occur within earthen cases. Each possesses a pair of pointed structures at the corners of the tip of the abdomen.

Biology

Distribution-- Occur throughout North America, seldom distributed over any large area.

Host Plants-- Many fruit, vegetable, perennial and annual flowering plants, trees and shrubs as well as weeds and grasses.

Damage-- The adults infest over 100 different plants, feeding on both foliage and blossoms. Larvae are seldom found uniformly distributed over large areas. They show a preference for grasslands, but may be found in flower and vegetable gardens. Moist, loamy to sandy soils are preferred. Larvae apparently feed scattered at different depths and do not as severely prune the roots off close to the surface as Japanese beetles. The larvae feed on the roots of practically all plants.



Life History-- The beetle has four life stages: egg, larva, pupa, adult. Its life history is similar to the Japanese beetle and rose chafer. There is one generation per year. Eggs are laid in the soil in clusters of up to 20, held together by a gelatinous material. The larvae, or grub, is a typical C shaped scarab. Mature grubs are about 0.75" (2 cm) long. The larva pupates in an earthen cell, during late June, with adults flying in July or August. The adults are highly attracted to light and may be very numerous at windows, doors, or wherever there is bright light. The females burrow into the soil to lay their eggs (50+). Eggs hatch in about 2 weeks and the larvae begin feeding.

White-fringed beetles, *Graphognathus* spp., Curculionidae, Thylacitinae, Coleoptera

Description

Adult-- Although a complex of several species, this beetle family is characterized by stout beaks which are square shaped and widened toward the tip. The first antennal segment passes below the eye when pressed against the head. The adult is about 0.5" (10 mm) long, gray with pale white margins extending along the pro-thorax and elytra (wing covers). Only the females are known.

Egg-- The eggs are white, soft and somewhat shapeless. Clusters of 20-60 are pushed between pieces of ground litter and cemented together with bubbly mucus which hardens into a protective film, enabling them to withstand drought.

Larva-- The mature larva is about 0.625" (15 mm) long, cream (yellow-white) colored, robust and almost hairless. Like most other weevils, the larvae have no legs. The pale head is tucked under the pro-thorax, with only the black mandibles protruding.

Pupa-- The larva initially pupates into a dense white (fat deposits) pupa. It prepares its pupation cell by rotating its body while exuding droplets of mucus from the anus to bind together soil particles into a strong, smooth lining. The mature pupa is white with adult features visible.

Biology

Distribution-- Accidentally introduced into the United States from South America. Populations are sporadic and very localized primarily in the south/southeastern United States.

Host Plants-- Hundreds of plants are hosts including clover, peas, watermelon, potatoes, grass, pine seedlings and many species of grasses and weeds.

Damage-- Larvae feed on roots, causing damage which is usually noticed when plants begin to show stress becoming yellow or stunted and wilting; seedlings and drought or grazing-stressed plants are most affected. Seedling trees planted in the soil of old fields are often attacked. In potatoes, larvae tunnel inside the tubers. Adults feed on foliage.

Life History--. Adults emerge form the soil in summer (May-October) feed on foliage. When present during the day, adults can be found hiding on leaves and stems. Oviposition occurs in the soil where clusters of 20-60 eggs are laid. Reproduction is parthanogenic. The larvae hatch in about 3 weeks then burrow into the soil, where they feed on roots. When fully grown, the larvae cease feeding and move towards the surface ready to pupate. It remains there for several weeks before molting. The newly emerged adult may be found hiding on leaves and stems during the day. There is one generation per year.

2. Wireworms (Click beetles), Variety of species, Elateridae, Coleoptera

Click beetles are elongated, flattened insects with a large, moveable prothorax whose posterior corners are usually pointed. The body is often greatly tapered posteriorly. The spine-like prosternal process fits into a socket in the mesosternum and the loosely joined prothorax and mesothorax enable the beetle to flip over when it is upside down. The beetle arches its body and then quickly straightens it, forcing the spine back into the socket and snapping the pronotum and elytral base against the supporting surface; the beetle flips over with an audible clicking sound. The family is large containing over 7,000 species world-side and nearly 800 species in North America. Several examples follow:

Description

Adult--
Agriotes mancus (Wheat wireworm): 7-9 mm, yellowish brown to dark brown; pronotum broader than long; dense coarse punctures in deep elytral grooves; posterior corners of pronotum and sides of elytra dull yellow; short dull pubsecence; east of Rocky Mountains.

Alaus oculatus (eyed click beetle): 25-45 mm, shiny black with sparse gray-white scales; pronotum with 2 large oval eyespots margined with gray-white scales; east of Rocky Mountains

(in decaying logs). *A. melanops* similar, 25-36 mm, without scales on pronotum, Far West. *A myops* also similar, 24-38 mm, sparse pubescence, small pronotal eyespots with indistinct margins, chiefly southern U.S.,

Ampedus collaris: 8-9 mm, shiny black; prothorax bright red; antennae and legs dark brown; eastern North America.

Conoderus vespertius (Tobacco wireworm): 7-10 mm, yellowish with dark reddish brown or blackish markings, eastern half of the United States.

Ctenicera inflata: 8-11 mm, bronze-black, relatively broad, convex, legs and sides sometimes reddish, dense yellowish pubescence pressed against body, 3rd abdominal segment greater than twice the length of second and longer than fourth, most of U.S. and southern Canada.

Ctenicera lobata tarsalis: 9-12 mm, shiny black, elytra dull yellow, lateral and inner margins with narrow black line, second antennal segment very small, third triangular and larger than fourth. eastern U.S. *C. pruinina* (Great Basin wireworm similar but all black, elytra deeply grooved, Pacific Northwest, Great Basin).

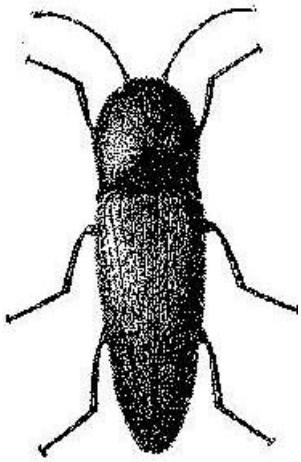
Limonius califronicus (Sugarbeet wireworm): 7-10 mm, antennae and femora dark brown, elytra reddish brown, dense white or yellowish pubescence, dorsum coarsely punctured, western North America.

Melanotus communis: 11-15 mm, reddish-brown, sparse pubescence, finely punctate, third antennal segment twice the length of second and together as long as or longer than fourth, eastern U.S. (very common, flies to light). M. similis similar shape, 13-17 mm, dark brown to blackish, most of North America.

The remaining description and biology is common to all species

Egg-- The white, glistening egg is oval to spherical in shape.

Larva-- Larvae, called wireworms, are cylindrical and elongated, usually reddish brown and have a hard and shiny cuticle.



Pupa- The white, soft-bodied pupa has no protective covering and is approximately the same size and shape as the adult.

Biology

Distribution-- Throughout the United States. See species specific distribution.

Host Plants-- Wireworms occur chiefly in the soil and many are pests which feed on roots, seeds and stems of many grasses. They may also attack the roots, seeds, and tubers of many flower and vegetable crops. Some species inhabit rotting wood or occur beneath bark and feed on other insects.

Damage-- The most significant damage occurs to germinating seeds and seedling plants. Wireworms feed on the seed and often leave only the empty hull (pericarp). Roots are snipped off as they emerge and often rot. Above ground symptoms include yellowing and wilting or death or terminal shoots.

Life History-- Wireworms have a life cycles from 1-7 years. For example, *Melanotus communis* is characterized by a six year life cycle. In June of the first year, adults deposit eggs singly among grass roots. First instar larvae emerge in July and begin feeding. During the first year, larvae continue to develop throughout the summer and overwinter in the ground as second instars. Most of these immatures remain in the larval stage for 5 years although life cycles as short as 3 years have been reported. In late July or August of the sixth year, mature larvae construct oval cells 9-12" (15- 30 cm) deep in the soil and pupate. Adults emerge about 18 days later and feed on pollen before hibernating in protected areas. They become active and deposit eggs the following May or June.

3. **Billbugs, Variety of Species, Curculionidae, Rhynchophorinae, Coleoptera**

Description

Adult-- Adult billbugs are weevils varied in color with long, downward-pointing snouts and elbowed, clubbed antennae. Size ranges from about 5-12 mm in length. Common species include:

Phoenix billbug (*Sphenophorus phoeniciensis*)- Dark brown about 8 mm long. Characterized by a "Y-shaped" marking on the thorax with separate, inward facing marks that resemble parentheses on either side of the Y.

Hunting billbug (*Sphenophorus venatus vestitus*)- Dark brown about 8 mm long. Characterized by a Y shaped marking on the thorax with separate, inward facing marks that resemble an M on either side of the Y.

Sphenophorus zeae- 6.5 to 9 mm long, shiny reddish-brown to blackish, pronotum with 3 raised longitudinal bands, central band widest in middle and lateral bands wavy, area between bands coarsely punctured, elytra with many rows of alternating coarse and fine punctures.

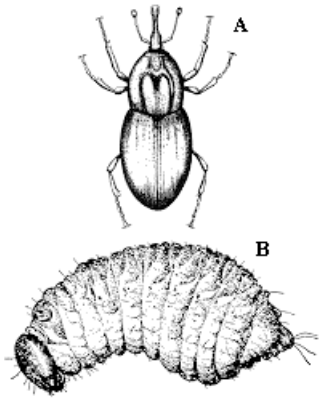
Bluegrass billbug (*Sphenophorus parvulus*)- Similar to *S. zeae*, about 5-8 mm long, black with gray crust, pronotum without raised bands.

The following characteristics are common to all species:

Egg-- The elongate, creamy white eggs are 0.062" (2-3 mm) long and turn yellow before hatching.

Larva-- The white, legless larvae have hard, yellowish- or reddish brown heads. When mature, these larvae vary from 0.5-0.75" (9-16 mm) in length.

Pupa-- Pale yellow or white pupa are similar to adults in size and shape.



Hunting billbug. A, Adult. B, Billbug larva.

Biology

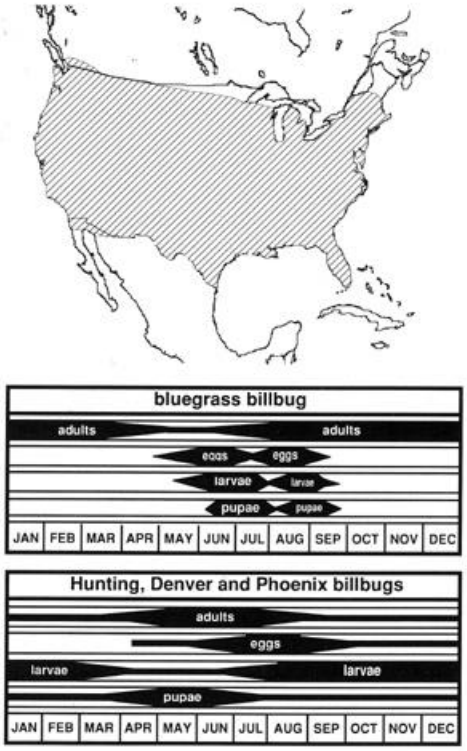
Distribution- Located throughout the United States with the following species specific distribution:

Phoenix billbug-Common in the western United States particularly in California.

Hunting billbug- Occurs along the eastern seaboard from Maryland to Florida. It has also been reported in California and Hawaii.

S. zeae- Commonly found in the eastern United States

Bluegrass billbug- Common where bluegrass is grown



Host Plants-- All species of turfgrass may be damaged.

Damage-- Billbug larvae first feed on the inside of the turfgrass stem and crown, then move into the soil where they feed on roots. Fine, whitish sawdustlike larval excrement (frass) may be observed on the soil surface. Because billbugs feed higher up on the plant than white grubs, billbug damaged turf is easier to pull from the soil as it breaks at the crown. Root feeding depth of 3" (7.5 cm) does occur, however, damaged turf cannot be rolled back like a carpet and the soil does not feel spongy underfoot. Drought-stressed turfgrass may be severely impacted. Adult billbugs also feed on grass stems and blades, but only cause minor injury to the turf. Billbug damage rarely occurs in turf stands less than three years old.

Life History-- In southern states, billbugs may overwinter in any life stage, although adults are best able to withstand severe winters. Emerging in the spring, adults feed and mate. Females place eggs in cells cut into grass stems. Two days to two weeks later, larvae appear and work their way down from the inner leaves to the root system. They feed for 3 to 5 weeks before pupating in cells in the soil. The pupal period lasts 3 to 7 days. Afterwards, the new adults may remain in the pupal cells to overwinter or may emerge and be active until the onset of cold weather. One generation is completed each year.

4. **Mole Crickets, Gryllotalpidae, *Gryllotalpa* and *Scapteriscus* spp. Orthoptera**

Description

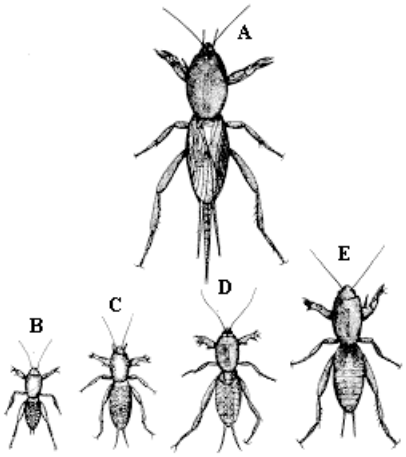
These brown crickets are usually more than 1" (25 mm) long and have relatively short antennae. The front legs are very broad and modified for burrowing. Mole crickets resemble pygmy mole or pygmy sand crickets (non-pests) in general appearance but have 3 instead of 1-segmented tarsi and their hind legs are not enlarged for jumping as are the pygmy crickets. The genus

Scapteriscus, characterized by having two "fingers" on the front tibiae, contains several species that cause damage to crops and grasses growing in moist sandy soils of the southeastern states.

Adult-- Common species

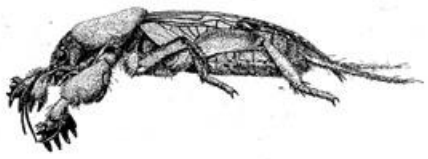
Northern mole cricket (*Neocurtilla hexadactyla*)- 1-1.25" (21 to 33 mm) long, brown, pointed head, fine short hairs, front tibia with four fingers that curve outward, apices of hind tibia with 8 spines. Song is loud, low pitched chirps delivered 1-3 per second with regularity. Eastern and midwestern North America.

Scapteriscus vicinus- 1.25" (26-29 mm), pale brownish-yellow, pronotum with irregular blotches but not definite spots, front tibia with 2 fingers, distance between fingers at base < 1/2 width of each finger, southeastern U.S. (lawns, golf courses, cultivated fields).



Mole crickets. A, Adult. B-E, Nymphs.

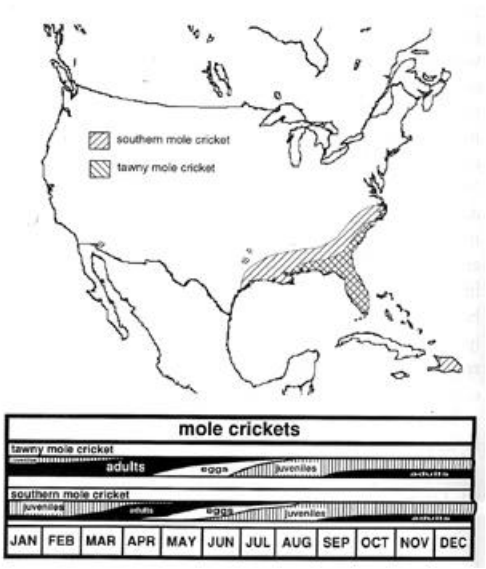
Egg-- May be greenish, yellowish or whitish oval eggs and are generally about 0.06" (3 mm) long.



Nymphs-- Although wingless and slightly smaller, the nymphs resemble the adult in shape.

Biology

Distribution-- Found primarily in the southeastern United States. They are particularly attracted to moist soil containing manure or rotting vegetative debris.



Host Plants-- Although they have a varied diet, most mole crickets feed on underground plant parts of vegetable crops, assorted fruits and turfgrass.

Damage-- Burrowing in the soil, mole crickets feed at night on roots, stems and tubers. The burrows cause the soil to dry, thereby affecting more plants than are actually fed upon. Some plants may be uprooted, but turf usually dies from root damage and drought. Small numbers of mole crickets are capable of extensive damage, especially on newly seeded turf.

Life History-- Mole crickets generally overwinter as nymphs 2.75-10" (7-25 cm) deep in the soil. Nymphs become active in March and feed until they mature in late spring. In May or June, new adults emerge from the soil and are attracted to lights as they engage in mating flights. Eggs are laid in the soil in cells constructed by the females. Approximately 35-50 eggs are placed in each cell. Hatching occurs in 10-40 days depending on temperature. Nymphs develop through 8 instars and may become adults by winter or may overwinter as immatures. One generation occurs each year.

5. **Ants, Variety of Species, Formicidae, Hymenoptera**

Description

Adult-- Ants have constricted "waistlines" and may be smooth or hairy; winged or wingless; red, brown, black or yellow; and 0.03-0.5" (1-10 mm) long. Adult ants may be males (winged), females (winged), or workers (wingless females). Winged ants have two pairs of wings, the front pair being much larger than the rear.

Egg-- The white or pale yellow eggs are almost microscopic in size and vary in shape according to the species.

Larva-- The translucent, soft, legless larvae are segmented and vary in shape. One of the most common forms is gourd- or squash-shaped with the head located at the constricted end. Size varies with species. The larvae are small enough to be carried by the worker ants.

Pupa-- The soft, colorless pupae resemble adults in size and shape. They may or may not be enclosed in papery cocoons.

Biology

Distribution-- Although distribution of a particular species may vary, ants in general are cosmopolitan insects. They are found from the Arctic to the tropics. Around buildings, ants may nest near sidewalks, foundations, and driveways as well as in the turf.

Host Plants-- The ants which damage turf do not actually feed on the plants. Often, however, they are attracted by sap from wounds or honeydew on the foliage of ornamental trees and shrubs. Ants feed primarily on seeds, small insects, and honeydew excreted by aphids associated with plant roots.

Damage-- Ants build nests in the ground. They are particularly troublesome around the fringes of golf greens, in fairways and in lawns. The anthills and mounds often smother the surrounding grass. They also feed on grass seeds in the ground, thereby preventing good stands of newly re-seeded grasses. Moisture stress is common in ant-infested lawns due to root damage and tunnels promote water loss from the soil.

Life History-- Ants live in colonies usually started by a fertile, winged female (queen) that makes a small nest and lays a few eggs. Such females eventually lose their wings. The queen cares for and feeds the first brood of larvae which develop into workers (wingless females). The workers construct and repair the nest, gather food and feed the immature and adult ants, care for the brood and defend the nest. Male ants appear only in very large or old colonies and die soon after mating with the new queen.

Fire Ants
Black Imported, *Solenopsis richteri*
Native, *Solenopsis geminata*
Red Imported, *Solenopsis invicta*
Southern , *Solenopsis xyloni*

Description

The various developmental stages are similar to the general ant description. All species of fire ants closely resemble the red imported fire ant. Species identification is difficult but may be made by a specialist.

Biology

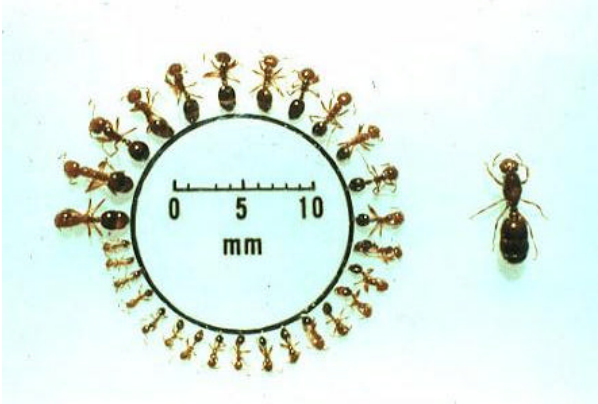
Distribution-- Since their introduction from South America in about 1918 through the port of Mobile, Alabama, imported fire ants have spread into Texas, Louisiana, Mississippi, Georgia, Florida, North and South Carolina and Arkansas.

Host Plants-- Although soil infesting, imported fire ants feed on a wide variety of food, which includes plant seeds and parts. They are predaceous on some agricultural pests.

Damage-- Fire ant damage is most significant to agriculture in losses resulting from reduced efficiency of labor and machinery and perhaps reduced land value.

These ants prefer land exposed to the sun; consequently valuable farming and pastureland may be heavily infested. In urban areas, these ants invade lawns, parks, playgrounds, school yards, cemeteries and golf courses. Fire ants may inflict a severe bite and sting and will attack anything that disturbs their nest. Each ant is capable of stinging several times. The sting causes a burning or itching to occur followed by the formation of a white pustule. Scratching of the pustule may lead to secondary infection.

Life History-- The red imported fire ant is the most troublesome species. It has colonized large areas in the South displacing both the native and southern fire ant. The ant colony is composed of three forms; the winged reproductive females (queens), winged reproductive males and three classes of worker ants called minim, minor and major workers. The queen lays and looks after the initial egg cluster. Later she only lays eggs as the workers take care of the other functions of the colony. The average colony may contain 100,000 to 500,000 workers and relatively few winged or reproductive forms. The short-lived males die shortly after mating with the queens in a large aerial mating swarm. The fertilized queens land and excavate a cell in which the eggs are laid to start a new colony.



Fire Ant Mound

Harvester Ants, (*Pogonomyrmex* spp.), Formicidae, Hymenoptera

Description

Adult-- Harvester ants are about 0.5" (5-6 mm) in length. Different species can vary in color from reddish-brown to yellow or black. The pedicel between the abdomen and thorax has two segments. They have elaborate fringes of hairs underneath the head. As is the case with other ants, adults may be winged males or females, or workers (wingless females). Winged ants have two pairs of wings, the front pair being much larger than the rear.

Egg-- The eggs are minute, less than 0.5 mm long, white and elliptical in shape.

Larva-- The larvae are white and legless. The body is covered with short hairs and is shaped like a squash with a small distinct head.

Pupa-- Found in a cocoon, the pupa resemble the larva except that the body is straight and rigid with legs and wings visible.

Biology

Distribution-- The harvester ant complex occurs west of the Mississippi except for one species. The two most common species are the Texas harvester ant and the Western harvester ant.

Host Plants-- Harvester ants do not consume grass for food but denude areas around mounds and along trails. Their principle source of food is seeds of various grasses and arthropods.

Damage-- The harvester ants not only construct large mounds which cause loss of grass but also clear areas of grass along forage trails radiating from the nest. Cleared areas around the nest may be 7 meters or more in diameter. Generally, nests are constructed in open areas and are often problems on golf courses, recreational areas and occasionally lawns. It is also thought that they may hinder re-seeding of different grasses by collecting seeds. They produce painful stings.

Life History-- Harvester ants are social insects, living together in colonies. Winged males and females swarm from the parent colony and mate. The males die soon afterward. The females lose their wings, find suitable nesting sites in the soil and begin laying eggs. After hatching, the queen feeds and cares for the young larvae. The larvae mature, pupate, and then emerge as adult workers. The adult workers then begin to take care of the queen as well as eggs and larvae.

(b) Leaf and Stem Damaging Insects

1. Sod webworm: *Crambus* sp., *Pediasia trisecta*, Pyralidae, Leipdoptera
Topical sod webworm: *Herpeto gramma phaeopteralis*, Pyralidae, Lepidoptera

Description

Adult-- The moths range from 0.5-0.75" (13-19 mm) long and have a wingspan of about 0.5-1.25" (15-35 mm). They have a large forward projection (labial palps) on the head. The forewings are brown or dull ash gray, with a whitish streak from the base to the margin; the hind wings are brownish. When at rest, the moths fold their wings in a tent-like manner over their body.

Egg-- The tiny, oblong eggs are white to pale yellow. Each egg is about 0.5 mm long and 0.3 mm wide.

Larva-- Most larvae vary from pinkish-white to yellowish to light brown. They are 0.5-1.25" (16-28 mm) long when fully grown, with thick bodies, coarse hairs and paired dorsal and lateral spots on each segment. The head is yellowish-brown, brown or black. Individual grubs often assume a C-shaped position. Tropical sod webworm are greenish and up to 0.5" (19 mm) long.

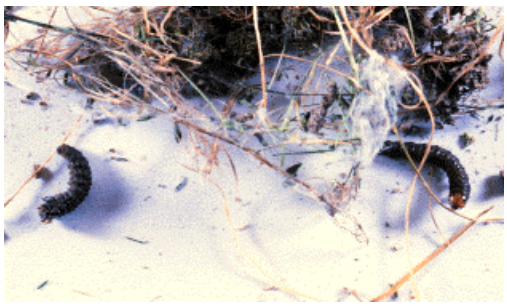
Pupa-- The reddish-brown pupae are 11-13 mm long.

Biology

Distribution-- Many species of sod webworms occur in the United States. The actual species present in any given area, however, is highly variable. Whereas many *Crambus* species are generally distributed, the tropical sod webworm is common primarily in Florida, and *Pediasia trisecta* is primarily located in Tennessee.

Host Plants-- Sod webworms feed on lawns, golf course grasses, some clovers, corn, tobacco, bluegrass as well as pasture and field grasses. They usually favor bluegrass and Tifdwarf hybrid bermudagrass, but will attack most grasses.

Damage-- Larvae cut off grass blades just above the thatch line, pull them into their tunnels and eat them. The injury appears as small brown patches of closely cropped grass. If many larvae are present, the patches run together to form large, irregular brown patches.



Life History-- Webworms overwinter as young larvae a few centimeters below the soil line among the roots of weeds and grasses in silk-lined tubes. During early spring, larvae feed on the upper root systems, stems and blades of grass. They build protective silken webs, usually on steep slopes and in sunny areas, where they feed and develop. In early May, they pupate in underground cocoons made of silk, bits of plants and soil. About two weeks later, adults emerge. The moths, erratic and weak flyers, live only a few days and feed solely on dew. They are active at dusk, resting near the ground in the grass during the day.

The eggs, which are deposited over grassy areas, hatch in 7-10 days. Young larvae immediately begin to feed and construct their silken tubes. The most severe damage occurs in July and August when the grass is not growing rapidly. During hot weather, the larvae feed at night or on cloudy days. Most sod webworms complete 2-3 generations/year, with approximately 6 weeks

elapsing between egg deposition and adult emergence. In Florida, tropical sod webworms may produce a new generation every 5-6 weeks.

2. Burrowing Sod Webworm, *Acrolophus popeanellus*, Acrolophidae, Leipdoptera

Description

Adult-- This moth is variable in size and coloration. The forewings are predominantly yellowish or grayish-brown with a paler border along the folds and inner margins. Irregular dark brown spots are usually present but may be obscure. The hind wings are yellowish to bronze-brown. Wingspan ranges from 1-1.5" (25-38 mm). The labial palps of the male are large, hairy and recurved over the head and thorax.

Egg-- No description is available

Larva-- The grayish or dirty-white larva has a brown head capsule and measures about 20-30 mm long when full grown.

Pupa-- The brown, chitinized pupa is 15-20 mm long.

Biology

Distribution-- Primarily tropical insects, burrowing sod webworms range from South America northward into the United States. They occur in Arizona, New Mexico and Texas, northward through Oklahoma, Kansas and Nebraska, and eastward into Pennsylvania, New Jersey, North Carolina and Florida.

Host Plants-- Within the grass family, burrowing sod webworms have a large number of hosts. In addition to infesting the roots of most lawn grasses, these worms also feed on the roots of corn, bromeliads and orchids.

Damage-- Like sod webworms, burrowing sod webworms sever blades of grass near the thatch line, and feed upon these leaves within the burrow. Closely cut, irregularly shaped spots are indicative of burrowing sod webworm damage. The burrows of this webworm, however, tend to be deep and vertical, whereas other webworms make their burrows nearer the surface.

Life History--Little information concerning the life cycle of burrowing sod webworms is available. Occasionally emerging as early as May the moths usually do not appear until June or July. Several days after the eggs are laid, larvae emerge. The larvae construct burrows, approximately the diameter of a pencil, which extend 0.5- 24" (15-60 cm) into the ground. Fine, tubular webs mixed with soil particles and frass lead from the lower leaf blades into the burrow. When disturbed, larvae retreat into the burrow.

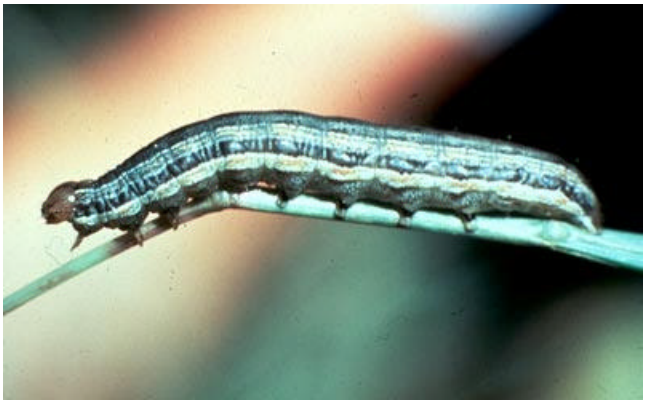
3. Armyworm, *Pseudaletia unipuncta*, Noctuidae, Lepidoptera

Description

Adult-- The adult moth is pale brown to grayish-brown in color, with a wingspan of about 1.5" (40 mm). There is a characteristic white spot in the center of each forewing.

Egg-- Greenish-white and spherical, tiny eggs are laid in masses.

Larva-- The young larva is pale green. The full-grown larva, approximately 1.25-2" (35-50 mm) long, is distinctly striped and yellow to brownish-green in color. Like a cutworm, it may curl into a C-shaped ball when disturbed.



Pupa-- Initially reddish-brown, the pupa darkens until it is almost black.

Biology

Distribution-- Armyworms are found throughout the world. In the United States they are most common east of the Rocky Mountains.

Host Plants-- All common lawn grasses are susceptible but are less likely to be attacked than corn, millet, small grains and some legumes.

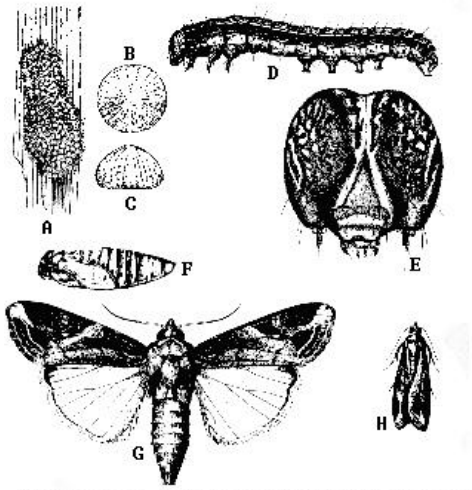
Damage-- Varying in abundance from year to year, young armyworm caterpillars skeletonize the surface of leaf blades and the inner surface of the sheaths. Older caterpillars begin feeding from the leaf edges and consume entire leaves. Extensive feeding causes circular bare areas in lawns.

Life History-- Armyworms overwinter as partially grown, inactive larvae which resume feeding in early spring. Their habit of moving in a group from one area to another accounts for their common name. First generation adults appear in May or June. They feed on nectar for several days, after which females begin laying eggs. Eggs are laid in clusters of as many as 130 between the sheath and the blade of growing grass or in other similar places. A female can lay up to 2000 eggs which hatch in 6-10 days. Second generation larvae feed for a few weeks, then enter the ground to pupate in earthen cells 5-8 cm deep in the soil. The duration of the larval stage depends primarily upon food and temperature but generally lasts about 4 weeks.

4. Fall Armyworm, *Spodoptera frugiperda*, Noctuidae, Lepidoptera

Description

Adult-- The moth has a wingspan of about 1.5" (40 mm). The hind wings are white; the front wings are dark gray, mottled with lighter and darker splotches. Each forewing has a noticeable whitish spot near the extreme tip.



Fall armyworm. A, Egg mass. B, Egg (top). C, Egg (side). D, Larva. E, Larval head capsule. F, Pupa. G-H, Adults.

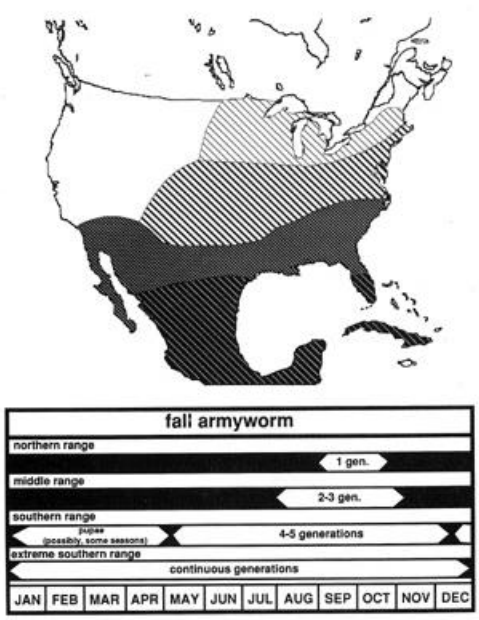
Egg-- Minute, light gray eggs are laid in clusters and are covered with grayish, fuzzy scales from the body of the female moth. The eggs become very dark just prior to hatching.

Larva-- The mature green, brown or black larva, 1.5-1.75" (35-40mm), has a dark head usually marked with a pale but distinct inverted "Y." Along each side of its body is a longitudinal, black stripe. There are four black dots on the dorsal side of each abdominal segment.

Pupa-- The pupa, approximately 1.25" (30 mm) long, is originally reddish-brown and darkens to black as it matures.

Biology

Distribution-- The fall armyworm is a continuous resident of the tropics of North, Central and South America and some of the West Indies. With mild winters, it may persist year round along the Gulf Coast of the southern states. Each year it migrates as far northward as Montana, Michigan and New Hampshire.



Host Plants-- The fall armyworm has a wide host range but prefers plants in the grass family. Most grasses, including coastal Bermudagrass, fescue, ryegrass, bluegrass, corn, sorghum and small grain crops are subject to infestation.

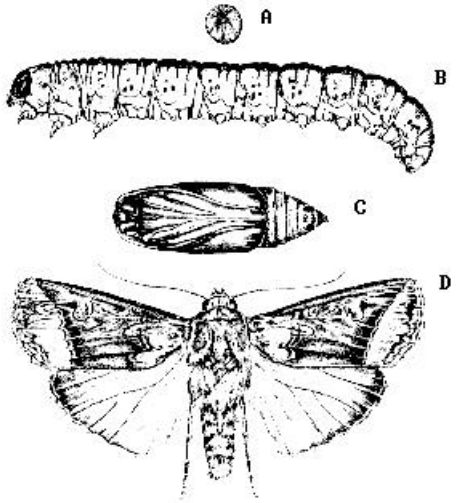
Damage-- Fall armyworms, often migrating in large armies, are potential turf and pasture pests in late summer and fall. Consuming all above-ground plant parts, they are capable of killing or severely retarding the growth of grasses.

Life History-- Fall armyworms probably overwinter as pupae in the Gulf Coast region of the United States. Egg laying moths migrate northward throughout the spring and summer. New moths may continue to appear into November. Each female lays about 1000 eggs in masses of 50 to several hundred. Two to 10 days later small larvae emerge, feed on the remains of the eggs masses, then scatter in search of food. Unlike the nocturnal true armyworms, fall armyworms feed any time of the day or night, but are most active early in the morning or late in the evening. When abundant, these caterpillars eat all the food at hand and then migrate to adjoining areas. After feeding for 2-3 weeks, the larvae dig about 20 mm into the ground to pupate. Within 2 weeks, a new swarm of moths emerges and usually flies several miles before laying eggs.

5. **Cutworms, Noctuidae, Lepidoptera**
   Black cutworm, *Agrotis ipsilon*
   Granulate cutworm, *Feltia subterranea*
   Variegated cutworm*, Peridroma saucia*

Description

Adult-- When resting, cutworm moths hold their wings back in a triangular position. The moths are generally stocky and have a wingspan of about 1.75" (40 mm). The forewings are dark brown and mottled or streaked; the hindwings are lightly colored and unmarked.



Black cutworm. A, Egg. B, Larva. C, Pupa. D, Adult.

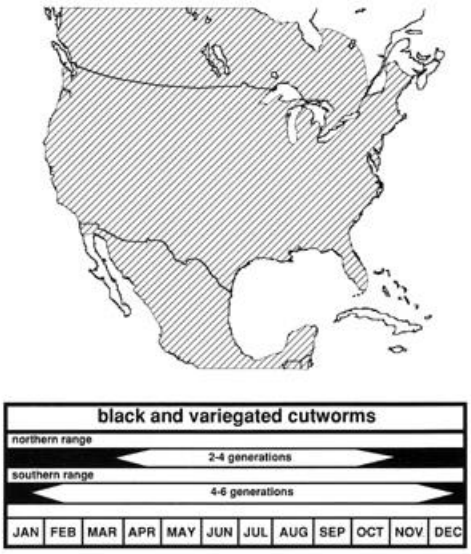
Egg-- The eggs are usually white (becoming darker prior to hatching), round, and 0.5-0.75 mm in diameter.

Larvae-- If disturbed, the larvae usually curl into a C-shaped ball. Cutworms are fat, smooth, dull-colored caterpillars that measure about 1.75" (45 mm) when fully grown.

Pupa--Pupae are brown and 0.5-0.75" (15-22 mm) long.

Biology

Distribution-- Cutworms are found throughout the United States.



Host Plants-- Besides field and vegetable crops, cutworms also attack most turf grasses.

Damage-- Many cutworms prefer wilted plant material and sever the plants sometime prior to feeding. Stems are chewed near the soil. Some cutworms climb the host and feed on unopened buds.

Life History-- Cutworms are caterpillars that feed on the stems and leaves of young plants and often cut them off near the soil line. Each cutworm differs slightly from the others in details of habits and appearance, but their life histories are generally similar. Adults and larvae are nocturnal and hide during the day but may become active on cloudy days. The overwintering forms of cutworms occur in the soil either as pupae or mature larvae. In the spring, the hibernating larvae pupate. Adults begin to appear in the middle of March. Female moths deposit eggs singly or in clusters, and each female can lay as many as 500 eggs. Under optimal conditions, eggs hatch in 3-5 days, and larvae develop in 3-4 weeks passing through 6 instars. Pupae mature in 2 weeks during the summer and as many as 9 weeks in the fall.

6. **Grasshoppers, Variety of Species, Acrididea, Orthoptera**

Description

Adult-- Ranging in length from 0.75-1.5" (19-38 mm), fully grown grasshoppers have enlarged hind legs suited for jumping. Most grasshoppers are basically reddish brown or yellow with variously colored markings.

Egg-- Egg pods are oval to elongate and usually curved. Often the size of kernels of rice, eggs may be white, yellow-green, tan or various shades of brown depending on the species.

Nymph-- Nymphs resemble small wingless adults. Newly hatched nymphs are white; however, after exposure to sunlight, they assume the distinctive colors and markings of adults.

Biology

Distribution-- Grasshoppers occur throughout the continental United States. Severe damage, however, is fairly restricted to sub-humid, semi-arid areas of the country which receive 25-75 cm of rain annually. This area consists of a band from Montana, southward into New Mexico and Texas.

Host Plants-- Grasshoppers normally feed on a wide variety of row crops and range grasses, as well as forage legumes and grasses. They generally do not feed on well managed turf except when grasshoppers are very numerous and other forage is scarce.

Damage-- During particularly dry weather, grasshoppers may infest turf grasses. As chewing insects, they damage lawns by eating blades of grass. Such injury is rarely economically important.

Life History-- Many grasshoppers overwinter as eggs in the soil. Eggs hatch throughout April, May and June as soil temperatures rise and spring rains begin. The first nymph to hatch out from the egg sac leaves a tunnel from the sac to the soil surface making emergence easier for the nymphs which follow. Nymphs feed and grow for 35-50 days, molting five or six times during this period. Development proceeds most rapidly when the weather is warm and not too wet.

Two weeks after mating, females begin to deposit clusters of eggs in the soil. During the process, a glue-like secretion cements soil particles around the egg mass, forming a protective covering. Each egg sac may contain 15-150 eggs depending on the species of grasshoppers which laid them. Each female may produce 300 eggs. Swarms of grasshoppers usually adopt a specific area, sometimes as much as a few hectares as their breeding site and lay all the eggs in that vicinity. On a sunny, slightly breezy day when temperatures reach about 75F, swarms of grasshoppers may fly in search of new feeding sites. Generally, grasshoppers produce only one or two generations each year.

(c) Sucking Insects

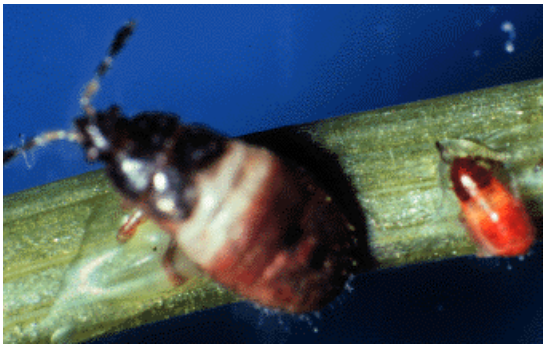
1. Chinch Bugs, *Blissus leucopterus leucopterus*, Lygaeidae, Hemiptera

Description

Adult-- The adult chinch bug is about 0.25" (4 mm) long with black, opaque wings. The wings may be as long as the body or 1/3 to 1/2 the length of the body. In either case, each wing bears a distinctive, triangular black mark.

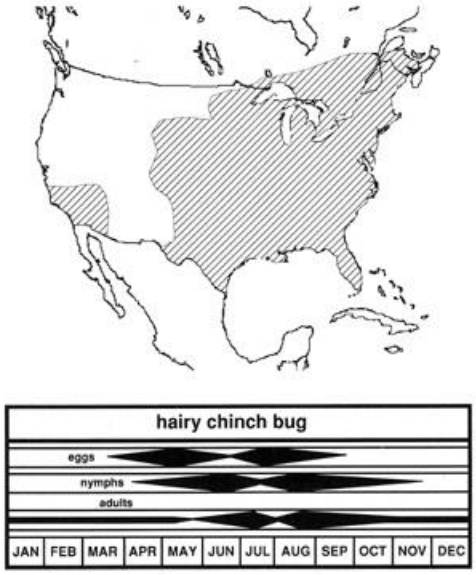
Egg-- The egg, approximately 0.8 mm long, is flattened at one end which bears three to five minute projections. The egg gradually changes in color from pale yellow to red before hatching.

Nymph-- The wingless nymph is smaller than but similar in shape to the adult. The head and thorax are brown; the eyes are dark red and the abdomen is pale yellow or light red with a black tip.



Biology

Distribution-- The chinch bug is found from the east coast into the western plains of Nebraska, Kansas, Oklahoma and Texas. Specimens have been found as far north as Maine, Wisconsin, Minnesota and South Dakota and as far south as Louisiana and Alabama. Confined primarily to the Midwest, damaging infestations can be associated with above-normal temperatures and below-normal rainfall between March and October in the Southeast.



Host Plants-- Chinch bugs attack many forage, lawn and wild grasses.

Damage-- The chinch bug pierces the plant with its beak and sucks out the plant sap. This feeding prevents normal growth and results in dwarfing, lodging and yield reduction. Severe infestations during early development may cause plants to wilt and die prematurely. Most injury is caused by the nymphs.

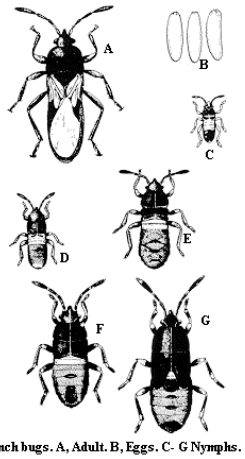
Life History-- Chinch bugs overwinter as adults in protected areas, particularly among weeds and grasses near fields. Adults emerge in the spring and deposit eggs singly behind the leaf sheath or in the soil at the base of the small grain or turf. In a few days, the eggs hatch and the nymphs begin feeding on all parts of the host plant from the roots to the leaves. The nymphs undergo six developmental stages, the last being the adult stage. Two to three generations occur per year, the later generations migrating to areas with ample food supply.

2. **Southern Chinch Bug, *Blissu insularis*, Lygaeidae, Hemiptera**

Description

Adult-- The adult chinch bug is about 0.25" (4 mm) long and black with opaque wings. The wings may be as long as the body or only 1/3-1/2 the length of the body. Each wing bears a distinctive triangular black mark.

Egg-- Each egg (0.8 mm long) is flattened at one end, that end bearing 3-5 minute projections. Its color gradually changes from pale yellow to red before hatching.



Chinch bugs. A, Adult. B, Eggs. C- G Nymphs.

Nymph-- The wingless nymph is smaller than but similar to the adult. The head and thorax are brown, the eyes are dark red and the abdomen is pale yellow or light red with a black top.

Biology

Distribution-- The southern chinch bug is common throughout the Gulf states and into Georgia and North and South Carolina. It is primarily affects thick mats of turf in sunny, open areas.

Host Plants-- The southern chinch bug is commonly a pest of St. Augustine grass but also infests pangola, torpedo, centipede and occasionally bermudagrass.

Damage-- Chinch bug populations are concentrated near the surface of the soil. The nymphs, which extract plant juices, are responsible for lawn damage. On St. Augustine grass, feeding is primarily restricted to the tender basal area of the grass blades and to the nodes of runners. As the nymphs feed, yellowish spots, which soon become brown dead areas, appear in the grass. As the grass dies, the nymphs move to the periphery of the dead spots thereby causing them to enlarge. Chinch bug damage is greatest during hot, dry weather.

Life History-- Except in southern Florida where they remain active year round, southern chinch bugs overwinter as eggs. The eggs are usually found inserted in crevices at grass nodes or between overlapping leaf blades. In spring, the eggs hatch releasing nymphs which subsequently infest lawns. Nymphs feed and develop for 2-6 weeks depending on weather conditions.

The new generation of adults causes little damage. Each female, however, deposits 100-300 eggs which hatch 2 weeks later. With 3-5 chinch bug generations each year, lawns may be infested from spring through late fall.

3. Leafhoppers, Variety of Species, Cicadellidae, Homoptera

Description

Adult-- Leafhoppers average 0.25" (7 mm) in length (rarely as long as 0.5":13 mm). They have a triangular, often elongated head and may be yellow, green or gray. Some species are mottled and speckled.

Egg-- The white, elongate eggs are 1 mm or less in length.

Nymph-- The pale, wingless nymphs are smaller than adults but similar in shape.

Biology

Distribution-- Common throughout the United States.

Host Plants-- Infest many varieties of cultivated and wild plants.

Damage-- Leafhoppers stunt grass growth by piercing stems and leaves with their needle-like mouthparts and extracting sap. This type of feeding causes infested areas to have a whitened or bleached appearance. This symptom can be mistaken for drought or disease damage. Newly seeded lawns are sometimes killed by leafhoppers.

Life History-- Leafhoppers may overwinter as eggs or adults. Resuming activity in the spring, the adults begin to feed and mate. Females insert 75 to several hundred eggs, singly into the leaf veins of tender new foliage. About 10 days later, nymphs emerge. Over a period of 12-30 days, these immature leafhoppers feed on new leaves and develop through five instars. Fully developed nymphs then molt to become adults and the life cycle is repeated. Leafhoppers produce one to four generations each year depending on the area and species.

4. Scale insects, Coccoidea, Homoptera

Families in this group consist of small (0.5-8.0 mm), winged and wingless insects that are often unlike other Homoptera in appearance. Adult females are always wingless, very sluggish or fixed in position and usually covered by a hard scale or waxy secretion, or have a tough integument. Some females lack legs and have reduced antennae, and often the abdominal segmentation is indistinct. Adult males have no beak, one pair of well developed wings (rarely wingless on the mesothorax, a pair of filaments, halteres) on the metathorax, and sometimes an elongate process at the tip of the abdomen.

The first instar nymphs (crawlers) are generally the most active stage. After the first molt, legs and antennae are generally lost and most species become sedentary. A waxy or scale-like covering may be secreted as the nymph develops toward the adult stage. Adult females reproduce under their permanent scale or wax covering. The wings of the male develop in the pupa-like resting stage of the last instar. Adult males are tiny, active, flying insects. Several species of scale insects damage turf, mainly in southern states. Species listed below are the most common scale pests of cultivated turf.

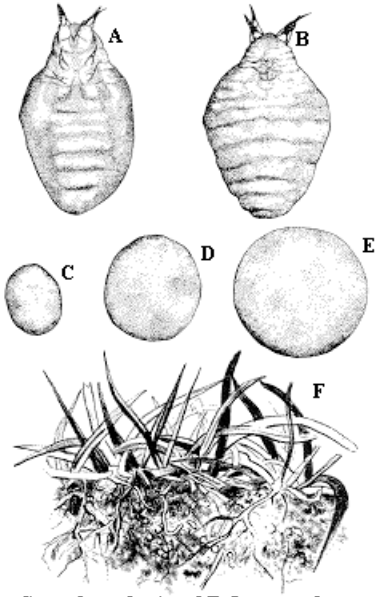
A. Ground Pearls, *Margarodes* spp., Margarodidae, Hemiptera

Description

Adult- About 1.5 mm long, the adult female is a pinkish scale insect with well-developed forelegs and claws. The male is a gnat-like insect varying from 1-8 mm in length.

Egg-- Clusters of pinkish-white eggs are enveloped in a white waxy sac.

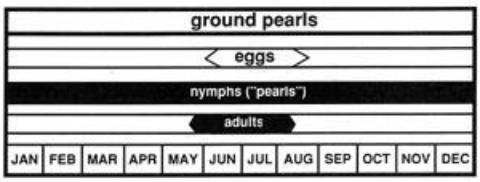
Nymph- Commonly referred to as a ground pearl, the slender nymph is covered with a hard, globular, yellowish-purple shell. An encysted nymph varies from 0.5-2 mm in diameter.



Ground pearls. A and B, Lower and upper views of adult removed from pearl. C-E, Exterior view of nymph pearls (waxy secretions). F, Portion of infested turf.

Biology

Distribution-- Ground pearls are potentially serious problems in both southeastern and southwestern states.



Host Plants-- The roots of Bermuda, St. Augustine, zoysia and centipede grasses are most commonly infested with ground pearls.

Damage-- The ground pearl nymphs extract juices from underground plant parts. The damage is most apparent during dry spells when irregularly shaped patches of grass turn yellow. The grass in these spots eventually turns brown and usually dies by fall.

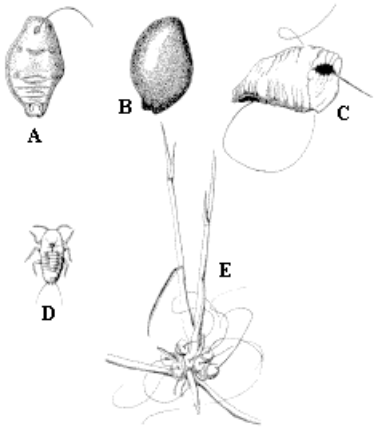
Life History-- Overwintering takes place in the ground pearl stage. Females usually reach maturity in late spring and emerge from their cysts. After a brief period of mobility, the wingless females settle 5-8 cm deep in the soil and secrete a waxy coat. Within this protective covering, females develop eggs and deposit them throughout the early summer. Approximately 100 eggs are laid by each female. The slender nymphs emerge in mid-summer and infest grass roots. Once they initiate feeding, nymphs soon develop the familiar globular appearance. There is usually one generation per year. However, if conditions are not favorable for emergence, female nymphs may remain in the ground pearl stage for several years.

B. Rhodesgrass Mealybug, *Antonina graminis*, Pseudococcidae, Hemiptera

Description

Adult-- The adult is saclike, lacking appendages. The dark, purplish-brown body is oval to almost circular and averages 3 by 1.5 mm. The body is enclosed in a felted white waxy sac turning yellow with age.

Nymphs-- These scales are born live. The first instar or crawler is oblong-oval, cream colored and very active. The second and third instars are saclike. They become sessile (non-mobile) and the body is enclosed in a felted waxy sac resembling that of the adult, except for size.



Rhodesgrass mealybug. A-C, Adults. A, lower view. B, Upper view. C, Adult with waxy covering and excretory tube (right). D, Crawler. E, Infested turf.

Biology

Distribution-- Rhodesgrass mealybug is a problem from Florida, through the Gulf States to California.

Host Plants-- Rhodesgrass, Johnsongrass, bermudagrass and St. Augustine grasses are preferred hosts of economic importance. There are more than 60 grass hosts other than those mentioned, the other grasses are only occasionally or lightly infested.

Damage-- Heavy infestations can kill infested grasses. Infested grass plants gradually turn brown and die. St. Augustine grass may become discolored and spots appear with severe infestations. Heavy infestations appear as an overdose of fertilizer that has caked around the grass nodes.

Life History-- The adults are parthenogenic (no males) and reproduce ovoviviparously (live born) over a period of 50 days. The crawlers move about the plants actively, settling near the crown or lower nodes of the plants. The crawlers wedge themselves beneath a leaf sheath at the node, insert their mouthparts in the plant and become sessile. Shortly, the felted white waxy sac is secreted. The life cycle requires 60-70 days with about 5 generations annually.

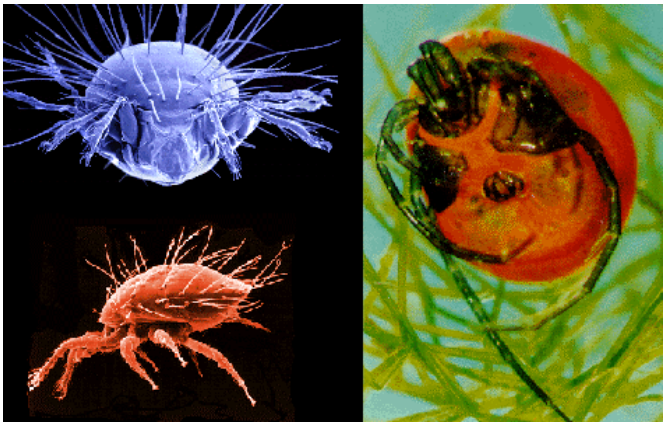
5. Clover Mites, *Bryobia praetiosa*, Acarina

Description

Adults- Clover mites are about 1/30" long, oval shaped arachnids, reddish-brown to olive to pale orange or sometimes green-brown after feeding. They are eight legged with the front pairs of legs very long, protruding forward at the head. These front legs are sometimes mistaken as antennae or feelers. There are feather-like plates on the body and fan-shaped like hairs along the back edge of the body when viewed under a magnifying glass. Crawling mites are sluggish, slow-moving and normally invade the home where the sun is warmest at south, southwest and east sides.

Eggs- Bright red and very small.

Nymphs- Similar to adults, but much smaller and bright red.



Biology

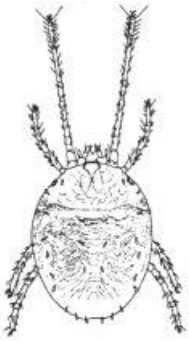
Distribution-- Cosmopolitan, infest clover in northern and southwestern United States, St. Augustine and Bermuda grass in Florida, and Bermuda grass in California.

Host Plants- Variety of plants including St. Augustine and Bermuda grass and clover.

Damage-- Infested plats become pale and sickly looking.

Life History-- Clover mites develop from unfertilized eggs. Females lay about 70 eggs each, singly or in masses, in cracks and faults in concrete foundations, mortar crevices, under loose bark, in thatch or other protected places. Eggs lay dormant during the hot summer, hatching in early autumn when temperatures fall below 85 F, followed by two nymphal stages and the adult.

Each stage lasts 2-6 days, and the life cycle is completed in one month with two or more generations per year. Mites may live 1-7 months depending on climatic conditions. Most mites overwinter as eggs, but all life stages can be present. Overwintering eggs hatch in early spring.



6. Spittlebug, *Aphrophora* spp., *Clastoptera* spp., *Lepyronia* spp., *Philaenus* spp., Cercopidae, Hemiptera

Adults are small (less than 13 mm), very common hopping insects that are shades of gray or brown. Spittlebugs are distinguished from the similar leafhoppers by the one or two stout spines on the hind tibiae rather than the rows of small spines. Spittlebugs feed on weeds, grasses, shrubs and a few trees. The name is derived from the inactive nymphs that surround themselves with a conspicuous mass of white spittle-like froth which provides a moist habitat.

A. Twolined Spittlebug, *Prosapia bacincta*, Cercopidae, Hemiptera

Description

Adult-- The black, leafhopper-like adult is 6-10 mm long and has two red or orange lines across the wings. The eyes are dark red.

Egg-- The bright yellow orange, oblong egg is pointed at one end and measures about 1 mm long. Red and black areas develop before the egg hatches.

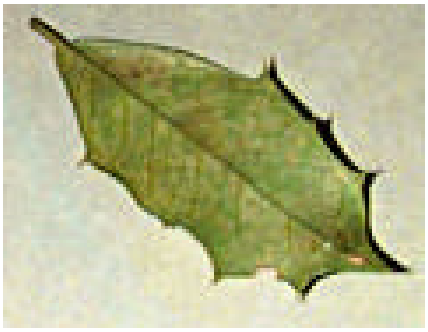
Nymphs-- The wingless nymph resembles the adult in shape but is slightly smaller. Enveloped in a white, frothy mass, this red-eyed immature form may be yellow, orange or white with a brown head.

Biology

Distribution-- The twolined spittlebug occurs from Maine to Florida and westward to Iowa, Kansas and Oklahoma.

Host Plants-- This spittlebug feeds on many crops, ornamentals and weeds in addition to turf grasses. Ornamental and weedy grass hosts include Coastal bermudagrass, St. Augustine, centipede, pangola, bahia, rye, crab, Johnson and orchard grasses. Plants commonly infested by adults include holly, redbud, aster, gerbera, blackberry, pea, peach, honeysuckle, morning glory and most small grain crops.

Damage-- Spittlebugs are rarely a problem on well-managed turf. Both nymphs and adults extract plant juices through piercing-sucking mouthparts. Feeding by large numbers of spittlebugs may kill, wither or stunt the growth of turf grasses.



Life History-- Twolined spittlebugs overwinter as eggs in hollow stems, behind leaf sheaths or among plant debris. Emerging in the spring, the nymphs seek sheltered, humid, hiding places among plants and begin feeding. Soon they produce white, frothy fluid which protects then from natural enemies and desiccation. After feeding for at least a month and developing through four instars, nymphs become adults. Most active early in the morning, spittlebugs spend the warmer hours of the day hiding deep in the grass. Adults live about 23 days and females spend the last 2 weeks of this period depositing eggs. Hatching occurs about two week later.

(2) Vertebrate Pests

(a) Skunks, Eastern striped skunk (*Mephitis mephitus*), Spotted skunk (*Spilogale* spp.)

Description

Adult-- Including the tail, spotted skunks are 48-51 cm long, striped skunks are 47-82 cm long. Skunks are black with white stripes (two in the eastern striped skunk) or spots (in the spotted skunks four stripes are broken into various stripes and spots).

Young-- Newborn skunk kits weight about 10-30 g. Six to 8-week old skunks are weaned so that by this time they probably resemble the adults except for size.

Eastern striped skunk.

Biology

Distribution-- Eastern striped skunks are found from southern Canada to northern Mexico. Spotted skunks are found throughout the southeastern United States except for western Kentucky and Tennessee and eastern North Carolina and southeastern South Carolina and Georgia.

Hosts-- Omnivorous, feeding primarily upon vegetable matter and insects during the summer and smaller mammals during the winter.

Damage- Skunks damage turf when they discover abundant white grub populations. Skunks dig through the sod and feed on the white grubs thereby uprooting the sod and aggravating the damage already begun by the grubs. Skunks may also spray a disagreeable substance.

Life History- After a 63-day gestation period during the spring and early summer, four to 10 kits are born in a den lined with dry vegetation. Spotted skunks sometimes nest in hollow trees. Striped skunks live in burrows, under buildings or in almost any dry place. The kits are weaned in 6-7 weeks and breed the following year. Skunks probably live 10 years. They are active at dusk and throughout the night.

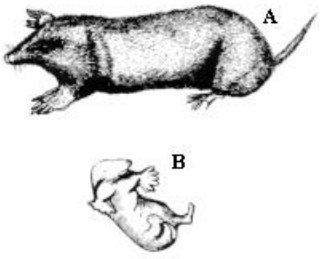
Skinks hibernate during the winter except during warm periods when they emerge to forage. Striped skunks often overwinter gregariously with several females and one male to a den. Skunks apparently rely on their coloration to warn other animals of their defensive capabilities.

(b) Mole, *Scalopus aquaticus* and other spp

Description

Adult-- Covered with velvety gray to black fur, moles are small (14-16 cm , 85 g) mammals with short legs and tails. Their front feet are enlarged and have stout claws.

Young-- Newborn moles weight about 4 g and are 4 cm long. They are pink but covered with fur in 14 days.



Moles. A, Adult. B, Young.

Biology
Distribution- Found throughout the United States

Hosts--Moles feed on earthworms, grubs, wireworms and adult beetles. They also feed on millipedes, slugs, and snails.

Damage-- Moles do not feed on plant roots or tubers. However, as they tunnel along in their surface runs, moles damage turf roots and may destroy newly seeded lawns. In established turf, mowers may skip the tops of the runs and dull the mower blade as well as create gaps in the sod. Moles also tunnel deep, and the throw excavated soil out of the opening, forming hills.

Life History-- After a period of 4 weeks gestation, young moles are born in a den which is lined with dry grass and leaves. Most moles are born in April and May, although some are born from February through June. Five weeks later, the young are weaned and begin to fend for themselves. This new generation overwinters as fully grown but sexually immature individuals which mate the following spring. Moles do not hibernate and may even tunnel in the snow.

Moles dig two kinds of tunnels: surface runs and deeper galleries. Moles burrow in fresh soil to seek food, but they also maintain older burrows and patrol them regularly to catch insects and worms. All digging is dome with the front feet. The snout of some moles is apparently very sensitive to touch. There are sensory vibrissae (whiskers) on the snout and tail which are used to maneuver in the burrows. The eyesight of moles is very poor. Their sense of smell is not well developed. Hearing is well developed and moles squeal while they feed or fight.

Moles seem to be quite aggressive is establishing territories and sometimes fight to the death over possession of burrows. Life span is about 3 years.

(3) Miscellaneous

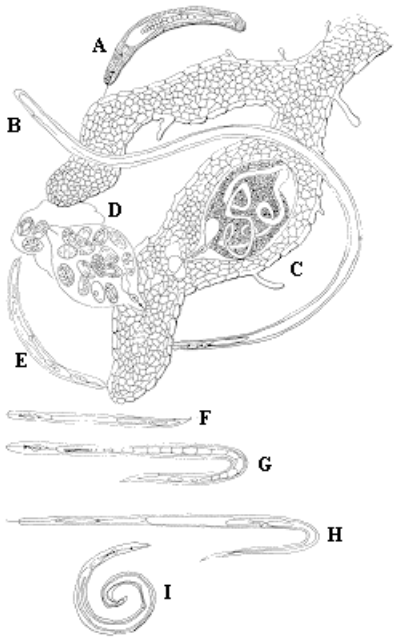
(a) Nematodes
Dagger nematode (*Xiphinema* spp.) Dorylaimidae
Lance nematode (*Hoploaimus* spp) Hoploaimidae
Pin nematode (*Paratylenchus* spp) Paratylenchidae
Ring nematode (*Criconemoides* spp) Criconematidae
Rootknot nematode (*Meloidogyne* spp) Meliodogynidae
Sheath nematode (*Hemicycliophora* spp) Criconematidae
Spiral nematode (*Helicotylenchus* spp) Hoploaimidae
Stubbyroot nematode (*Trichodorus* spp) Diphtherophoridae
Cyst nematode (*Heterodera* spp) Hoploaimidae
Sting nematode (*Belonolaimus* spp) Belonolaimidae
Stunt nematode (*Tylenchorhynchus* spp) Tylenchorhynchidae

Description

Adult-- Plant feeding nematodes are slender, round, legless worms that are transparent and microscopic (up to 2 mm long). Plant parasitic nematodes have a spear-like structure (stylet) on the anterior end. Different nematodes are identified by their body shapes. Mature female cyst nematodes become lemon-shaped and white, yellow or brown (0.5-0.75 mm long). Dagger nematodes have very long stylets. Lance nematodes are cylindrical and taper slightly to the front; the rear is blunt. Female pin nematodes have long stylets and the body curved at the rear. Ring nematodes are short, stout and have body constrictions or rings (annulations). Female rootknot nematodes become pear-shaped and whitish, and are found inside galls on roots. Sheath nematodes retain the exuviae as they molt and have long slender stylets. Spiral nematodes are slender and hold the body in a spiral shape at rest. Sting nematodes are long and slender, females have blunt tails and have an elongate stylet. Stubby root nematodes taper at both ends and have curved stylets. Stunt nematodes are cylindrical and taper slightly at each rounded end. Much experience is needed to identify nematodes under a microscope.

Egg-- Nematode eggs are microscopic (about0.1 mm), oval and transparent. Rootknot nematode eggs are laid in a mass of brown jelly. Other nematodes lay their eggs separately.

Larva-- Newly hatched to mature larvae resemble the adult stage except for size (0.5-2.0 mm) and the lack of an exterior genital opening.



Nematodes. A, Ring nematode. B, Sting nematode. C, Rootknot nematode. D, Cyst nematode. E, Stunt nematode. F, Pin nematode. G, Sheath nematode. H, Dagger nematode. I, Spiral nematode.

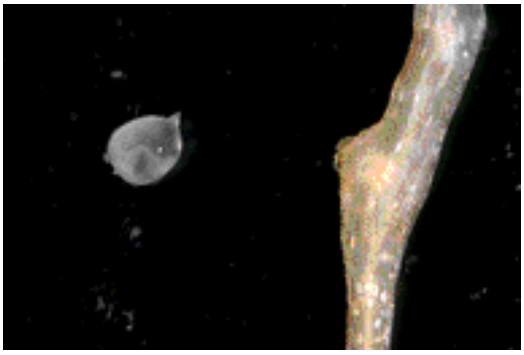
Biology

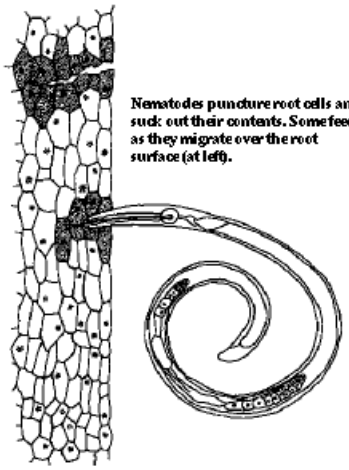
Distribution-- Nematodes are found throughout the United States in turf but are usually more troublesome on sandy soils.

Host Plants-- Nematodes are found on most turfgrass species. Some species may cause severe damage. The ring nematode has been associated with decline of centipede grass and is often found in the soil around turf grasses. Spiral nematodes have been associated with damage to bluegrass and Bermudagrass. Sting nematodes may affect warm season grasses and bentgrass.

Common symptoms of nematode injury to turf are yellowing foliage, thinned turf canopy, and premature death.

Damage-- Plant parasitic nematodes insert their stylets into the root cells and inject enzymes or other toxic substances. The cell contents are then sucked out by the nematode through the stylet. This feeding activity may cause surrounding cells to die or swell. Damaged roots may be more susceptible to other plant diseases. Affected plants are usually stunted, wilt in hot weather, develop nutrient deficiencies, respond poorly to fertilizers and may die during prolonged droughts. Damage is usually more severe in sandy soils and less severe in clay soils.





Nematodes puncture root cells and suck out their contents. Some feed as they migrate over the root surface (at left).

Life History-- Many species of nematodes other than plant parasitic nematodes live in soil and water where they feed on other small animals (including other species of nematodes). Many nematodes are beneficial to the balance of nature in the soil ecosystem. Of the several hundred nematodes that feed on plants, relatively few damage turf grasses. Two of the most important nematode pests of turf, the sting and stubby-root nematodes, feed externally on the outer surface of turf roots. The larval rootknob nematode penetrates into the root and causes a very small gall to form around it. As the rootknot nematode grows, its gall on the grass root also grows. Female rootknot nematodes never leave the galls, but lay their eggs in a jelly which is usually outside the root. The first stage larvae hatch inside the egg. Second stage larvae wriggle to the roots, penetrate into the growing tips and cause new galls to form as the nematode matures.

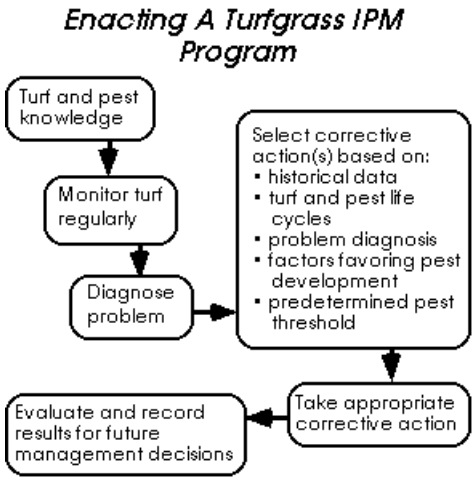
The larvae of all species of plant nematodes develop through four stages, molting between each stage. With the fourth molt, larvae become adults. After mating, eggs are laid. The body of the cyst nematode mother forms a resistant cyst which may be carried on equipment or blown by the wind to infest new areas. Under favorable conditions (warm, moist), development for most species may be completed in 3-4 weeks. In general, nematode populations are highest in late summer and fall and lowest in the spring. Cold soil temperatures inhibit reproduction.

d. Vertebrate and Invertebrate Integrated Turfgrass Pest Management Programs

(1) Introduction

Turfgrass is very susceptible to attack from a variety pests. Often, we react to infestations by applying chemicals. While this may produce short-term relief, successful, sustainable programs incorporate the three following techniques: biological, cultural and chemical. Selection of the most appropriate strategy is dependent on a multitude of factors such as environmental considerations, aesthetics, economics, and pest populations. Though all of these factors are of importance, probably the most important factor to consider when designing a program is the size and age of the pest population.

Clearly, an effective program is based upon knowledge. Turf managers need to understand life cycles of turfgrasses and pests, as well as their responses to cultural and chemical treatments. When turf knowledge is used to monitor growing conditions, set pest thresholds and make sound turf management decisions an IPM program begins to take shape.



(2) Turfgrass IPM Program Components

(a) Surveillance

Periodic inspections should be made to determine whether potential pests are present and whether they are reaching levels which may cause unacceptable damage. Each IPM manager should have a 10X hand lens and be willing to search in the turf, leaves and thatch or dig below the surface. Occasionally, the presence of moles, birds or animals on turf may be indicative of an infestation of grubs, sod webworm, cutworms or billbugs. Check to make sure.

Pest Surveillance Monitoring for Turf Insects

Most detection and sampling methods may be classified as either active or passive techniques. Both have the capability to help in predicting pest problems or quantifying existing damage and pest infestations. The most popular and efficient active sampling method involves visual inspections (scouting). Passive systems use either light, pheromone or mechanical traps that require fewer site visits per season. The trade-off between visual and passive systems is accuracy. Traps will tell you if an adult insect is present in the sampling area, but will not show you if it is causing injury or how extensive the population is. These factors can only be determined by some type of visual inspection. The best monitoring program combines both visual and a variety of passive methods.

Monitoring Based on Key Locations

Pre-determined locations should be consistently monitored to detect the first occurrence of a pest or first damage. Many turf insect pests require warm, moderately dry turf conditions for optimal development. For example, chinch bugs prefer the full sunlight of southern and eastern exposures. Japanese beetle adults lay more eggs in well-watered, sunlit turf areas as compared to dry areas and billbugs will lay more eggs close to driveways and sidewalks than in the open turf. In southern regions areas first damaged by migrant adult mole crickets in the spring will become the most severely damaged in late summer. These examples demonstrate the need for understanding the biology and behavior of turf pests in relation to site.

Other key locations that require special monitoring are areas regularly infested every year. Accurate records or experience are important in identifying these sites. If historical documentation is unavailable, pest damage, site, weather and turf characteristics must be correlated. Over time these sites will become evident. This type of detailed record keeping will help select the appropriate management tactics. Once a key site is identified, modification of the habitat or vegetation can reduce the re-infestation problem and, in the long-term, reduce pesticide usage. In many situations, the elimination of turfgrass or replacement with a better turfgrass species will solve the problem.

(b) Sampling Techniques

Visual Inspection

These methods are the quickest, most accurate and most frequently used technique for detection of turf insect problems. The observer, however, must have extensive training or experience in turf management, disease management and insect pest management in order to make the correct diagnosis. Detection of insect damage or the prediction of pest outbreaks also depends upon repeated observation of insect activity as well as recognizing changes in plant appearance that may be diagnostic of pest injury. The frequency of scouting visits will depend on the pest, expectation of turf appearance, thresholds and costs. Typically a weekly or bimonthly schedule in spring and summer is sufficient, while monthly schedule is acceptable after mid-August into the fall.

Spot Sampling

Trained individuals can quickly make accurate observations and pest counts. A 30-second spot count per square foot sample in 20 + locations should provide information on the scope of damage, stages of pest present and population estimates. Spot counts require searching the thatch and root zones thoroughly. All pest species can be detected with this method. Although accurate, visual inspections only reflect a population response to the environmental and site conditions at one point in time. Generally, samples taken under extremes in temperature and moisture tend to underestimate populations. This can be avoided by increasing the number of sample dates each month or avoiding sampling during weather extremes. Supplemental sampling with traps should provide a better population estimate because the counts reflect an average over longer periods of time.

Irritant Sampling

This method is more accurate than the 30-second spot counts, particularly where insects are hidden in thick thatch or soil cracks. The irritants are only recommended for sampling highly mobile insect pests. Irritants will not expose soil pests such as white grubs and billbug larvae. It is most effective when turf is mowed or clipped before making observations.

Species living in the thatch such as sod webworms, cutworms, chinch bugs and billbug adults respond to irritants. Flushing mole crickets from the soil is also possible, but accuracy may be reduced due to variations in thatch thickness, soil temperature, soil moisture and depth of feeding activity. To flush with soap in non-thatch situations, use 1 ounce of liquid detergent in 1 gallon of water per square yard.

Use of the irritant method requires both a thorough soaking of the thatch layer or soil and close observation in order to detect the insects. Most insects will exit the thatch within five minutes and move out of the sample area quickly. One person may have difficulty observing this activity over an area of 1 sq. yd.; the area can be reduced to 2 sq ft if necessary. To take an irritant sample, a circular metal retaining frame which is 27" across by 6" high is forced into the soil through the thatch layer and filled with 4 ounces of liquid detergent in 4 gallons of water. Count the number of insects which float to the surface after ten minutes.

Flotation Sampling

This is used primarily for estimating chinch bug populations. A 1-2 pound open ended coffee can or a specially made cylinder with handles is forced into the soil through the thatch layer and 3-4" of water poured inside. If the water recedes more water must be added to maintain that level. All stages of the chinch bug, as well as the principle predators such as the big-eyed bug, should float to the surface within 5-10 minutes. Although very accurate, floatation sampling is also very time-consuming. This method confirms chinch bug infestations or determines the extent and population density of infestations.

Soil Sampling

Although the most difficult and time-consuming of all the visual sampling methods used in turf monitoring, soil sampling provides the most accurate method for determining white grub and billbug larval population densities. Samples are initially taken in areas where turf insects have been or are expected to be a problem, including sunny areas with adequate moisture, areas where insect damage is visible and areas where previous treatment was needed. The location and severity of grub infestations are detected by a circular sampling pattern. Once areas of grub infestation are located, samples are taken in a circular pattern which expands out from the initial site. Continue to sample outward from the initial site until grub counts become low enough to no longer be a concern.

The square foot sod spade method is the least destructive but most time consuming way to sample turf. A 1 sq. ft. sample is cut on three sides to a depth of 3-4" and the sod square is folded back to expose the soil. The soil is then broken apart, the grubs counted and the soil returned to the hole. The grub counts are recorded and the sod flap is returned on top of the loose soil. This method is more accurate than the sod cutter but many samples are required for a good population estimate. Adjustments in the depth of the cut can be made in the fall and spring when grubs are more widely distributed throughout the soil profile.

A standard golf course cup cutter allows more samples to be taken, increasing the sampling accuracy relative to the spade technique. The standard cup cutter is 4.25" in diameter; this one-cup cutter grub count can be converted to a square foot basis by multiplying by 10.15. Begin by taking soil cores to a depth of 3-4" at key locations; do more extensive sampling if grub activity is detected.

A sod cutter produces the quickest soil sample. During the summer and early fall, population estimates are made by removing a series of 1-2" thick sod slabs and counting the unearthed grubs. Unfortunately, some grubs will be missed if they feed at the thatch level or well below the 2-3" level, particularly species that move rapidly up and down in the soil profile in response to moisture, such as the European chafer, green June beetle and oriental beetle. This method is less accurate in the late fall and early spring because grubs are moving up and down in the soil profile.

Passive Sampling Techniques

Light, mechanical and pheromone traps are best used in large areas. Although less accurate than the visual method, these traps are still useful in pest monitoring, especially yearly and seasonal fluctuations.

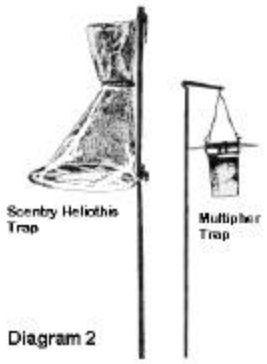
Blacklight Traps

This system can collect large numbers of sod webworm and white grub adults. To date there is no accurate way to estimate the damage potential or the resulting larval population from adult counts, but information on adult activity obtained from these traps is useful in determining when larvae will be active. These traps also provide notice of the first occurrence of a pest and delineate the species distribution over a large area. Determining the relative abundance of species and risk assessment of damage from one year to another at the same sampling site is another important use of light traps.

Black LIght Trap

Pheromone Traps

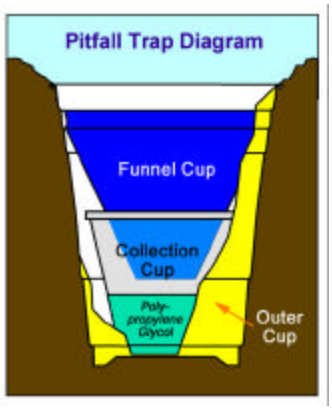
Pheromones are chemicals which are emitted by an organism to communicate with other members of the same species. The most widely used pheromone trap in turf grass pest management programs is for the Japanese beetle. This trap uses a floral lure and female sex pheromone. Trapping can be used as a monitoring tool to detect buildup of populations and to monitor variations in populations between geographic locations or from one year to the next. Daily beetle trap catches will be strongly influenced by temperature, rain, distance from host plants, soil type, groundwater levels and natural enemies. Using several traps at each sampling location will help reduce the effect of this variability on population estimates.



Pheromone Traps

Pitfall Traps

These are primarily used to monitor billbugs, mole crickets, chinch bugs and other highly mobile arthropods. The basic design is a small hole or pit lined with a slippery-sided container with the bottom filled with a liquid such as soapy water or alcohol. Small pinholes should be punched into the bottom of all the cups to allow drainage. Although the trap line setup takes time, daily, season-long inspection is quick. This trap is best utilized for monitoring of first occurrence for the length of the adult period.



(c) Cultural Control

Proper agronomic care of turf is important to reducing the incidence of pest problems. Probably the most important cultural techniques of reducing turf pests are:

Thatch management
Mowing
Species and Cultivar Selections
Soil Management

Thatch Management

Reducing thatch development or removing existing thatch will eliminate sheltering ability and improve efficiency of pesticides (if needed).

Mowing

Higher mowing heights often shade sun dwelling chinch bugs or billbugs as well as raise humidity so that naturally occurring insect diseases may reduce pest numbers.

Turfgrass Species/Cultivar Selection

Each turf species is suited for specific environments. Fine fescue tolerates shady, cool habitats, but rapidly becomes stressed and is attacked by chinch bugs in sunny areas. Tyegrasses and Kentucky bluegrasses do best in full sun, but become susceptible to diseases in shady areas. Improved tall fescues seem to grow well in sun and shade. Additionally, each turf species has many cultivars selected for specific use. Many have been evaluated for insect and disease resistance. Selection of resistant cultivars can almost eliminate the chances of insect or mite outbreaks. Presented below is a list of common turfgrass cultivars exhibiting resistance.

Perennial ryegrasses	Tall Fescues
All Star	Arid
Citation II	Mesa
Dasher II	
Pennant	
Regal	
Repell	

Certain perennial ryegrasses and turf-type fescues contain symbiotic fungi called endophytes. These endophyte cultivars appear to be toxic to sod webworms, armyworms, chinch bugs and billbugs that feed on them. If a new turfgrass is to be established or renovation is due, consider using an endophyte enhanced turf to eliminate many of the surface insect and mite problems.

Soil management

Proper soil management is important. Many turf problems can be traced to soils that are excessively wet, dry, acidic or alkaline and to soils that are infertile, prone to compaction, or full of debris. Fertile soils with a pH of between 6-7 are desirable.

The best time to make major soil modifications is at establishment. Begin by taking soil samples for test. A properly prepared planting bed meets the growth demands of turf. Incorporate amendments based on soil test recommendations to provide the best possible turfgrass growing conditions.

Even established turf will benefit from a soil test. Major changes, however, are not often possible because of potential turfgrass damage. Modifications to soil in which established turf is growing can be accomplished by supplying amendments in small increments.

(d) Biological Control

Healthy turf contains a variety of predatory insects, mites and other arthropods. Ground beetles and rove beetles readily attack turf caterpillars as well as the eggs of sod webworm and white grubs. A number of tiny flies and wasps also parasitize turf pests. If pesticides are used indiscriminately or as a "preventive measure" many of the beneficial predators and parasites will be destroyed. This may allow for a rapid re-invasion by the pests with nothing to keep them in check.

Several insect specific diseases may be found in the soil and turf canopy. For example, chinch bugs, sod webworms and billbugs are often affected by fungal diseases which may reduce population density. In years where above average rainfall occurs, chinch bugs and sod webworms rarely reach pest status.

A few artificially produced biological control agents are available for use in managing turf insects. Most notably the bacterial milky disease of Japanese beetle grubs, *Bacillus popillae*, has been used.

The bacterium, *Bacillus thuringiensis* (Bt) and its toxins has commonly been used to control various caterpillars. Early marketed Bt products were registered for sod webworm control, though there was little effect on the larger sod webworm and virtually no effect on cutworm. Newer strains have greatly improved activity on these pests. Recently discovered strains of Bt have been extremely effective on white grubs.

Several insect parasitic nematodes have been successfully reared in commercial quantities and are beginning to be available for turf insect control. Strains of *Steinernema carpocapsae* are fairly good in controlling turf caterpillars, especially cutworms and billbugs. Other strains and species, especially *Heterorhabditis bacteriophora*, show promise for control of white grubs.

(e) Chemical Control

Chemical control employs both natural or synthetic compounds to reduce pest populations. Most consider chemical control to be limited to pesticides or those chemicals which cause immediate death of pests. However, chemical controls also include repellents, attractants or pheromones, and growth regulators. Unfortunately, there are few of these chemical controls currently registered for use in control of turfgrass insects and mites.

<u>Turf Characteristics Which Influence Chemical Controls</u>

The presence of considerable organic material in turf, often as thatch, also presents problems. Many pesticides may "stick" to this organic matter and are either inactivated or do not come in contact with the target pest. Therefore, an integrated approach which reduces thatch buildup will improve most pesticides' performance.

Pest Resistance

Pest populations placed under severe pressure by pesticides usually are characterized by the genetic ability to counteract this pressure, resulting in resistance. Certain white grubs, billbugs and chinch bugs have been identified to have resistance to the older chlorinated compounds. Pesticides with long residuals tend to cause development of resistance. Therefore, short lasting pesticides, used only when needed, may reduce the chances of resistance developing in pest populations.

Preventive versus Reactive Pesticide Applications

Preventive treatments are made to reduce the risk of an outbreak or establishment of a pest. Reactive treatments are made after pests are developing, but hopefully before any significant damage is done. Clearly, preventive treatments are preferred by some because no thinking or sampling is required. Reactive treatments require careful monitoring and decision making. Generally, preventive treatments, as a tactic, runs counter to the IPM principle that mere presence, or in this case, the expectation of presence is no justification for control action. Preventive applications are often made when no pest damage would have occurred. This results in the unnecessary application of pesticide.

However, certain annual weeds, diseases and nematodes are best controlled by using preventive pesticides. Using a pre-emergent crabgrass herbicide is more preferable to the sue of post emergent products. Many diseases must be kept from invading turf plants because control is almost impossible once infection has occurred. Most insects, however, can be adequately controlled after they are discovered but before they cause significant damage.

Newly developed chloronicotinyl and diacylhydrazine insecticides work most effectively when applied as preventives. These insecticides are most appropriately used where turf has a history of insect attack or the turf has attributes that put it at high risk of having insect damage (e.g, thatchy, sunny turf).

(3) Invertebrate Pest Specific Management Programs

(a) Soil and Root Infesting

White Grubs (General)

White grubs are periodic pests, attacking turf areas irregularly from year to year. The major factor influencing development of damaging numbers of grubs is soil moisture and rainfall. In general, in years with normal or above normal rainfall, grub populations increase. Well maintained turf next to ornamental plants favored by adults seems to be more commonly attacked. However, masked and European chafer adults do not feed as adults and these pests build up in well watered and maintained turf. Green June beetle seems to be highly attracted to turf with decaying thatch layers.

<u>Management Strategies</u>

Sampling

Adults: Adult activity of May/June beetles, masked chafers, European chafers and Asiatic garden beetles can be monitored using light traps. Useful predictive data can be obtained by monitoring beetle captures one to two times a week. Simply plot the number of beetles collected over the date samples on graph paper. If the number of beetles collected drops from seven to ten days in a row, you can assume that the peak emergence and oviposition time has passed. Most species have eggs that hatch within 14-21 days. Therefore, grub insecticides can be applied three to four weeks after the peak adult activity was noted in order to target the young grubs feeding at the soil/thatch interface.

Pheromones have been identified for Japanese beetles and Oriental beetles. These pheromones can be used in traps to monitor adult activity similar to light trap monitoring.

Larvae: White grub populations should be assessed when the grubs become large enough to be easily seen. Taking a square foot sample several places over the turf area. Square foot samples are taken by cutting through the turf and thatch on three sides of a square. Peal back the turf and inspect the thatch and upper inch of soil for grubs. A more convenient method is to use a standard four inch golf course cup changer. This equipment cuts a round core that is about 1/10th of a square foot. Take the cores in a zig-zag pattern across the turf area and multiply the average grubs per core by ten to get an approximate number of grubs per square foot.

Populations of annual grub species that are less than six grubs/sq foot can usually be masked by water and fertilizers. Populations between 10-15 per square foot can cause significant turf damage in September and October. Populations that reach 40-60 grubs per square foot may cause damage by late August.

Time spent grub sampling may usually be reduced by sampling only the most likely areas of infestation. Most of the annual white grubs seem to prefer frass in sunny areas. The night flying species are often attracted to street lights at night and may lay large numbers of eggs under or near these lights. Black turfgrass ataenius adults prefer to lay their eggs in compacted, moist and decaying thatch. The green June beetle prefers sunny, thatchy turf or areas that have had manure applied as a fertilizer. Japanese beetle adults usually attack high quality turf near favorite food trees and shrubs.

Cultural

Host Plant Modifications- Certain species of scarab adults prefer specific host plants. Where Japanese beetles are common, do not plant roses, grapes and lindens, around high maintenance turf areas. May/June beetles prefer oaks and the green June beetles feed on ripening fruit such as peaches. The fine and tall fescues are not as severely attacked as Kentucky bluegrass and perennial ryegrass.

Water Management- Practically all white grub species require moist soil for their eggs to hatch. The young larvae are also very susceptible to desiccation. In areas where turf can withstand some moisture stress, do not water in July and early August when white grub eggs and young larvae are present. Moderate grub infestations can be out grown if adequate water and fertilizer is applied in August through September and again in May when the grubs are feeding. This latter strategy is not preferred because mammals may dig up the turf or irrigation bans may occur.

Biological

Parasites- Several parasitic wasps, *Tiphia* spp. and scoliids, attack white grubs and may effectively reduce populations in certain areas. Masked chafers and green June beetles are the species most commonly attacked. However, these parasitic wasps may take two to three years to build up effective populations during which time turf damage may occur.

Tiphia wasp

Scoliid wasp

Milky Diseases- Several strains of the bacterium, *Bacillus popillae* have been found that attack white grubs. However, the commercial preparations of this bacterium is extracted from the Japanese beetle grubs and is most effective against this species. This bacterium is picked up by feeding grubs and it causes the body fluids to turn milky-white before death. Fresh bacterial preparations should be used and three to five years are needed to provide lasting control.

Parasitic Nematodes- Insect parasitic nematodes in the genera *Steinernema* and *Heterorhabtitis* have been shown to be effective against white grubs. At present, available strains do not appear to be effective from one season to the next.

Nematode Infection

Chemical

Early Reactive Pesticide Applications: Most of the modern soil insecticides have short active residual periods (three weeks or less) and must be used when the grubs are actively feeding. No registered insecticide is 100% effective; they usually kill 75-90% of the grubs present in any given area. This is why re-applications may be necessary when grub populations are very high. Timing of treatments is critical for success. Pesticides should be applied when the grubs are small and actively feeding yet late enough to catch all of the population. In general, reducing thatch and using good irrigation after making a pesticide application will increase control.

Late Season Reactive Pesticide Applications- Occasionally, turfgrass damaging populations of white grubs may go undetected until late in the season. By this time, the annual white grubs are usually third instars and may be 70-80 times the body weight of a newly hatched grub. These mature grubs are voracious feeders but are ready to dig down into the soil when cold weather arrives. Chemical control of these large grubs is difficult. If a late season insecticide application is needed, diazinon, isazophos and trichlorfon have been the most successful. Be sure to irrigate well after the application in order to keep the grubs near the soil/thatch interface and to wash in the pesticide.

Spring Pesticide Applications- As with the late fall pesticide applications, spring treatments are often ineffective. Though the grubs feed during the spring, they are quite large and the span of time for treatment is short. If a spring application is necessary, check to make sure that the grubs are actively feeding at the soil/thatch level. Diazinon, isazophos and trichlorfon have been proven to be effective.

Insecticide Application- an appropriate registered pesticide should be selected according to the current needs and situation. If irrigation is available, liquid application are very effective; granular insecticides are often more effective where irrigation is not possible. The following table contains published data on the performance of currently registered insecticides for white grub control. (Adapted from The Ohio State University Extension Service)

Insecticide	Rate lb.ai/acre	Ave % control	# Tests	Range % Control	% of Tests below 70%
Bendiocarb (Ficam, Turcam)	2.0	80.7	29	21-100	14
	3.0	79.1	21	0-100	14
	4.0	83.5	23	38-99	17
Carbaryl	8.0	74.7	35	13-100	37
Chlorpyrifos	4.0	52.0	29	0-96	59
Diazinon	4.0	70.4	16	47-99	38
	5.5	74.5	40	25-100	30
Ethoprop	5.0	76.7	38	48-97	34
Fonofos	4.0	71.4	20	8-100	30
Imidacloprid	0.3	93.2	18	64-100	6
Isazofos	2.0	88.6	60	46-100	12
Isofenphos	2.0	82.1	75	40-100	19
Trichlorfon	8.0	76.1	61	0-989	20

Recent studies have established that 95-99% of any pesticide used for grub control ends up in the thatch. Pre- or post-irrigation does not seem to change this binding. If the thatch layer is one inch thick or more, the grubs probably will not contact a lethal amount of the pesticide.

Grub insecticides may not demonstrate consistent effectiveness across geographic regions. Grub resistance and accelerated microbial degradation may be responsible.

In general, irrigating after an insecticide treatment is made will improve performance for soil insect control. It is also generally recommended that grass clippings be returned to the area for one to two mowings after grub insecticide application. Do not wait more than 30 days to re-check the grub infestation, especially if the original population was high. If the grub population has not been reduced below six grubs per square foot consider reapplication of another pesticide. Remember, the smaller the grubs, the easier they are to kill with insecticides.

White Grub-May/June Beetle

Monitoring and Thresholds

Sections of turf about 1 square foot and 2-4" deep should be examined. If sampling reveals an average of three grubs, treatment should be initiated.

Biological Control

Several reports of infectivity by *Bacillus popilliae* have documented the efficacy of the Japanese beetle milky disease but it is considered a rare occurrence and of minor influence. Since these species are native to the United States, many species of nematode, bacteria and fungal pathogens have been recovered throughout their range.

The entomophathogenic nematode, *Heterorhabditis bacteriophora*, has shown good activity against white grubs and is commercially available.

Similar to the microbial pathogens, numerous species of parasitic wasps and flies attack the adult, grub and pupa stage. These natural control agents appear to maintain populations in most areas below aesthetic damage levels.

Chemical

Insecticidal control may be warranted if threshold levels of 5-7 grubs per square foot exist. Improved control will occur if the following conditions are met; proper timing of insecticide application, sufficient irrigation after application (1/2") and removing excessive thatch layers (more than 1/2"). The preferred timing for a majority of the recommended insecticides is in late summer to early fall when damage is first noticed. The other time period is in the spring from April and to mid-May. Consult the Command entomologist or EFD applied biologist for guidance.

Japanese Beetle

Monitoring and Thresholds

Larvae feed on grass roots and may move up into the thatch layer after consuming the total root system. In Kentucky bluegrass, populations of 6-8 grubs per square foot may kill turf during August-October when it is drought stressed, while under the good growing conditions in spring, counts of 10-15 per square foot may cause no damage symptoms. Clump grasses such as tall fescue tolerate higher summer populations but in mixed tall fescue/bluegrass sod, grubs will selectively kill the bluegrass component.

This root feeding injury gives the turf a spongy feeling ; after heavy feeding the roots are severed and the sod easily rolled back. Without irrigation the turf will turn brown, die and usually not recover.

Generally, treatments are recommended when grub populations exceed 6-8 per square foot. However, moles and skunks may also destroy turf; because of these small mammals, treatment thresholds may range be as low as 4-5 grubs per square foot. In this situation the grubs do not kill the turf, the animals destroy the sod when they dig for grubs. Cultural conditions such as turf type, amount of irrigation, or time of year may also affect treatment thresholds. If bluegrass turf areas are frequently irrigated during July-August stress periods, populations as high as 20-25 grubs per square foot may not produce damage until irrigation stops. Kentucky bluegrass, perennial rye and fine fescue grasses are most sensitive to grub feeding damage. Tall fescue and warm season species such as zoysia and bermuda can tolerate moderate to heavy populations during the hot dry conditions that kill Kentucky bluegrass.

Biological

Biological options include milky disease (*Bacillus popilliae*), *Bacillus thurengenisis* strains, parasitic wasps and flies and parasitic nematodes.

Milky disease is the first option in the mid-Atlantic states for low to moderate maintenance turf. This bacterial agent is characterized by excellent residual action, species-specificity and easy application, but only suppresses Japanese beetle grub and requires the presence of moderate grub populations in order to increase the soil spore counts and spread the disease to untreated areas. Spores can remain viable for 20-30 years once established. The spore dust product is recommended for newly established turf areas. Areas with ten or more years of turf coverage may already have naturally infected soils.

Milky disease is not compatible with insecticides because it kills the grub population which is required to increase and maintain the soil spore count. Fortunately spores will remain viable after an insecticide treatment and continue to increase in later years when grub populations return.

Natural Microbial Control: Japanese beetle grubs are infected by many species of bacteria, fungi, protozoans and nematodes. Few of these have commercial possibilities but combined they constitute one of the major regulators in established turf and meadows. In many older communities, problems rarely occur, particularly where turf has been established for 8-10 years or more. The highest risk of grub damage occurs in new lawns 2-5 year old or newly disturbed sites reseeded to turfgrass. New turf areas are often developed from farm fields or wood lots that lack a grub pathogen complex. Once grub populations become established after several years, key pathogens and other biological agents also become established and help to maintain low levels.

Wasp and Fly Parasites: The most effective wasp parasite are the *Tiphia* wasps. Introduced from Japan, *Tiphia popilliavora* and Korea, *T. vernalis*, these species attack the grub stage in thatch and soil. These two species are most effective in areas that have had high populations of grubs (10-30 sq ft) over a long period of time. They do not appear to be effective at low population densities.

When abundant, the adult wasp appears behaves in a fashion similar to honeybees and other wasps and is often mistaken. However, they are not aggressive and rarely sting even if handled.

The only major Japanese beetle adult parasite is a fly imported from Japan, *Istocheta aldrichi*, sometimes referred to as the Winsome fly. This species prefers adult female beetles and deposits an egg just behind the head on the prothorax. The egg hatches within 24 hours and the maggot enters the beetle body. The adult beetle is eventually consumed and dies within 6 days. After the adult falls to the ground or buries itself before death, the parasitic fly larva pupate and remains in the soil until the following year.

Cultural Control:

Soil moisture levels are very important in assessing damage risks in turf. Japanese beetle eggs must acquire moisture from the soil in order to develop and hatch. Research has shown that soil moisture levels less than 10% are lethal to the eggs and newly-hatched grubs. Irrigated areas are also very attractive to egg-laying females and they ensure good larval survival.

Turfgrass species and variety selection can greatly influence the susceptibility to grub damage. Perennial rye, Kentucky bluegrass and fine fescue species are the most susceptible to severe damage, whereas the warm season grasses like zoysia and bermuda simply outgrow damage and tolerate higher grub densities. Tolerance of tall fescue varieties is intermediate to that of bluegrass and warm season grasses.

Chemical Control: Consult the Command entomologist or EFD applied biologist for guidance.

Green June Beetle

Monitoring and Thresholds

The green June beetle grub differs from other white grubs in their feeding behavior. Damage to turf occurs as a result of their unusual habit of tunneling as well as root feeding. Smaller stage grubs tunnel horizontally in the top 4" of ground, loosening soil, eating roots and thinning the thatch. This activity begins in early August when the turf may wilt or die. Damage is minimal when grub density is low or if the grass received plenty of moisture. As the grubs grow, tunnels become vertical and deeper with turf damage becoming more severe. Grubs keep tunnels to the surface open by pushing little mounds of loose soil to the surface. The resulting mounds appear similar to earthworm castings. To determine that a mound was made by a green June beetle grub, wipe the mound away and feel for a hole in the ground about as wide as your finger. Earthworm holes rarely exceed the diameter of a pencil. The soil mound will reappear the next day. Fecal pellets about as big as mouse or small rat droppings may also be present on the soil surface near the holes. Fresh mounding activity is especially visible after a heavy rain. The mounds and holes are visible by mid-August, but damage becomes more pronounced in the following months as the grubs continue to grow. The grubs feed on some roots, but the major damage to the turf results from upheaval of the subsoil, dislodging of turfgrass roots from the soil, and subsequent weed problems. Sections of turf about 1 square foot and 2-4" deep should be examined for grubs. If examination reveals an average of 6-8 larvae, treatment is usually necessary.

The large green June beetle grubs come to the surface at night to feed or graze on the turf. Individuals may migrate long distances (20-30' per night). Grubs may also be found in the twilight hours and on overcast days. Their trails through the dew can frequently be seen of golf course greens.

Monitoring is conducted in a similar manner to the Japanese beetle. Treatments are recommended on perennial ryegrass/bentgrass when grub-counts exceed 5 per square foot. Damage thresholds for Kentucky bluegrass and tall fescue are 6-7 grubs per square foot. To prevent damage to turf, apply controls to grub stages before many mound become evident. A threshold of 5 third instar larvae per square foot. Damage cycles run for 3-6 years. During these outbreaks, damage may be expected if high populations of grubs were present the previous year and insecticide control was inadequate. An increase in the number of adults over the previous year's observations is also reason to expect damaging populations of grubs.

Biological

The most common parasite of green June beetle is the digger wasp, *Scolia dubia*. This wasp enters the grub tunnel, stings the insect, and then lays an egg on the paralyzed grub. The resulting larva feeds on the grub eventually killing it. These wasps are not aggressive.

Milky disease products effective against Japanese beetle do not control green June beetle grubs nor do B.t. products.

Cultural Control

Some turfgrasses recover from damage once stress factors are removed. For example, species having stolons and rhizomes may repair the damage once the grub population is controlled. Also, damage resulting from grub tunneling is less severe when the turf received sufficient moisture, fertilizer and lime. Overseeding in the fall is critical in preventing weed encroachment the following season.

It is helpful to remember that grass cut at a greater height (2.5-3") is less stressed and therefore the damage is less visible. Also, grass species such as tall fescue with the broader leaf blades

hide damage better than fine bladed grasses such as perennial ryegrass, bentgrass, or fine fuscue.

Chemical Control

Insecticides are effective on all grub stages and application may be warranted anytime between August and November, as long as damaging numbers remain active. Spring applications of chemicals are not generally recommended since the grubs are active only for a few weeks and many may have pupated by the time damage becomes obvious. Once the grubs reach the third instar, they migrate freely and can easily move from an infested areas to an adjacent area. The insecticides normally used to control sod webworm, cutworm and armyworm will generally suppress migrating green June beetle.

Most insecticides labels for Japanese beetle grubs will effectively control green June beetle grubs. Even insecticides that do not penetrate the thatch later can work because green June beetle grubs come to the surface and become exposed. To control early instars before the migration phase, application of insecticides must be followed by irrigation with 1/2" of water, or timed with rainfall.

A word of caution. After treatment, the grubs come to the surface within 12 hours and die, causing a foul odor as they decay. Turf managers should also consider the possibility that these poisoned grubs may be eaten by other animals. Finally, treated areas should be monitored carefully because migrating grubs may reinfest an areas once the insecticide is no longer effective. Consult the command entomologist or EFD applied biologist for guidance.

Northern and Southern Masked Chafer

Monitoring and Thresholds

Adult masked chafers do not feed, but grub damage is identical to Japanese beetles. Populations of 10-15 grubs per square foot can severely damage turf. The adults of both species can be monitored with blacklight traps. The southern species flies just after sundown and activity stops around midnight. The northern species starts to fly at about 0200 and continues until sunrise. Both species are highly attracted to irrigated lawns. During dry weather, both flight and egg-laying activities will increase significantly after rainstorms.

Masked chafer grubs also feed or organic matter. This results in higher population thresholds for these species. Damage thresholds are about 10 grubs per square foot for moisture stressed turf and 15-20 per square foot for non-stressed irrigated turf. Similar to Japanese beetle, masked chafers frequently intermix with other annual white grub species.

Unlike the day-flying and feeding Japanese beetle adults, the masked chafer adult flies at night and cause no feeding damage, therefore not providing any indication of an outbreak. Masked chafer grub injury is often misdiagnosed as Japanese beetle feeding.

Biological

Natural enemies of masked chafer grubs include entomophathogenic nematodes, fungal pathogens, parasitic flies and wasps and ground beetles. The entomophathogenic nematode, *Heterorhabditis bacteriophora*, has been effective against white grubs and is commercially available under the name Cruiser.

Another product which mimics the insect molting hormone, ecdysone and causes premature molting is Mach 2 (halofenozide).

Cultural

Females prefer to oviposit in moist soils that are high in organic matter. Avoiding irrigation during egg laying in July will increase mortality of eggs. However, the use of irrigation during August-September can mask larval feeding damage.

Chemical

Insecticidal control may be warranted if threshold levels of 10 grubs per square foot exist. Improved control will occur if the following conditions are met; proper timing of insecticide application, sufficient irrigation after application (1/2") and removing excessive thatch layers (more than 1/2"). The preferred timing for a majority of the recommended insecticides is in late summer to early fall when damage is first noticed. The other time period is in the spring from April to mid-May.

Consult the Command entomologist or EFD applied biologist for guidance.

Asiatic garden beetle

Monitoring and Thresholds

Asiatic garden beetles feed at night and are attracted to lights. Surveys consist of using a light trap. Hang a light bulb above a pan of soapy water. Because this beetle tends to feed close to the ground, place the pan of soapy water on the ground and the light source about six inches above it. Monitoring for larvae is conducted in a manner similar to other white grubs.

Cultural/Physical

Proper turf maintenance including mowing and fertilization. The beetle is mostly attracted to areas which are cool and moist. Adjust irrigation as necessary.

Chemical

A variety of insecticides are available. Consult with the Command Entomologist or EFD applied biologist for guidance.

.**White-fringed Beetle**

Monitoring and Thresholds

This beetle is not a major turfgrass pest and is characterized by sporadic distribution. Monitoring conducted similar to other white grubs.

Cultural/Physical

Proper maintenance of turf areas to include irrigation, fertilization and mowing.

Chemical

A variety of insecticides are available. Consult with the Command Entomologist or EFD applied biologist for guidance.

Non-White Grub Pests

Billbugs

Monitoring and Thresholds

Billbugs damage turfgrass in two ways. Early damage occurs in late June into mid-July. At this time the larva tunnels into the stem and crown causing them to brown and die. A good diagnostic sign of this kind of billbug injury is the compacted frass found inside the dead stems. The second type of damage occurs when older larvae feed on roots. These larvae are often intermixed with white grub larvae in the soil.

The collection of 6-8 adults in a five minute search is considered a moderate infestation. Observations may be made on sidewalks, driveways and patio areas around buildings. Adult billbugs rarely fly, usually walking. This sampling method is limited because of the daily variation in adult activity caused by differences in weather, site microclimate, sampling time, and landscape. Not all billbugs are active at one time and most are active on cool, rainy days. Monitoring dome under these conditions will result in less accurate population estimates.

A preferable sampling method is the use of pitfall traps. This methods continuously samples populations throughout the adult activity period from early April to late May when egg laying begins providing a more accurate population estimate. When trap counts range from 2-5 adults per day, moderate, spotty turf injury can be expected within 2-3 weeks. Severe losses can occur when adult counts exceed 7-10 per day over several days sampling.

Pitfall traps should be used in conjunction with degree-day heat unit models and visual scouting. The degree-day models help predict insect activity based on temperature and serve as a better estimate of peak activity periods during years with abnormal growing seasons.

Biological

Naturally occurring fungal diseases frequently kill adults during cool, prolonged, rainy periods.

Cultural

Watering and fertilizing to stimulate turf growth is important for turf recovery from billbug damage. Grass varieties with extensive rhizome and underground stem systems are able to quickly recover from billbug damage. Tall fescue and perennial ryegrasses appear to tolerate billbug damage. Avoid using Kentucky bluegrass cultivars in problem areas. Some resistant varieties are available but these may have limited usefulness. Endophyte infested tall fescue and perennial ryegrasses are excellent sources of resistance and highly recommended for use in high-risk billbug areas.

Chemical

An adult control program offers the best option when billbugs become habitual problems. Exploitation of two key behavioral characteristics is essential for success with chemical treatments. Since the adult female rarely flies, migration into uninfested turf areas each spring is slow. Once established, they require a pre-oviposition period of 2-3 weeks before egg laying. Thus, an April to mid-May application of insecticide will kill the adult females before they lay eggs. Since there is only one generation per year, re-infestations may not occur again for 2-3 years after treatment because of the limited migration mentioned. Billbug grub control is generally less satisfactory than adult treatments. Consult with the Command Entomologist or EFD applied biologist for more information.

Mole Crickets

Monitoring and Thresholds

Nymphs and adults burrow in loose soil, feed on grass roots and cause the turf to dry out. Damage is usually localized in irregular areas and can be severe in newly planted turf. Infested areas may feel soft underfoot due to the tunnels under the thatch. Suspect turf can be visually inspected for the presence of entrance holes (0.5-1" in diameter) in the soil or thatch layer. A quantitative estimate of mole cricket populations is obtained using the soap flush technique. A solution of 1-2 ounces of dishwashing soap in 2 gallons of water is sprinkled over a marked 4 foot square area of turf. The soap irritates the insects, driving them to the surface. All mole crickets coming to the surface in a three minute period following the treatment are counted and the total divided by four to convert to number per square foot. Insecticides are usually recommended after the emergence of 7 mole crickets.

Another source of aesthetic damage is the mound of soil that accumulates at the tunnel entrance. These small mounds produces by the tunneling nymphs and adults will cause problems on golf course greens and tees, regardless of population levels. Their presence also interferes with play and mowing activities.

Biological

Naturally occurring parasitism and predation is limited, but fire ants, ground beetles, spiders and mole crickets themselves help regulate populations. A variety of nematodes are also used. Two imported parasitoids have been released in Florida with moderate results. The sphecid wasp, *Larra bicolor,* which is found in southern Florida, seeks out mole crickets in the tunnel, paralyzes them and lays an egg on their thorax. In about two weeks, the developing wasp larvae kill its host. The other imported parasitoid is a tachinid fly *Ormia depleta*. This fly is attracted to the sound produced by the mole cricket. After finding the mole cricket, the fly lays an egg on the host. The developing maggot then kills the host.

Cultural

The combination of fertilizing, irrigating and rolling the turf in the spring will lessen tunneling damage. Rolling helps prevent root systems from drying out in light sandy soils.

Chemical Control-

Because mole cricket migratory flights occur twice yearly and both adults and nymph tunnel extensively, the risk of continuous re-infestation is high. Therefore, two insecticide treatments may be required. Contact insecticides are most effective against the newly hatched crickets. With late-season outbreaks or with early spring tunneling, short-residual insecticides are recommended. Insecticide baits also work well against the nymphs, but are relatively ineffective against adults in fall. Regardless of the insecticide, adults are relatively difficult to control. Consult with the Command Entomologist or EFD applied biologist for more information.

Wireworm

Monitoring and Thresholds

Although a minor turfgrass pest, wireworms may adversely affect areas which are poorly drained or near agricultural fields. Solar bait stations may be used to survey for wireworms. Two stations are recommended per acre. Bait stations, which are really solar traps, are made by digging a hole 4 inches deep and about 9 inches wide. Place 1/2 cup of corn-wheat mixture in the bottom of the hole. The hole is then filled with loose dirt. Do not pack the dirt. Cover the area with plastic. Gases produced by the breakdown of the corn-wheat mixture attract wireworms to the

station. The stations are checked in two weeks by digging up the bait and searching through the seeds for wireworms

Cultural/Physical

Proper drainage of soil will prevent damage by some species of wireworm. Proper mowing and fertilization will also reduce damage caused by wireworms.

Chemical

Consult with the Command Entomologist or EFD applied biologist for more information.

Ants (General)

Sampling and Thresholds

Ants may be detected by inspecting turf areas for mounds/worker ant activity. They also can be detected by sprinkling 1/4 cup of lemon-scented household detergent mixed in two gallons of water over one square yard of turf and observing the insects as they move to the surface.

Cultural/Biological

Maintain turf health through proper mowing, fertilization and irrigation. Removal of certain types of vegetation may also be effective. Additionally, natural controls including parasites and parasitoids may also reduce population levels.

Chemical

Effective ant control normally requires destruction of the queen. In most cases, this necessitates one or more applications of a liquid or granular insecticide. In situations where only a few colonies are present apply insecticides directly to colony openings and the areas surrounding the mounds. If colonies are numerous, broadcast treatments over the entire area may be the most practical solution. When liquid insecticides are used, apply sufficient spray volume to ensure thorough wetting of the soil surface. For granular applications, irrigate thoroughly after treatment to move the insecticide down through the soil profile. Additional treatments may be needed if the queen was not eliminated or if ants recolonize the area. In addition to standard liquid and granular formulations, there are several baits that may be placed in areas where workers are observed. Consult with the Command Entomologist or EFD applied biologist for more information.

Fire ant

Monitoring and Thresholds

Population monitoring for fire ant control generally consists of determining the number of active mounds in a particular unit area. Any mound where at least three ants are observed after a mound disturbance should be considered active. Heavily infested fields may contain over 100 active mounds per acre.

Another method of estimating ant populations for comparison studies is by collecting ants attracted at baits in a test area. A small piece of hamburger and a small piece of agar containing 40% honey are each placed on a small piece of aluminum foil or in a small plastic cup. The two baits are placed on the ground at each bait station, 1-3" apart. Bait stations are located about 10 yards apart. The number of ants attracted to the baits per unit time is determined.

The threshold population level for fire ants will vary according to the species and the sites. In certain areas (actively visited by people), very few active mounds per acre would likely be

tolerated, particularly of the imported species. In contrast, a few active mounds per acre probably would be acceptable. Every effort should be made to correlate fire ant populations observed through the use of monitoring techniques with complaints. In this way, a complaint threshold level may be established for each site.

In areas where fire ants are not causing any problems, the best solution may be to do nothing. Some sites will only support a limited number of fire ants. These may be in the form of a few large colonies or many smaller ones. Established mounds defend territories, preventing the establishment of new colonies. Maintaining several large and well-marked colonies may be a sound way to stabilize fire ant populations in an area, as long as the risk to people is low.

Cultural/Physical

Boiling water has been applied to individual mounds with varying degrees of success. Approximately 3 gallons of hot water poured into each mound will eliminate about 60% of the mounds treated. Surviving mounds will need to be treated again. Water has also been applied as steam, using a steam generator, usually on a cool day. Both techniques are cumbersome in the field, especially where large numbers of mounds are involved.

Area-wide flooding or prescribed burning of fire ant infested areas has proven ineffective and may promote the establishment of new colonies.

Mechanical

Mounds may be excavated and destroyed, but not without risk that fire ants will successfully attack the individual conducting the operation. Dragging or knocking down mounds may provide a limited level of control, but only if mounds are dragged just before the first hard freeze. Destroying mounds during the warm season will not reduce the number of active mounds; ants quickly rebuild their nests.

Biological

A number of biological control agents have and are being evaluated for effectiveness. One of the most effective is a nematode, *Neoaplectana carpocapsae*.

Chemical

Mound treatment: Treating individual ant mounds is time consuming, but is generally the most effective method of control. It takes from a few hours to a few weeks to destroy the mound depending on the product used. Individual mound treatment is usually most effective in the spring. The key is to locate and treat all the mounds in the area. If many young mounds are missed, reinfestation of the area may take place quickly. Methods to treat individual mounds include drenching, injection, baits, dusting, and fumigation .

Broadcast treatment: Several different types of products are labeled for application over wide areas to control fire ants. Granular insecticides are often applied with hand-operated fertilizer spreaders or agricultural application equipment. Sprays are also sometimes used. Because of the broad spectrum of such treatments, they may have an adverse effect on non-target organisms.

(b) Leaf and stem damaging

Sod webworm

Monitoring and Thresholds

The sod webworm complex represents over 20 species in the United States, but leaf feeding damage and construction of silken tunnels appears to be behaviors common to all species. Generally, the high risk period for damage is from mid-July to the end of September, when many of the cool season grasses go dormant. The presence of one to two larger species, or three to four smaller species in Kentucky bluegrass or fine fescue is sufficient to cause defoliation during late summer.

Larval damage can be expected 10-14 days after observations of heavy adult flight activity. Adults are highly attracted to blacklights, so this method can help indicate areas at risk for damage. High trap counts may not always correspond to high damage because of insect predation of webworm eggs and larvae.

Larval populations can be samples using a visual thatch inspection or an irritant flush. Because the small first and second larvae are very difficult to find in the dense thatch, visual inspection tends to underestimate populations. The soap flush, if too concentrated, may also underestimate populations numbers by allowing only the mature individuals to exit, killing the more susceptible young larvae.

Excessive bird feeding activity in turf may also indicate the presence of mature larvae.

Biological

The major predator of webworm eggs and young larvae are ants, mites and big-eyed bugs. Older larvae are affected by birds, ground beetles, parasitic flies and wasps. Several pupal parasites are well established in the northeast and together all these agents usually keep webworm populations below aesthetic threshold levels. Frequent use of insecticides kill these beneficial species and their populations may require one to two years to recover.

Several naturally occurring *Beauveria* fungal and *Nosema* and *Phelohania* microsporida diseases have been recovered from field collected larvae. However, the impact of these and other pathogens is poorly understood and probably greatly underestimated.

Several commercial B.t. products and various species of parasitic nematodes provide good larval control.

Cultural Control

The warm season turf species such as zoysia and bermuda appear to be resistant to webworm feeding. Tall fescue varieties are intermediate with Kentucky bluegrass, fine fescue, hard fescue and perennial rye species, varying from highly susceptible to moderately resistant. The selection for turfgrass insect resistance appears to be less important and more difficult to obtain in breeding programs than other major characteristics.

Resistance due to fungal endophyte offers a combination of a high level of insect and drought resistance, plus some limited disease tolerance. Endophytes are fungi or bacteria that live inside a plant but do not cause disease. Instead, they enhance a grass's ability to survive drought, disease and insect attack. A limited number of varieties of tall fescue, perennial rye and fine fescue are available that possess high levels of protective endophytes

Chemical

All species of webworms are controlled with several registered insecticides. Consult the Command Entomologist or EFB applied biologist for more information.

Armyworms

Monitoring and Thresholds

Defoliation damage is nearly identical to sod webworm injury. The only difference is that it may proceed at a faster rate due to the large caterpillar size. Synchronous egg-laying and subsequent population growth also contribute to the increased defoilation rate. Both species may be active throughout the growing season and outbreaks may conincide with sod webworm activity.

Treatment for armyworm infestation may be warranted when May larval populations reach about one per square foot. Fescue turf may suffer severe late summer damage if fall armyworm populations reach about one per square foot. Other grasses may be more tolerant.

Methods used to sample sod webworm larvae will also work to detect armyworms. Because these two moth species are important agricultural pests, most states monitor the seasonal flight activity with blacklight traps. Information may be obtained from State Extension Service representatives.

Biological

Armyworms are susceptible to a wide variety of pathogens that occasionally become epizootic during major outbreaks. Several Bt. products will control the true armyworm but the fall armyworm requires special strains.

True armyworm larvae may be effectively controlled by the parasite tachinid fly *Winthemia quadripustulata*. Other insect parasites include *Telenomus minimus* (egg parasite), the braconid wasps *Apanteles laeviceps, A. marginiventris* and *A. militaris*, ground beetles, sphecid wasps, birds, toads, domestic fowl and small mammals.

Parasites of fall armyworm eggs and larvae include the ichneumon wasp *Ophion bilineatus*, the braconid wasps *Chelonus texanus, Meterous laphygmae* and *Apanteles* spp, *Trichogramma minutum*, Euplectrus wasps and the tachinid flies *Winthemia quadripustulata* and *W. rufopicta*. Predators include ground beetles, birds and many small mammals.

Cultural

As armyworm damage is similar to scalping the turf with a lawnmower, watering and fertilizing will quickly stimulate growth. Turf varieties with high levels of fungal endophytes are highly resistant to both species.

Chemical

Armyworm and fall armyworm prefer to feed at night, so insecticide application should be conducted in the evening. Most insecticides labeled for sod webworm will also be effective for armyworm. Consult with the Command Entomologist or EFD applied biologist for more information.

Cutworm

Monitoring and Thresholds

Close examination of infested turf will reveal clipped or skeletonized grass blades mingled with green fecal pellets. Larvae will be found near the edges of damaged areas. The presence of birds and other animals foraging in turf areas is often an indication of cutworms.

To confirm the presence of cutworms, apply 1 tablespoon of 1% pyrethrins or 1/4 cup of lemon-scented household detergent in two gallons of water over one square yard of turf. This irritates the grubs and forces them to the surface where they may be identified and counted. Scratching around in the thatch with a knife may also reveal their presence.

Cultural/Biological

Good cultural practices may allow a healthy, vigorous turf to withstand a moderate cutworm infestation. In most cases, the turfgrass will outgrow the injury. Generally, it takes fewer grubs to damage mismanaged or stressed turf. Overgrown or lodged grass in the vicinity of the turf area create an ideal environment for later cutworm infestation.

Many natural factors help reduce cutworm populations. When the weather is warm and humid, fungal diseases sometimes infect the insects, reducing infestation levels. In addition, several parasitic flies and wasps lay their eggs on cutworm larvae. These caterpillars are later killed by the internal feeding of the parasitoids. Bird predation may also result in significant reductions in cutworm populations.

Chemical

Treatments are similar to that used to control sod webworm. Consult with the Command Entomologist or EFD applied biologist for more information.

Grasshoppers

Monitoring and Thresholds

Grasshopper infestation levels can be estimated by surveying for nymphs or adults. One method is the square-foot method. In the area to be sampled, count the number of grasshoppers that hop or move within a square-foot plot. With 15 to 20 paces between each square foot sample, conduct 18 square foot samples and divide the total number of grasshoppers by two to obtain the number per square yard. If the grasshoppers are predominantly first to third instar, (wingless and generally less than 0.5" long), divide the number by three to give the adult equivalent. Consider fourth instar nymphs and above as adults. Control will generally be necessary when square -yard counts reach the threatening level. Use the table below to determine the need for control:

Rating	Adults per sq. yard
Non-economic	5-10
Light	11-20
Threatening	21-40
Severe	41-80
Very severe	80+

Biological

Grasshoppers have many natural enemies that help suppress populations. A fungus, *Entomophthora grylli*, often cause locally high mortality. Infected grasshoppers grasp the plant with front and middle legs while the hind legs are extended. It dies in this position. Fungal

spores will then continue to develop in and on the body of the infected grasshopper. Under warm, humid conditions, a large number of grasshoppers may be destroyed by this fungus. A protozoan, *Nosema locustae*, is normally present to some extent in grasshopper populations, but generally does not cause significant mortality. *N. locustae* spores incorporated on bran baits are sold under such names as Semaspore, Nolo Bait or Grasshopper Attack. These baits kill some nymphs but virtually no adults. However, infected adults lay fewer eggs. Nematodes called hairworms commonly infest adult grasshoppers. They reduce the vigor of grasshoppers, but do not cause significant mortality. Insects that feed on grasshoppers include the larvae of blister beetles (predators of the eggs), bee flies (parasites of eggs), robber flies, ground beetles, flesh flies and tangle-veined flies. Birds and mammals consume grasshoppers, but have little impact in outbreak years.

Cultural

Eliminate tall grass and weeds from around those plants/areas you wish to protect. This reduces food sources so grasshoppers are not attracted to these areas, exposes grasshoppers to greater predation from birds and makes these areas less attractive for egg-laying.

Chemical

Consult with the Command Entomologist or EFD applied biologist for more information.

(c) Sucking Pests

Chinch Bugs

Monitoring and Thresholds

The chinch bug prefers the following grasses listed in order of importance:

Bentgrass/St. Augustine
Fine fescue
Perennial ryes
Kentucky bluegrass
Zoysia
Tall fescue

Chinch bugs damage grass plants by inserting their piercing/sucking mouthparts into the stems, sucking the plant juices and injecting chemicals into the plant which obstruct the vascular system. The area around the feeding puncture usually turns yellow. Damage appears as patches of dead or gradually yellowing grass, especially where heat is radiated into the grass from sidewalks or roadways. Once the grass turns brown, the turf will not recover.

Re-seeding or renovation may be necessary after moderate damage. Usually 15-20 chinch bugs per square foot will require treatment. Chinch bugs prefer warm, sunny, dry locations. Adults rarely fly in the mid-Atlantic region. The best way to monitor chinch bug activity is by flotation sampling.

Biological

Naturally occurring fungal diseases such as *Beauveria globcelifera* regularly control chinch bugs during cool, wet weather. Another regulating biological agent is the big-eyes bug, which can destroy entire populations. Unfortunately, chinch bugs frequently cause serious damage before

big-eyed bug populations peak. The wasp *Eumicrosoma beneficum* may parasitize up to half of the chinch bug eggs in favorable locations.

Commercial parasitic nematode products which contain the nematode *Steinernema carpocapsae* are effective against chinch bugs.

Cultural

Several highly resistant varieties are now marketed, particularly for the southern species. The cooperative extension service can provide variety recommendations for your geographic area. Chinch bugs both avoid turf plants with endophyte or die quickly after feeding.

Chemical

Areas with habitual problems should receive an insecticide treatment in April to mid-May that will control the overwintering females and subsequent generations during the summer. Reinfestation may occur from adjacent areas, but this process is slow and may require an additional. This treatment must be made before the egg-laying occurs in early to mid-May in the mid-Atlantic states. Consult with the Command Entomologist or EFD applied biologist for more information.

Leafhoppers

Monitoring and Thresholds

Leafhoppers may be detected through visual observation or by sampling the suspected infestation with an insect sweeping net. When walking through the grass, look for the presence of flying/jumping adults which scatter when disturbed. Also, the abundance of ladybugs, big-eyed bugs, parasitic wasps and other natural enemies may indicate a leafhopper infestation.

Cultural

Maintenance of healthy turf through mowing, fertilization and irrigation.

Chemical

There are no established treatment thresholds for leafhoppers on turfgrass. However, if leafhoppers are present in large enough numbers to be a nuisance or if injury appears, an insecticide application may be warranted. Apply a liquid insecticide to the infested area (thorough coverage is important) and do not irrigate for at least 24 hours after treatment. Multiple applications may be needed throughout the season because of continuous reinfestation from adjacent turf or outlying areas. Consult with the Command Entomologist or EFD applied biologist for more information.

Scale Insects (Rhodesgrass scale)

Monitoring and Thresholds

A standardized method has not been developed for Rhodesgrass scale. If white cottony masses are observed in the turfgrass and there is considerable activity of honeybees and ants feeding on the honeydew, there is most likely an infestation developing. Further close inspection of the turfgrass is suggested.

Biological

A few parasites of Rhodesgrass scale have been recorded including the encyrtid wasp *Anagyrus antoninae*. These parasites have effectively controlled populations in some situations. Failures have probably been due to parasite mortalities from insecticide applications.

Cultural:

Grass mowed at 1.5" or more is less prone to injury than grass that has been cut shorter. Proper irrigation and fertilization also contributes to damage prevention. Do not spread grass clippings from an infested area to uninfested area.

Chemical

Insecticidal control has not been very effective because of the waxy secretions protecting the scale. In Florida, malathion in combination with volck oil has been reported to give satisfactory control. Timing of insecticide application is important to contact the crawler stage. Consult with the Command Entomologist or EFD applied biologist for more information.

Scale Insects (Ground pearls)

Monitoring and Thresholds

Methods for monitoring have not been developed. Close examination of the turf for white oyster or clam-shaped scales will indicate the presence of the scale.

Biological:

A variety of parasitic wasps will parasitize scale insects. Effectiveness is site specific.

Cultural

Keep turfgrass in a healthy condition. Mow, fertilize and irrigate when needed. Do not spread grass clippings from an infested area into uninfested areas.

Chemical

Timing of the application is important to allow crawlers to contact the insecticide. The waxy covering protects the scale from insecticidal sprays, therefore an adjuvant or volck oil may be incorporated. Consult with the Command Entomologist or EFD applied biologist for more information.

Mites

Monitoring and Thresholds

Mite population cycles may be unpredictable, so timing of management practices must be based on pest observations. Timing of monitoring for mites is directly related to mite biology. For example, spruce mites may be active anytime temperatures are over 50F, but once prolonged, hot, dry weather occurs, they enter a state of dormancy and generally do not become active until cooler temperatures prevail.

Because mites are very small, they must be removed from plants before they are counted. This is dome by holding a piece of white paper under the plant and striking the leaves with a ruler. Generally, the plant is struck three times and the mites counted. Population levels may be

measured in a variety of ways, including simple presence/absence, ranges or actual population counts. In most cases, estimation will be sufficient.

Monitoring for mites is a time-consuming process. If you are willing to tolerate some mite injury, the time required for monitoring can be reduced by focusing on efforts on areas which are hot and dry, plants which have been under heavy nitrogen fertilization or plants which have had the most serious problems in the past. If low mite numbers are seen on these plants, then monitoring of less susceptible plants may be skipped at that time.

Leaf discoloration and stippling caused by mite feeding can easily be mistaken with several other insect and disease injury symptoms. It is important not to assume that just because stippling is observed, mites are the cause. Mites, eggs, or shed skins underneath leaves will facilitate a diagnosis.

Cultural/Physical

Infestations can often be reduced by irrigating the turf to disrupt mite colonies and to reduce moisture stress on the turf. Reduce fertilization if mites are found on turf. Plant vegetation that is not attractive to mites including zinnia, salvia, rose, chrysanthemum, petunia, juniper, spruce, arborvitae and yew.

Biological

A vast number of predators and pathogens have been examined for their potential to serve as biological control agents for mites. Some are currently being successfully used and others show potential.

Mites in the family Phytoseiidae are important predators of plant-feeding mites and have been used in biological programs for several species. Spiders, beetles, flies, thrips, and lace wings have been observed feeding on mites. Species in the ladybeetle genus, *Stethorus*, are voracious predators of mites and often eliminate infestations of European red mite. However, control often occurs after the mite populations have peaked. Tetranychid mites are also susceptible to fungal and viral infections, but no pathogenic bacteria have been reported as occurring in mites. There are no known insect parasitoids of mites.

Chemical

Treat when colonies are small. Treatments may be necessary at 10 to 14 day intervals (Thorough coverage is important) and withhold irrigation for at least 24 hours after treatment. Consult with the Command Entomologist or EFD applied biologist for more information.

(3) Vertebrate Specific Pest Management Programs

(a) Moles

Monitoring and Thresholds

Moles, in their search for food, burrow in lawns and other areas where soil conditions are suitable. In spring and fall, these burrows are just a few inches below the surface with the soil being pushed up into ridges. In dry summer or winter, burrows are deeper with the only evidence being mounds of soil pushed up to the surface. Both types of burrows produce damage to the turf.

Cultural/Physical

Trapping is the only known method to effectively manage moles. Traps designed especially for mole control are commercially available. These are the harpoon trap, choker trap and claw-type trap.

Since mole feed primarily on earthworms, assuming that grub control will eliminate moles from a area often results in major disappointment. Before applying grub controls to manage moles, be sure to sample the area to see if white grubs are present.

Chemical

Poison baits, chemical repellent and noise devices are commercially sold for reducing mole populations. Moles rarely take baits and are usually unaffected by repellent and noise. Fumigants are also available, but are rarely effective. Consult with the Command Entomologist or EFD applied biologist for more information.

(b) Skunk

Monitoring and Thresholds

Because skunks are nocturnal, surveys should be conducted during the evening. They will leave holes in turf when searching for grubs.

Cultural/Physical

Removal of grubs usually results in the skunks leaving, although not always immediately. Trapping, while effective should be considered with caution.

(4) Miscellaneous Pest Management

(a) Nematodes

Nematode densities in soil may be determined by having samples assayed by public or commercial laboratories. Management practices that maintain plants in a vigorous condition are an effective control against nematodes. Healthy plants can withstand nematode damage by regenerating new roots to replace those that have been damaged. If problem nematodes have been identified in soil samples, the best time to apply a nematicide is at the beginning of the growth season for the particular grass species. Some turf grasses may be damaged by certain nematicides.

Nematicides for use on turf are contact types. Contact nematicides are usually applied as granules and washed into the soil where they dissolve. Nematodes are killed as they come in contact with the chemicals in the soil water. Fumigant nematicides now available vaporize slowly and kill nematodes as they come into contact with the gases in the soil.

Aerification of the turf before treatment will usually enhance control if drenches or granules are used. Otherwise these pesticides may not be able to penetrate through the thatch and soil to reach the nematodes.

Most nematicides also control insects and some relief from soil-inhabiting insect pests may result from nematode control effects. Once a nematicide has been used, annual treatments may be necessary as certain nematodes may increase rapidly after treatment because of decreased competition and a rapid rate of reproduction. Nematicides should therefore be applied only when high quality turf cannot be maintained with good management practices and a nematode problem has been indicated by a soil assay.

8.6 TURFGRASS DISEASE

Turfgrass disease problems require accurate identification to obtain effective and safe control. In addition to the symptoms expressed by the grass, environmental conditions, grass species and previous cultural practices should be considered when identifying pest-related problems. Turfgrass diseases are particularly difficult to identify. Often environmental conditions modify the disease. Also, after the grass has been killed, it becomes increasingly difficult to identify the cause. In many cases, microscopic examination by experts is required to accurately diagnose a turfgrass disease problem. The following provides description and management information concerning several common turfgrass dieases.

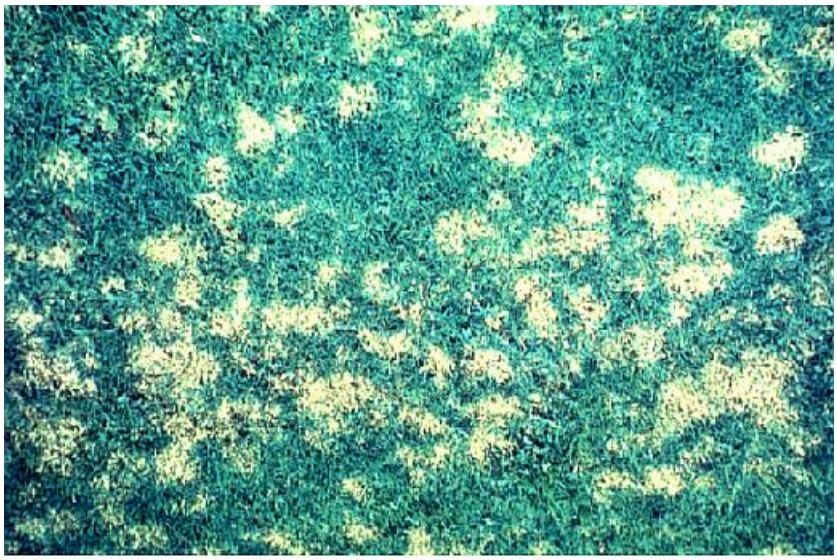
Dollar Spot

Dollar spot, a disease of turfgrasses caused by the fungus Sclerotinia homeocarpa, attacks most turfgrasses grown in the South. Bentgrass, hybrid bermudagrasses and zoysia are most susceptible to dollar spot. The disease occurs from spring through fall, and is most active during moist periods of warm days (70-85F) and cool nights (60 F) in the spring, early summer and fall. The disease is spread from one area to another by water, mowers and other equipment or shoes.

Symptoms

On fine textured and close-cut turf, the disease appears as round, brown to straw-colored and some what sunken spots approximately the size of a silver dollar. In coarse textured grasses maintained at taller cutting heights, the dead spots are larger and more diffuse. Under these conditions dollar spot can be confused with Rhizoctonia brown patch. Dollar spot is readily distinguished, however, by characteristic lesions on the leaf blades of live plants near the border of the affected area. Lesions are light tan with reddish-brown border and usually radiate from the margins of the leaf blade. On fine bladed grasses such as bentgrass, the lesions usually girdle the leaf blade.

If the turf is examined when the disease is active early in the day before the dew dries, cobweb-like mycelium of the fungus can be seen growing on affected areas. During the early stages of the disease, affected plants may appear water-soaked and wilted but spots quickly fade to a characteristic straw color.



Dollar Spot.
Courtesy Joseph Krausz, TAEX, 1996.

Disease Development

Several factors influence the occurrence and severity of dollar spot. Bentgrass, hybrid bermudagrass and zoysia are most susceptible, while St. Augustine and centipede are less frequently attacked by dollar spot.

Low soil moisture has been reported to enhance dollar spot activity, but moisture from dew, light rain or irrigation must be present on the foliage for the disease to develop.

The dollar spot fungus is capable of growth over a wide range of temperatures (50-90F), but disease development is greatest at temperatures between 70-80F. The dollar spot fungus survives unfavorable temperature and moisture conditions in plant tissue and thatch as dormant, compact masses of mycelium, called sclerotia.

Low nitrogen and potassium level in the soil have been reported to increase the severity of dollar spot. Some rather severe outbreaks of dollar spot have been brought under control by the application of soluble nitrogen fertilizer. However, the beneficial effect of nitrogen is thought to be due to rapid recovery of the grass during periods of reduced disease activity.

Control

Cultural practices that promote healthy turf help to reduce the occurrence and severity of dollar spot.

-Remove excess thatch

-Keep fertility levels adequate

-Avoid light, frequent watering and mow frequently at recommended heights

-Aerate compacted soils

To prevent dollar spot apply a fungicide labeled for the disease at recommended rates and intervals. Applications are most critical during moist weather in the spring and fall when day temperatures are between 70-80F.

Fairy Ring

Fairly ring may appear in any lawn, golf course of other turf area during spring and summer months. The rings appear as either dark green or brown circular bands ranging in size from a few inches to 50 feet in diameter. The fairy ring fungus grows outward from a central point at a rate varying from a few inches to as much as several feet a year. Where several distinct rings converge, fungus activity stops at the points of contact. As a result, the circular shape of the original rings is replaced by a scalloped effect.

Mushrooms frequently develop in a circle outside the dark green or brown ring during spring and fall after a period of heavy rainfall or irrigation.

Fairy Rings on golf green.
Courtesy Joseph Krausz, TAEX, 1996.

Disease Cycle

The disease is caused by a number of soil-inhabiting fungi. The causal fungi feed on organic matter in the soil and grow outward in all directions from a central point. Fungal strands (mycelium) spread throughout the soil to a depth of 10-12 inches. As the fungus grows, the first visible evidence of a new fairy ring may be a cluster of mushrooms or tuft of stimulated dark grass. Later, as the fungi spread outward from the point of origin, the ring-like pattern develops.

The initial tuft of dark green grass and the ring of stimulated grass that develops later result from the nitrogen released after the fungus breaks down the organic matter in the soil. A ring of brown or dead grass may also develop, caused by the depletion of soil moisture in the area where the fungus is concentrated. If you dig into the area of brown or dead grass, you will find a dense growth of white mycelium. Water will not penetrate this zone of dense mycelial growth.

During periods of unfavorable conditions, low temperatures and drought, mushroom production and fungal activity stops and may not be resumed for months or years.

Control

Fairy rings are very difficult to control with fungicides since the soil in the infected area is almost impervious to water. Some success has been achieved by aerating the soil and drenching the infected area with a fungicide. However, results have been sporadic and generally unsuccessful.

The only methods of eliminating fairy rings are (1) to remove the soil to a depth of about 18" in the affected area and replace it with fresh soil or (2) sterilize the soil in the affected area with a soil fumigant. Both methods are laborious, expensive and not always successful. Also, the area can become reinfected within a short period.

Masking the symptoms of fairy rings is most effective. Aerating and drenching the soil with a wetting agent will help prevent the development of the zone of brown or dead grass in the area of

dense mycelial growth. Keeping the fertility level of the turf adequate will also help to mask the appearance of the ring of stimulated, or dark green growth. Regular mowing removes the mushrooms.

Pythium Blight and Root Rot

Pythium blight also called cottony blight or greasy spot, is a fungal disease of both warm and cool season turfgrass that causes both a foliar blight as well as a root and crown rot. The disease is most severe during hot, humid conditions and where there is limited air circulation. Poorly drained soils also favor the occurrence of the disease.

Symptoms

Pythium blight of the foliage is most readily recognized as small spots or patches of blighted grass that suddenly appear during warm, wet periods. In early stages, the leaves appear water-soaked, slimy and dark. As the disease progresses, the leaves shrivel and the patches fade from green to light brown. When observing these patches in the early morning, cottony fungal growth may be seen on the foliage.

Sometimes these patches develop into diffuse streaks that follow water drainage patterns or mowing patterns. These streaks are caused by water or equipment picking up the causal fungus and spreading it along its path. Under favorable conditions for disease development, these streaks may coalesce to form large areas of dead grass. If a sudden drop in temperature or humidity of the application of a fungicide halts the development of pythium blight, distinct straw-colored patches develop.

Pythium damage to bentgrass golf green.
Courtesy Joseph Krausz, TAEX, 1996.

Pythium root rot causes a general decline of turfgrass stands and is more of a problem than is generally recognized. Affected turf may appear thinned, off-color, slow growing and non-responsive to fertilizer. It is most common on highly managed golf greens and home lawns. Symptoms may become visible at any time during the growing season. Pythium root rot is one of the major causes of a poor transition from overseeded grasses to bermudagrass in the late spring. Damage to the crown and roots of bermudagrass during the early spring severely

weakens the grass and slows its recovery. Such injury often goes unnoticed until it is too late to prevent.

As temperatures rise, large areas of turf may wilt, turn brown and die. Unlike pythium blight of the foliage, no cottony mycelium is evident during infection periods, and rarely can pythium root rot be diagnosed from field symptoms alone. Pythium root rot is difficult to diagnose. Although infected roots and crowns may be extensivey discolored, microscopic examination of the tissue is required to detect the presence of pythium in the root tissue.

Disease Development

Pythium spp. are commonly present in soils and thatch. Under favorable temperature and moisture conditions, the fungus resume growth and initiates infection. With pythium foliar blight, disease development can occur rapidly by a cobweb-like mycelial growth of the fungus from leaf to leaf. The foliar blight develops most rapidly under humid conditions when air temperatures are above 80F. As temperatures approach 90F, only a short time is required to destroy a stand of turfgrass. With pythium root and crown rot, the environmental conditions for disease development are not well defined.

Control

Cultural practices can do much to prevent pythium blight. Good water management is very important in reducing disease potential. Remove thatch on a regular basis through frequent verticutting and topdressing, avoid lush growth produced by over fertilization and overwatering, improve air circulation by pruning or selectively removing trees bordering on the site, and improve drainage through aeration and the use of soil amendments. Increasing the mowing height and other practices that promote toor growth may lessen the damage from pythium root rot.

During extended periods of warm, humid weather, a preventive fungicide program may be advisable to check the development of pythium. Fungicide control of pythium root rot is less consistent than control of foliar blight. Overseeded bermudagrass greens, Apron- Koban-treated seed can be used to limit pythium seedling slight during the establishment period. Fungicide applications may be needed 7-21 days after planting to protect the young seedlings.

Brown Patch

The name brown patch is not very descriptive of the varied symptom expression caused by *Rhizoctonia* sp. on turfgrass. Symptoms differ on cool- and warm season grasses and vary depending on environmental conditions and cultural practices.

Symptoms

Turfgrass affected by brown patch will generally exhibit circular or irregular patches of blighted grass. On cool-season grasses during periods of warm, humid weather, a darkened border or "smoke ring" may develop at the outer margin of the patches. This smoke-ring symptom occurs when the pathogen is actively causing a uniform and rapid wilting of the newly infected leaf blades. It frequently does not occur, but when it does, it is usually observed only in the morning when dew is still present or during very wet weather. The smoke-ring symptom is not reliable for diagnosis. Mowing height will also affect symptom expression.

Brown Patch of St. Augustinegrass.
Courtesy Joseph Krausz, TAEX, 1996.

On warm-season grasses, symptoms are different than on cool-season grasses. Circular to irregular patches of blighted turf up to several yards in diameter develop commonly in the fall, winter and spring when these grasses are approaching or emerging from dormancy, evening temperatures are below 70F, and rainfall usually increases. The smoke ring symptom sometimes is observed on cool season turfgrasses is usually absent, but active infections may be noticeable by yellowish leaves at the margins of the patches. Often infected basal leaf sheaths become rotted and a gentle tug on the leaf blade easily separates the leaf at the base of the leaf sheath. The roots of turfgrass with brown patch usually are not discolored. Brown patch develops most rapidly when air temperatures are between 75-85F and wet conditions are present. The disease progress generally subsides when air temperatures rise much above 90F.

Control

The severity of brown patch may be reduced by irrigating only on an as needed basis, watering early in the morning to remove dew and allow the grass to dry quickly as opposed to watering in the evening, and avoiding heavy applications of nitrogen during the spring and fall.
A number of fungicides are recommended for control. The fungicides are most effective when used on a preventive basis as compared to their use after the disease has become well established.

Take-all Patch

Take-all patch, caused by the fungus *Gaeumannomyces graminis* is a serious disease of St. Augustine grass and can also cause problems on bermudagrass. It seems to be active during the fall, winter and spring when there is abundant moisture and temperatures are moderate. The disease has the ability to destroy large sections of turfgrass if left uncontrolled and has proven to be a difficult disease to control.

Symptoms

When the disease is active, the first symptom is often a yellowing of the leaves which may eventually die and turn brown. The areas of discolored and dying leaves may be circular or irregular in shape and at least up to 20' in diameter. A thinning of the turfgrass within the affected

area occurs as roots, nodes and stolons become infected and the plants decline. Unlike brown patch, the leaves of take-all infected plants do not easily separate from the plant when pulled. The roots are sometimes so rotted that damaged stolons are easily pulled from the ground. Regrowth of the grass into the affected area is often slow and unsuccessful as the new growth becomes infected. During the stressful high temperatures of the summer, the weakened, infected grass will continue to decline.

Take-all Root Rot of St. Augustinegrass.
Courtesy Joseph Krausz, TAEX, 1996.

Disease Cycle

The pathogen survives on infested debris and on infected parts of living perennial grass plants. When conditions are favorable (cool, moist weather), the fungus grows on the surface of roots, stolons, rhizomes, crown and leaf sheaths of the grass and then penetrates and infects the tissues. As the weather becomes warmer and dryer, the infected plants are stressed and symptoms become more evident. The pathogen can be spread over long distances when infected plants or plant debris are transported mechanically. Infected sod may serve as a source of inoculum even if it shows no immediate symptoms of the disease.

Control

Controlling take-all patch is not easy and much has yet to be learned about the disease. Control efforts should be considered both cultural and chemical methods. Good surface and subsurface drainage is important. Excessive watering can also be favorable to development of take-all patch. Irrigating only when required to maintain good plant growth is suggested and infrequent but thorough watering is preferred to frequent shallow watering.

Since the pathogen can survive on infested thatch, prevention of thatch build-up is suggested. Efforts to de-thatch and to prevent thatch accumulation may prove helpful. If soil compaction exists, aeration will help to alleviate this condition and allow the grass to establish a deeper, more vigorous root system.

Balanced fertility is important. If possible, adjust the soil pH in the upper root zone so that it is slightly acidic, preferably within a range of 6.0-6.5. The use of ammonium sulfate as a source of nitrogen fertilizer will help to acidify the soil. There is evidence that the use of ammonium sulfate as the source of nitrogen fertilizer can significantly reduce the incidence of take-all patch if used

over a long period of at least two years. However, to avoid thatch build-up, it is not advisable to apply more than 4 pounds of nitrogen per 1,000 square feet per year or more than 1 pound of nitrogen per application per 1,000 square feet when ammonium sulfate is used on St. Augustine grass. More frequent but low-rate applications would be preferable. Application of elemental sulfur at the rate of 3-5 pounds per 1,000 square feet in several split applications can also help acidify the soil.

The fungicides Rubigan and Bayleton are labeled for the control of take-all patch caused by *Gauemannomyces graminis*. Since infection is tough to occur primarily in the fall, with disease progression continuing during the fall and winter months under cool, moist conditions, fall applications may be the best time for fungicides to be applied for preventive purposes. Their efficacy in controlling the already established disease may be disappointing.

Fusarium Blight

Fusarium blight is caused by the widespread fungi *Fusarium* spp. The disease is most troublesome on cool-season grasses such as bentgrass, bluegrass and tall fescue, but occasionally attacks the warm-season grasses as well. The disease is most serious during hot, humid conditions when the turfgrasses are under drought stress.

Symptoms

Initially, affected grasses show light green patches. The shape of the affected areas may appear as circular patches, elongated streaks or crescents. At high temperatures, the patches quickly change from light green to reddish-brown, then tan and finally straw-colored. Sometimes at this stage, a doughnut-shaped area up to 3 feet in diameter with healthy grass in the center will give a "frog-eye" pattern to the disease area. When conditions of high temperature and high humidity persist for an extended time, these diseased areas become numerous and may overlap. Thus, large areas of turf may appear blighted. As the disease progresses, the grass dies as a dark-brown to black dry rot of roots, crown, rhizomes and stolens occurs.

Sometimes, on individual leaves, irregularly-shaped tan spots with light brown to purplish-brown margins occur mostly on the older leaves.

Disease Cycle

The fungi that cause fusarium blight survive the winter in the thatch layer and on infected grass roots, crowns and rhizomes. *Fusarium* spp. cause leaf spots and abundant sporulation during warm, wet weather. High temperatures and drought seem to favor development of the crown and root rot expression of the disease, which occurs primarily in areas that are fully exposed to sunlight. The pathogen shows little activity when air temperatures are below 70F.

Control

Conditions that favor fusarium blight include excessive nitrogen application in the spring or summer, excessive thatch, and mowing at lower than recommended heights. Reducing plant stress aids in managing fusarium crown and root rot. Watering should be as infrequent as practical to avoid stress, but thorough and deep. Several fungicides are labeled for control of fusarium blight.

Spring Dead Spot in Bermudagrass

One of the most noticeable and destructive diseases of bermudagrass is spring dead spot (SDS). SDS has been observed in most states where bermudagrass is grown. The prevalence and severity of the disease have been increasing for several years, and it may be the most destructive disease of bermudagrass in some areas.

In North America, three fungi have been shown to cause SDS: *Leptosphaeria korrae, Ophiosphaerella herpotricha* and *Gaeumannomyces graminis*.

Spring Dead Spot of bermudagrass.
Courtesy Joseph Krausz, TAEX, 1996.

The symptoms of SDS are small circular dead areas of bermudarass 6" to several feet in diameter in the spring as bermudagrass resumed growth from winter dormancy. The bermudagrass roots and stolons in affected spots appear dark and rotted. The grass receovers very slowly during the summer months from stolons creeping in from the border of the affected areas. Bermudagrass stolons that grow into the affected areas usually produce short, stubby roots. The disease develops the following year again in the same areas. The spots enlarge each year and after 2-3 years may develop onto circular areas where bermudagrass survives in the center. At this stage the symptoms can be confused with those of fairy ring.

All varieties of bermudagrass are susceptible to SDS. Hybrid varieties appear to be the most commonly affected. The disease does not usually develop until 3-4 years after establishment and may be associated with moderate thatch accumulation

The fungus may be controlled by the application of fungicides beginning in late summer or early fall. Also, use of nitrogen fertilizer helps to reduce disease severity. Ammonium-based nitrogen fertilzer combined with potassium helps reduce SDS over time.

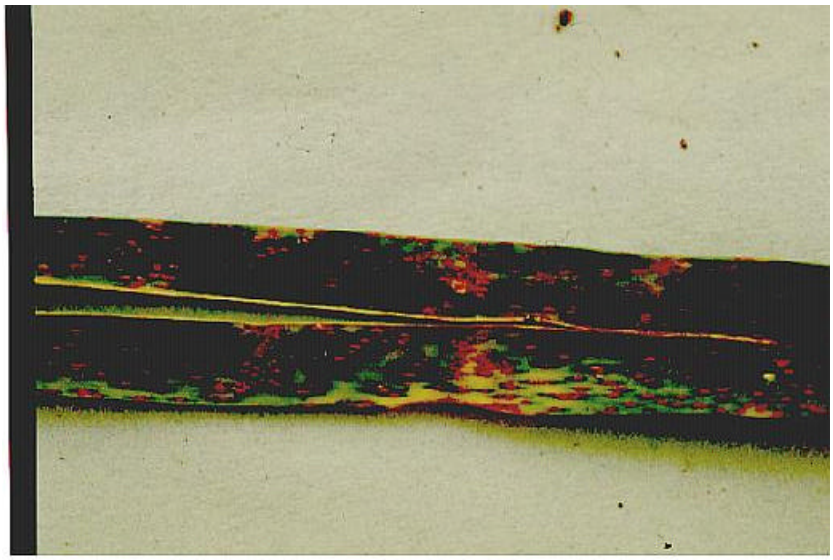
Rust

Rust diseases are found throughout the United States on most species of grasses. Bluegrass, ryegrass and zoysiagrass are most commonly affected. Rust diseases are favored by warm humid conditions and develop most frequently on grasses subject to stress such as droughty

conditions, low nitrogen fertility and shade. Low mowing heights, particularly on Kentucky bluegrass, also increase the susceptibility of grasses to rust.

Symptoms

The disease first appears on grass leaves as small orange to reddish-brown flecks that enlarge to form raised pustules on leaves and stems. Individual pustules are usually oval or elongated and contain a powdery mass of orange to reddish-brown spores. As the pustules mature they turn brown to black. Heavily infested turf becomes thin with an overall yellow-orange to reddish-brown color. Infected leaves turn yellow, wither and die.



Leaf Rust of St. Augustinegrass.
Courtesy Joseph Krausz, TAEX, 1996.

In southern states, ryegrasses are highly susceptible to rust in the spring, particularly where nitrogen fertility is low. Zoysiagrasses are most often affected by rust in the fall as the growth rate of grass slows and environmental conditions favor disease development.

Control

Cultural practices which improve the vigor of the turf also help prevent rust. To reduce the incidence of rust, keep nitrogen levels adequate for turf growth, avoid moisture stress or overwatering and adjust mowing heights according to the grass needs. In the case of Kentucky bluegrass and perennial ryegrass, use varieties that have good resistance to rust where the disease is a problem. Where these measures fail to provide adequate control of rust diseases, fungicides are available for its control.

St. Augustine Decline

St. Augustine decline (SAD) is a virus causing a chlorotic mottling or stippling of St. Augustinegrass leaves. St. Augustinegrass and centipedegrass are the only turfgrasses that the virus is known to affect.

Symptoms

In the early stages of infection, St Augustinegrass leaves show a chlorotic mottling or stippling. As the mottling progresses, leaves develop a chlorotic appearance. Usually 3 or more years after the early symptoms are observed, the turf becomes weakened to the extent that bermudagrass invades the lawn. Also, grass infected with SAD and growing under shade or other stress conditions will being to thin and be replaced by weeds.

St. Augustine grass infected with SAD is also slower to recover from dormancy than health grass. In the spring following an unusually cold winter, much of the diseased turf does not recover.

Lawns infected with SAD will respond to fertilization, but the symptoms remain. Early fall and late spring applications of complete fertilizer and summer application of iron will help maintain good color of SAD-infected lawns.

St. Augustinegrass Decline.
Courtesy Joseph Krausz, TAEX, 1996.

Early stages of SAD are often confused with iron chlorosis, but the two can readily be distinguished. Leaves showing chlorosis caused by iron deficiency are either uniformly yellow or show characteristic yellow stripes parallel to the mid-vein of the leaf. Iron chlorosis also appears first in the new or young leaves whereas SAD produces the mottling in young and older leaves. Iron cholorsis is readily corrected by foliar application of iron sulfate or iron chelate.

Control

The SAD virus is mechanically transmitted by mowing equipment, edgers and other tools. Mowing companies that mow several lawns with the same equipment can transmit the virus from an infected to healthy lawn. Cleaning the mowing equipment with steam or a 10% chlorine bleach solution will help prevent the spread of the virus.

The best control is to introduce resistant varieties of St. Augustine grass into the lawn

Gray Leaf Spot on St. Augustine grass

Gray leaf spot, caused by the fungal organism *Pyricularia grisea*, develops rapidly with abundant moisture and warm weather in the spring and early summer. The disease is especially troublesome in shaded areas.

Symptoms

Gray leaf spot causes oval or circular, tan colored lesions with brown or purplish borders on the leaf blades of St. Augustine grass. In severe cases, the leaves wither and die. Under these conditions, the disease causes serious thinning.

Control

To reduce the severity of gray leaf spot, avoid applications of soluble nitrogen fertilizers on moderately shaded lawns during summer months. Herbicide application, which may weaken the turf, should also be avoided on shaded lawns. Apply water to the lawn in early morning only when needed. Avoid late afternoon and evening watering which keeps the leaf surface moist for long periods. Also, catch and remove grass clippings in lawns where gray leaf spot is a problem. Several fungicides are recommended.

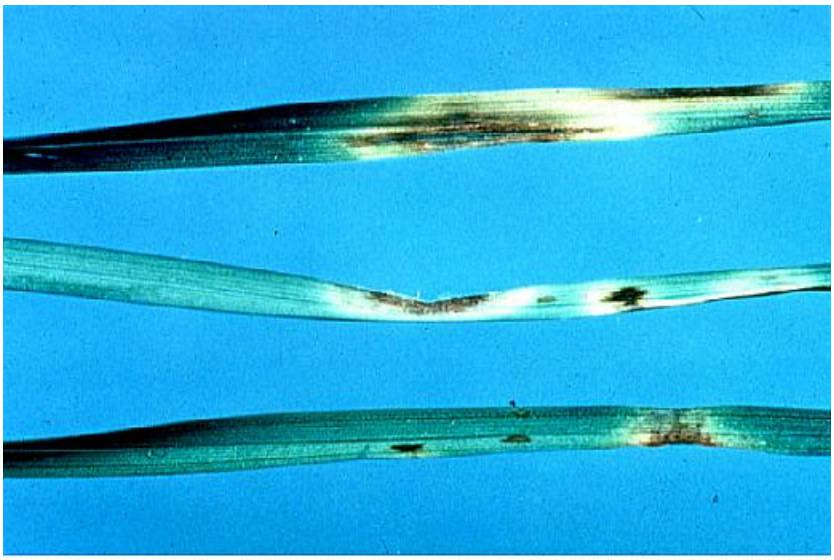
Grey Leaf Spot of St. Augustinegrass.
Courtesy Joseph Krausz, TAEX, 1996.

Bipolaris and Exerohilum Diseases

The *Bipolaris* and *Exserohilum* spp. of fungi were once grouped under the name Helminthosporium. They cause lead spots, crown rots and root diseases mostly on warm-season turfgrasses.

Symptoms

Small purplish to black spots may appear on leaves, stems or crowns of infected plants. The spots may eventually fade to brown and then tan to whitish. Severely infected leaves may die and appear light tan to straw colored. Extensive damage occurs when the pathogen attacks crown, stolons, rhizomes or roots. This results in a thinning or "melting out" of large areas of turfgrass in irregular patterns.



Bipolaris leaf spot.
Courtesy Joseph Krausz, TAEX, 1996.

Disease Cycle

The disease causing fungi survive the winter as mycelium in the tissue of infected plants and the thatch layer of the turfgrass. As temperatures warm in the spring, the disease first appears as small spots on the leaves or stems. The disease severity increases with increasing temperatures and humidity and is often greater when the grass is maintained at low levels of nitrogen and potassium fertility. Also, any stress situation such as drought, herbicide injury, soil compaction or heavy traffic seems to increase the severity of the disease.

Control

Healthy turfgrass is the best protection against this disease. Maintain moderately vigorous turf through proper fertilization, giving special attention to maintaining adequate, but not excessive levels of nitrogen and potassium. Try to reduce plant stress by eliminating any soil compaction problems, providing good surface and sub-surface drainage, watering adequately but not excessively or too frequently and avoiding herbicide applications during periods of disease activity. Disperse traffic in high traffic areas. Fungicides can help protect the turf. Preventive applications are much more effective than treating a severe outbreak.

Powdery Mildew

Powdery mildew is primarily a problem on Kentucky bluegrass turf growing in partial shade or in areas with poor air circulation. The disease is most often found in the spring and fall when days are cloudy and nights are cool and damp.

Symptoms

The disease appears as a white light gray powdery growth on the upper surfaces of leaves and leaf sheaths. It spreads rapidly in shaded areas and the powdery growth becomes increasingly dense. The lower leaves may be completely covered by the powdery growth. Infected leaves turn yellow, become tan or light brown and gradually shrivel and die.

Repeated infestations of the disease result in greatly reduced growth and eventual death of plants. Surviving plants often remain in a weakened condition.

Control

Reduced shading and increased air circulation will help control powdery mildew. Where these conditions cannot be changes, fungicides are available for control.

Centipede Decline

In mature centipedegrass lawns (3+ years) problem areas appear in the spring and increase throughout the summer. These problem areas usually develop in thatchy turf, compacted soils, droughty spots or areas under stress. Since a specific disease organism ahs not been identified as the causal agent, the problem ahs been broadly named.

Symptoms

Centipede decline is descriptive of the problem as the grass gradually deteriorates and is replaced by weeds or other grasses. Frequently, the grass greens up in early spring and gradually turns off color, wilts and dies. These areas may initially be less than 1 foot in diameter, but by mid-summer may have expanded to 3-6 feet. Individual areas may coalesce to produce large irregular shaped patterns of wilted discolored turf. Such areas resemble centipedegrass suffering from drought. Examination of the turf in these areas reveals very little root growth. In fact, many of the stolons have no root attachment to the soil.

Control

Cultural practices provide the most effective means of preventing centipede decline.
Mowing practices have been shown to affect the development of the disease. Mowing heights above 2" tend to promote the disease, while mowing heights of 1.5" or less at weekly intervals lessen the problem.

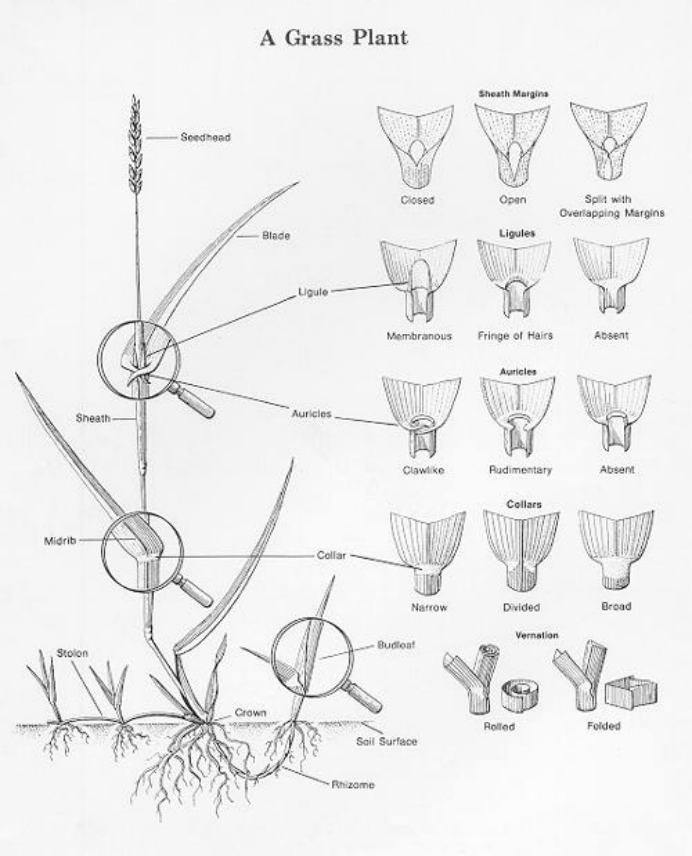
Application of nitrogen at rates above 2lbs per 1,000 square feet per year have been shown to increase the spread of the disease. Ideal nitrogen fertilization would be 0.5lbs per 1,000 square feet in April, June, August and October

e. **Contingency considerations**. During most contingency operations, protecting military personnel and materials must be the first priority. When contingency operations stabilize, shift attention to some turf pest problems as needed. Take care that grass species in the area are tolerant of any chemical applications made. When returning to CONUS from overseas contingency operations, all turf and soil must be removed from all military equipment and material. Refer to AFPMB Technical Information Memorandum No. 31 for USDA APHIS Quarantine Procedures.

APPENDIX A

TURFGRASS IDENTIFICATION

Turfgrass identification is an important, but sometimes difficult aspect for correct management. Seed heads are the main feature in identifying grasses, but they are not present in mowed turf. Therefore, it is necessary to learn identification by vegetative characteristics. A 10X or 15X hand lens is helpful when looking for small parts that distinguish between different grasses. *Indicates a key identification characteristic. (Key adapted from the Texas Agricultural Extension Service Publication B-5087).

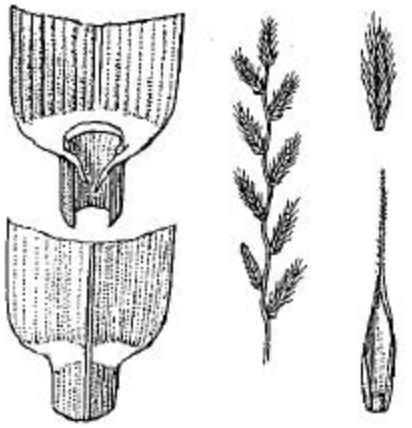


Annual Ryegrass (*Lolium multiflorum*)

Whole Plant

Spikelet

Floret



Characteristics:
- -Leaves rolled in the bud
- -Ligule membranous, short
- -Collar broad
- -Auricles narrow, long and claw-like*
- -Sheaths not compressed, yellowish-green at base
- -Blades long, 1/16-1/8" wide, tapered, prominent veins* above, very glossy below, edges smooth
- Bunchgrass*

Creeping Bentgrass (*Agrostis palustris*)

Whole Plant

Spikelet

Characteristics

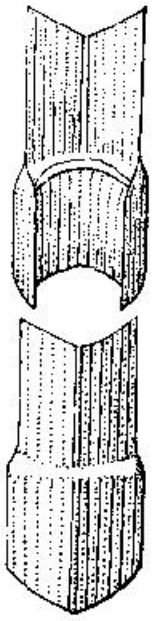
-Leaves rolled in the bud
-Ligule membranous, tall, rounded*
-Collar narrow
-Auricles absent
-Sheaths smooth, not compressed
-Blades narrow, 1/16" wide, flat veined, round along the edges*
-Stoloniferous*

Fine Fescue (*Festuca rubra*)

Whole Plant

Spikelet

Floret



Chracteristics:

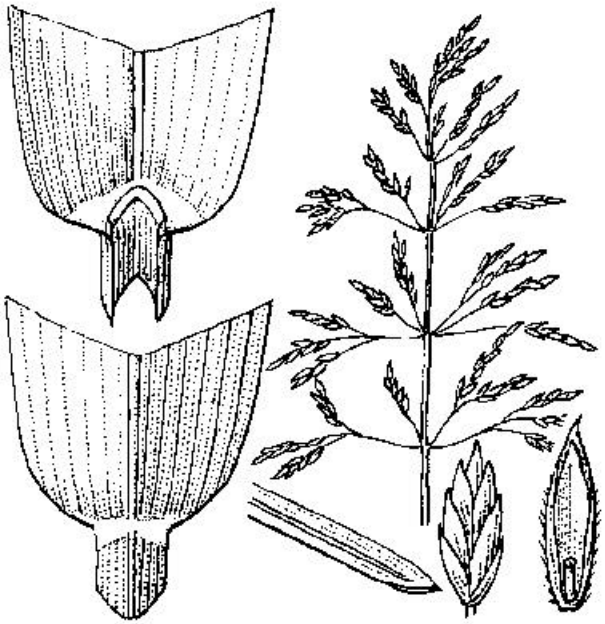
- -Leaves folded in the bud
- -Ligule membranous, very short
- -Collar narrow, indistinct
- -Auricles absent
- -Sheaths slightly rough, not compresses, wider than the blades, lower sheaths brown
- -Blades very narrow, 1/16" wide or less, bristle-like
- -Rhizomatous

Kentucky Bluegrass (*Poa pratensis*)

Whole Plant

Spikelet

Floret



Chracteristics

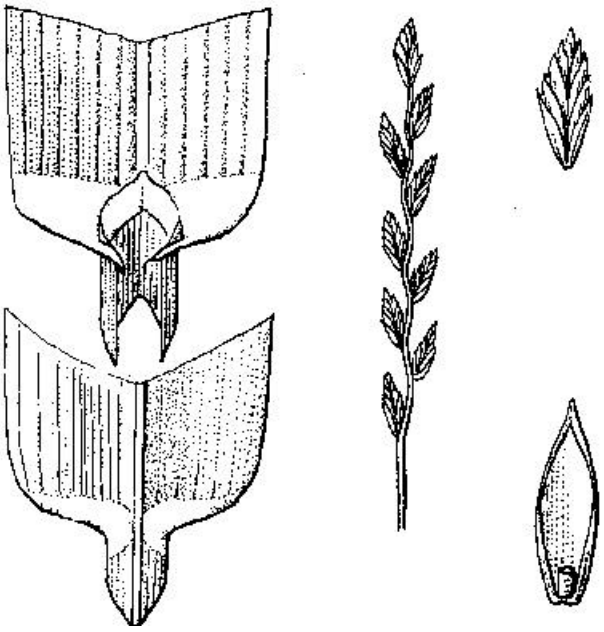
- -Leaves folded in the bud
- -Ligule membranous, very short, abrupt*
- -Collar narrow
- -Auricles absent
- -Sheaths green, compressed smooth
- -Blades long, less than 1/8" wide, the edges parallel to each other, terminating in a prominent mid-vein, "boat-shaped" tip.*
- -Rhizomatous*

Perennial Ryegrass (*Lolium perenne*)

Whole Plant

Spikelet

Floret

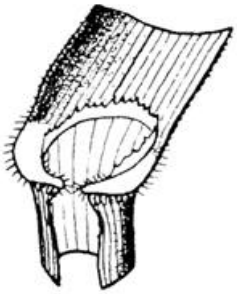


Characteristics

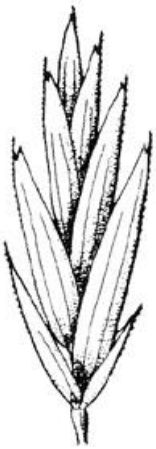
-Leaves folded in the bud
-Ligule membranous, medium tall, toothed near the tip*
-Collar narrow
-Auricles short, not clasping the stem*
-Sheaths reddish below ground, smooth
-Blades from 1/8-1/4" wide, prominently veined above, very glossy and smooth beneath*
-Bunchgrass*

Tall Fescue (*Festuca arundinacea*)

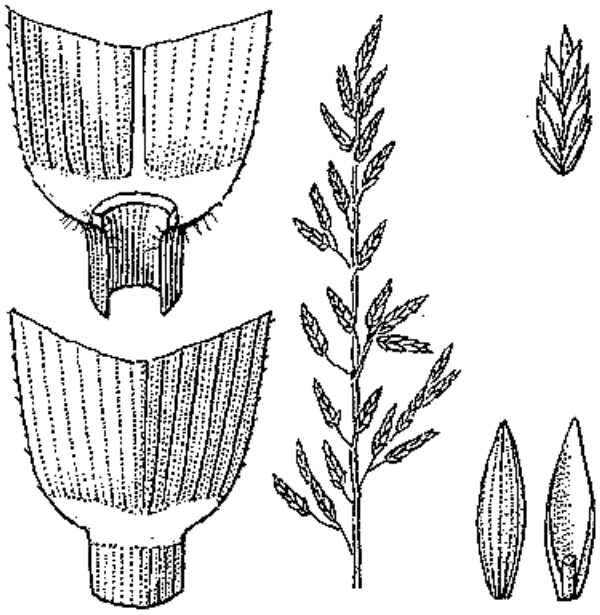
Whole Plant



Ligule



Spikelet

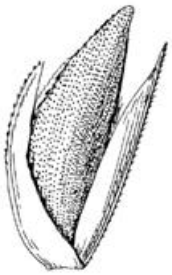


Characteristics

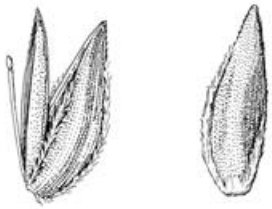
-Leaves rolled in the bud*
-Ligule membranous, short*
-Collar broad, continuous
-Auricles blunt, short, pubescent
-Sheaths not compressed, reddish-pink below ground
-Blades flat, 1/8-1/4" wide, strongly veined above, rough along the edges, sharp pointed.*
-Bunchgrass*

Bermudagrass (*Cynodon dactylon*)

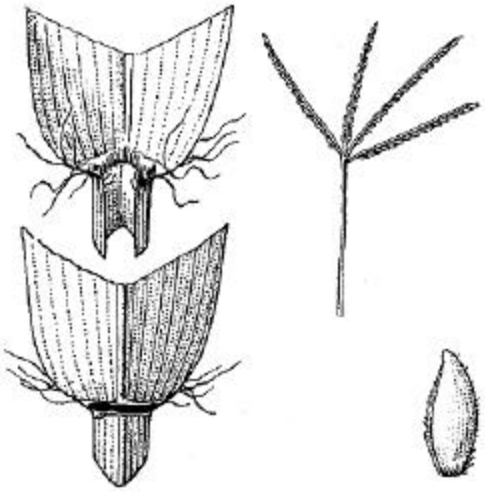
Whole Plant



Spikelet



Floret



Characteristics

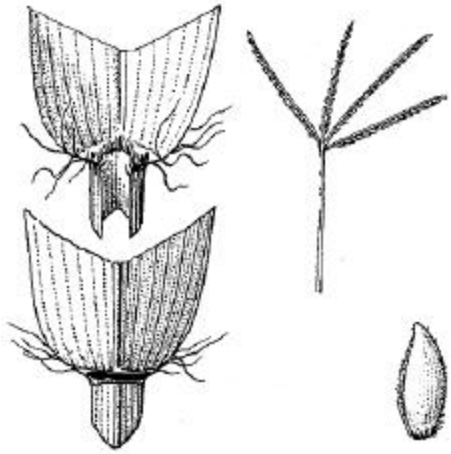
-Leaves folded in the bud
-Ligule a fringe of hairs
-Collar narrow, covered with long hairs
-Auricles absent
-Sheaths strongly compressed, sparsely hairy
-Blades short, 1/8" wide, rough along the edges, sharp pointed
-Stoloniferous and rhizomatous

Buffalograss (*Buchloe dactyloides*)

Whole Plant

Spikelet

Floret



Characteristics

-Leaves rolled in the bud*
-Ligule a fringe of hairs, short in the center, long at the edges*
-Collar broad, hairy
-Auricles absent
-Sheaths short, flattened, smooth*
-Blades less than 1/8" wide, flat, twisted or curled, sparsely hairy*
-Stoloniferous*

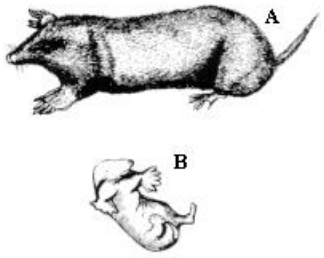
APPENDIX B

KEY TO TURF PEST DAMAGE
(Adopted form North Carolina State University Center for IPM)

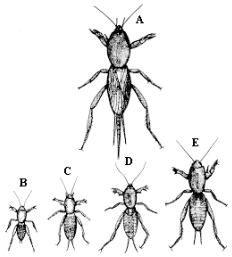
1. Pest of man in association with turf (21)
   Direct problem with turf itself (2)

2. Soil mounded over tunnels in the turf (3)
   Not as above

3. Mounds 5 to 8 cm wide (MOLES)
   Mounds 1.3 to 2 cm wide (MOLE CRICKETS)



Moles. A, Adult. B, Young.



Mole crickets. A, Adult. B-E, Nymphs.

4. Turf dug up in patches where grub populations are high (SKUNKS)
   Not as above (5)


Eastern striped skunk.

5. Small mounds of soil on turf (6)
   Not as above (7)

6. Mound of soil glued together in compact mass (Fig 1A) (worm casting) (EARTHWORMS)
   Mound of soil loose, not glued together (Fig 1B) (ANTS, WILD BEES, CICADA KILLER, WASP, GREEN JUNE BEETLE)


1A


1B

7. Holes (burrow opening) in soil near damaged plants, plants cut off near soil line, pest most troublesome in early summer and early fall (8)
   No hole in soil near damaged plants (9)

8. Burrow vertical and deep (Burrowing sod webworm)
   Burrow angled or nearly horizontal, not deep (Sod webworm)

9. Plants chewed on, severed near ground line, skeletonized, eaten around edges, or consumed completely (10)
   Plants yellowing, drying up or dying, but leaves not consumed by pest (15)

10. Plants severed near groundline (Cutworms, Sod web worms, Burrowing sod webworms)
    Plant not severed near groundline (11)

11. Caterpillars feeding on turf (12)
    No caterpillars present (13)

12. Problem in late summer or early fall only (Fig 2A)(Fall Armyworm)
    Problem throughout the growing season (Fig 2B)(Armyworm)

2A 

2B 

13. Problem on turf during especially dry years (Fig 3)(Grasshoppers, Shorttailed crickets)
    Problem in good years or grasshoppers and shortailed crickets not present (14)

3A 

3B 

14. Puncture-like holes in stems and crowns; circular holes in leaves; damaged turf may be easily pulled up (Billbug grubs and adults)
    No holes in leaves and stems (15)

15. Turf yellowing in spots and dying out; white, frothy spittle apparent on stems (Fig 4)(Spittlebug)
    No white, frothy spittle mass (16)

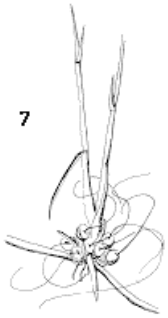

4

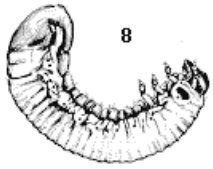
5 

16. Turf yellowing in spots and dying out. When bottomless can is pressed firmly onto periphery of damaged area and filled with water, small black and white bugs (4 mm) float to surface (Fig 5)(Chinch bugs)
No chinch bugs present (17)

17. Turf yellowing and dying out; difficult to pull from soil; small, pearl-like insects in soil below damaged area (Fig 6)(Ground pearls)
No ground pearls (18)

18. Turf yellowing and dying out; difficult to pull from soil; small brownish-purple or white (2 mm) insects on crown of plant (Fig 7)(Rhodesgrass mealybug)
No rhodesgrass mealybugs present (19)





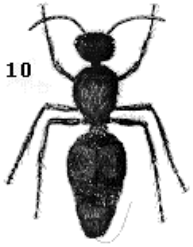
19. Turf yellowing and dying out; difficult to pull from soil; no apparent pest (Bermudagrass mite, nematodes)
Turf relatively easy to pull from soil (20)

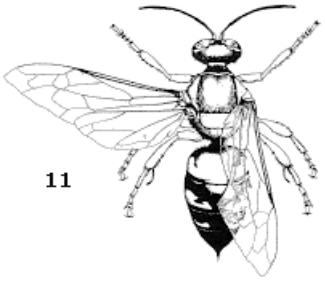
20. Irregular brown patches of turf; small mounds resembling ant hills, C-shaped grubs in soil (Fig 8)(Green June beetle grubs)
Irregular brown patches of turf; roots may be destroyed and turf may be rolled up like a carpet; C-shaped grubs in soil (Fig 9)(Japanese beetle grubs, May beetle grubs)

21. Stinging (or threatening in appearance)(22)
Not stinging (25)

22. Wingless, brightly colored and velvety (Fig 10)(Velvet ant)
Winged (23)

23. Large (up up to 32 mm); black and yellow; strong flyer (Fig 11)(Cicada killer wasp)
Smaller (24)

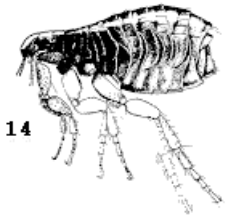




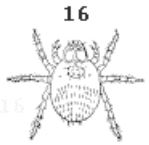
24. Bluish black with yellow spots on abdomen (Fig 12)(Scoliid wasp)
Yellow with black spots (Fig 13)(Yellow jacket)

25. Small (2 mm), brown, compressed, biting pest (Fig 14)(Flea)
Not as above (26)

26. Flattened, leathery brown, biting pest (bit not irritating, up to 7 mm long) with 8 legs (Fig 15)(Tick)
Not as above (27)


14


15


16

27. Very small; red; 8 legs; leaves itching welt especially where clothing is tight (Fig 16)(Chiggers)
Not as above (28)

28. With hard covering abdomen (29)
Abdomen exposed at least at rear (30)

29. Brightly colored, good flier, usually in bright sunlight on hard packed soil or pathway (Fig 17A)(tiger beetle)
Brown or black, good crawler; usually in thatch (Fig 17B)(Ground beetle)

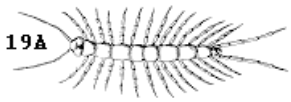

17A


17B

30. With "forceps" at rear of abdomen (Fig 18)(Earwig)
Without "forceps" (31)


18

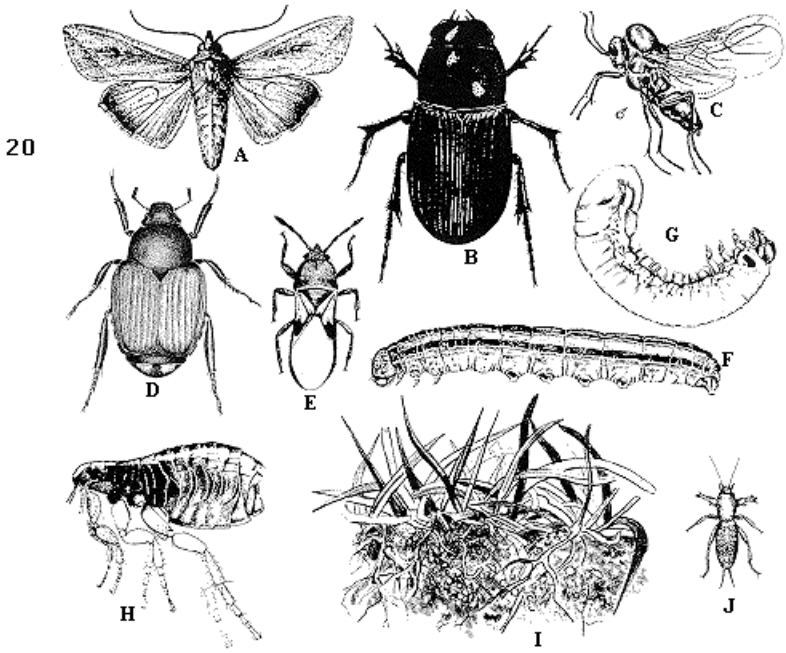
31. Many legs, one pair per body segment (Fig 19A)(Centipede)
Many legs, two pairs per body segment (Fig 19 B)(Millipede)


19A

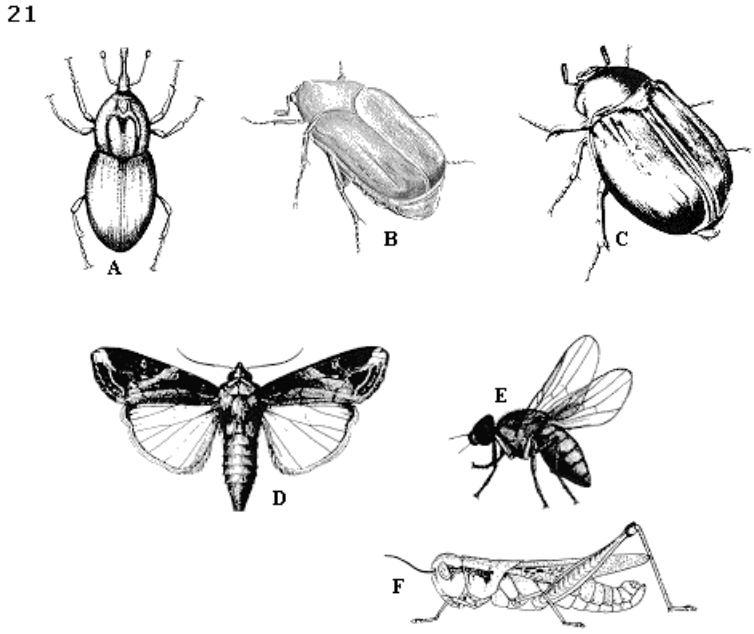

19B

APPENDIX C
KEY TO IDENTIFY TURF ARTHROPOD PESTS
(Adopted form North Carolina State University Center for IPM)

1. Wings present (Fig. 20A to E) (2)
   Wingless (Fog. 20F to J) (27)



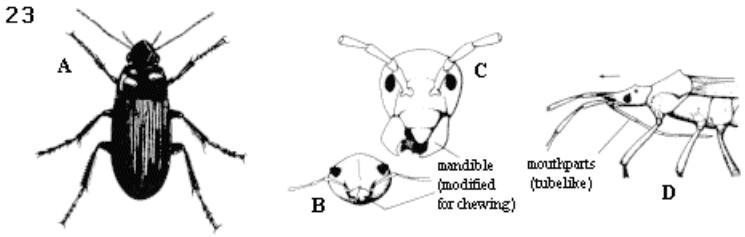
2. Front pairs of wings (the wings which lie on top when folded) partially or completely thickened, hard or leathery (Fig 21 A to C) (3)
   Front pair of wings flexible and papery, sometimes clear (Fig 21 D to F) (11)



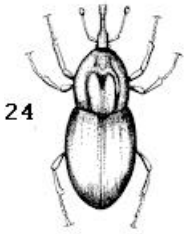
3. Front pair of wings leathery, short (much of abdomen is visible from top); forceps on rear of abdomen (Fig 22)(EARWIG)
   Front pair of wings covering most of abdomen or no forceps on rear of abdomen (4)

22

4. Front pair of wings usually hard, thick, opaque and lacking veins (Fig 23A); mouthparts chewing type (Fig 23 B,C) (Beetles)(5)
   Front pair of wings usually leathery, with veins (Fig 21F); mouthparts chewing type of extended into a tube (Fig 23D)(12)



5. Hard-shelled, brown to black beetle, 5-11 mm long with an elongate snout (Fig 24); often covered with soil particles (Billbug)
   Variable but lacking snout, 5-25 mm long (6)



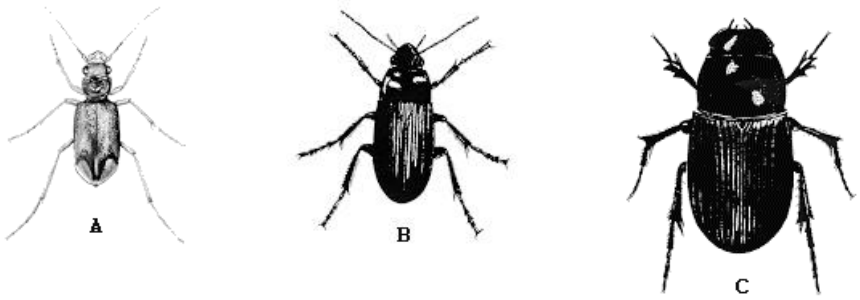
6. Antennae filiform (like a string of beads)(Fig 25A); beetles crawl rapidly (7)
   Antennae lamelliform (ends in small plates which may from a club)(Fig 25B), elbowed; beetles crawl slowly(8)

7. Found crawling through turf rapidly; fly seldom; mostly black to brown (Fig 26A) (Ground Beetles)
   Found crawling on paths through turf; fly rapidly when approached; brightly colored (Fig

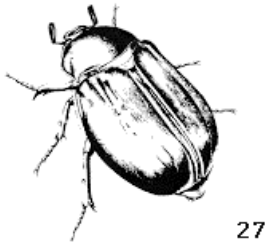
26B)(Tiger Beetles)

8. Small beetle (5 mm long); dark brown to black (Fig 26C) (*Ataenius spretulus*)
   Large beetle (15-25 mm long); color variable (9)

26



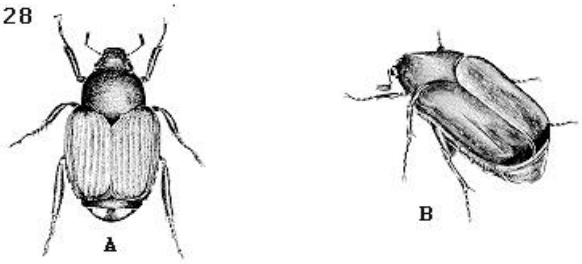
9. Beetle, 15-22 mm long, with shiny green head, legs and ventral surface (10)
   Reddish-brown to black beetle, 20-25 mm long (Fig 27) (May Beetle)



27

10. Front wings brownish, white tufts on abdomen, 11-22 mm long (Fig. 28 A)(Japanese Beetle)
    Front wings velvety green, no white tufts on abdomen, 15-25 mm long (Fig 28B)(Green June Beetle)

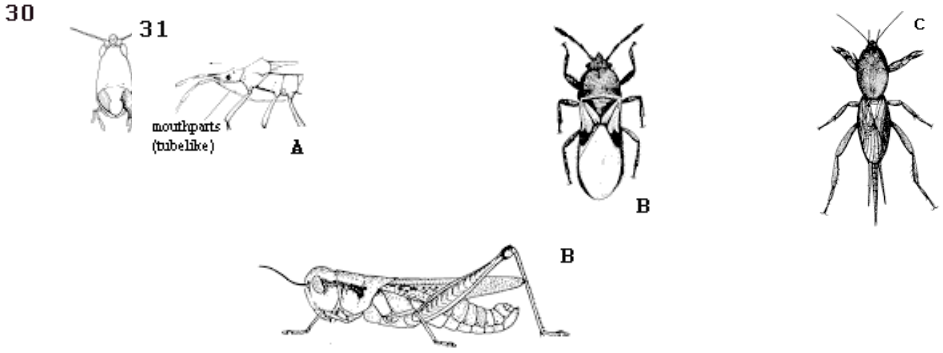
28



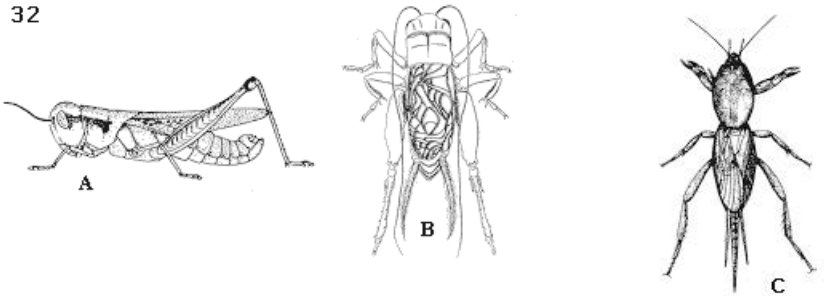
11. Mouthparts extended into a tube or hair like structure (Fig 29A); wings covered with tiny scales which resemble dust when smudged (moths)(Fig 29B)(14)
    Mouthparts variable or lacking; wings without scales (20)

29

12. Mouthparts chewing type (Fig 30A); hind legs modified for jumping (Fig 30 B) or front legs modified for digging (Fig 30 C)(13)
Mouthparts extended into a tube (Fig 31A); legs not modified for jumping or digging; body length 4mm or less; black body with white wings (Fig 31B)(Southern Chinch Bug)



13. Hind legs modified for jumping; antennae short, seldom half the length of the body; femlae with short, blunt ovipositor (Fig 32 A,B)(Grasshopper, shorttailed cricket)
Front legs shovel-like, modified for digging, brown, velvety body with beady eyes, burrows in soil (Fig 32 C)(Mole cricket)



14. Wingspan usually less than 38 mm, hind wings brown or yellow brown (15)
Wingspan 38 mm or greater, hind wings whitish or lightly colored (16)

15. Moth with a prominent snout-like projection (Fig 33A), wingspan averages 15 mm, forewings brown or ash gray with white streak from base to margin (Sod Webworm Moth)
Moth without prominent snout-like projection (Fig 33B), wingspan averages 25-38 mm, forewings yellowish or reddish-brown with yellow border and sometimes a row of dark brown spots (Burrowing sod webworm moth)

16. Forewings basically a solid color (17)
Forewings splotched or mottled with intricate designs (18)

17. Forewings primarily fawn-colored or grayish-brown each with a small, white spot near the center, wingspan about 38.5 mm (Fig 34A) (Armyworm moth)
Forewings primarily yellowish-brown, distinct black line on thorax, abdomen gray, wingspan 38-45 mm (Fig 34B) (Granulate cutworm moth)

34

18. Forewings basically yellowish-brown with pale mottled designs, wingspan 38-50 mm (Fig 35)(Variegated cutworm moth)
Forewings primarily a mixture of black and gray or white (19)

35

19. Long, dark narrow forewings pale near tips, 3 black lines on each forewing, wingspan 38-5-51 mm (Fig 36A)(Black Cutworm)
Forewings dark gray, mottled with lighter and darker splotches, noticeable whitish spot near extreme tip, wingspan about 38.5 mm (Fig 36B)(Fall armyworm moth)

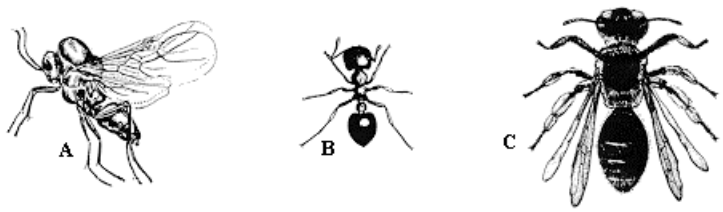
36

20. Hard-bodies insect, abdomen constricted at point of attachment to thorax, hind wings with fewer veins and smaller than front wings, chewing mouthparts (bees, ants, wasps)(Fig 37 A, C)(21)
Insect without constricted abdomen, one or two pairs of wings, mouthparts variable or lacking (24)

21. First abdominal segment very narrow but bearing a hump or node, antennae elbowed at least in females, with elongated first segment (Fig 37A,B)(Ants)
First abdominal segment constricted but without hump or node (22)

22. Insect fuzzy with many branched or feathery hairs all over its body (Fig 37C) (Wild Bees)
Insect not fuzzy though unbranched hairs may be present especially on the abdomen (wasps)(23)

37



23. Wasp 25-38 mm long, generally black with three yellow bands around the abdomen (Fig. 38A)(Cicada killer wasp)
Wasp about 13 mm long, wings dark blue, head, thorax and first part of abdomen black, two yellow spots on the middle of the abdomen, tip of abdomen brown and hairy (Fig 38B)(Scoliid wasps)

38

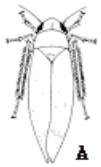
24. Tiny, gnat-like insect, 1-8 mm long, with one pair of wings (Fig 39A, B)(25)
Two pairs of wings; hind wings smaller than front wings; sucking mouthparts (26)

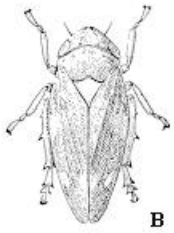
25. Tiny, waxy filaments trail from abdomen; mouthparts lacking (Fig 39 A)(Male ground pearl, male rhodesgrass mealybug)
No tiny, waxy filaments on abdomen; mouthparts sponging type (39B)(Frit fly)

39

26. Insects averaging 7 mm long with an elongated triangular head, yellow, green or gray; mottled or speckled (Fig 40A)(Leafhopper)
Black insect 6-10 mm long with two red or orange lines across the wings (Fig 40B)(Twolined spittlebug)

40



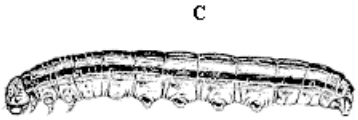


27. Chewing mouthparts (29)
Piercing-sucking mouthparts or other types of mouthparts (28)

28. Maggot (1-4 mm long) with mouthparts (Frit fly larva)
Not a maggot, piercing-sucking mouthparts (33)

29. Insect with three distinct body regions (head, thorax, abdomen, Fig 41A) or without distinct regions (Fig 41B)(30)
Insect with 2 distinct body segments (thorax not strongly differentiates from abdomen, Fig 41B,C)(37)

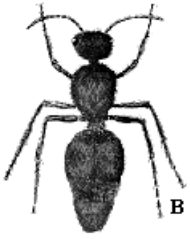
41



30. First abdominal segment very constricted (Fig 24A, B), insect nesting in turf but not feeding on it (31)
First abdominal segment not constricted, insect feeding on turf above or below ground (32)

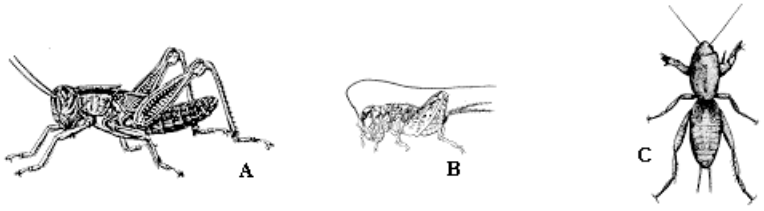
31. Insect social; first abdominal segment with hump or node (Fig 42A)(Ant)
Insect solitary; first abdominal segment without a hump or node; stridulates when stepped on; often brightly colored 9Fig 42B)(Velvet ant)

42



32. Insect with hind legs modified for jumping; feeding on blades of turf (Fig 43 A,B)(Grasshopper, shorttailed cricket)
Insect hind legs not modified for jumping, forelegs modified for digging; feeding on roots of turf (Fig 43C)(Mole cricket)

43



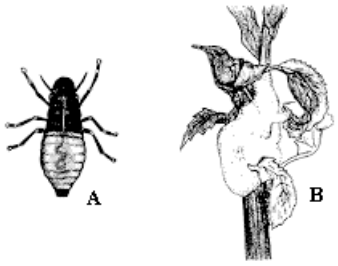
33. Pinkish or purplish, globular body with or without well-developed forelegs and claws; about 0.5-2.0 mm in diameter (Fig 41B)(34)
Body not globular (35)

34. Insect with well developed felt sac of matted, waxy white filaments (Fig 44A)(Rhodesgrass mealybug)
Insect without felt sac, covered with hard, round shell (Fig 44B)(Female or immature ground pearl)

44

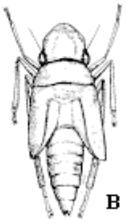
35. Yellow, orange or white insect with red eyes enveloped in a frothy spittle mass (Fig 45 a, B) (Spittlebug nymph)
No spittle mass (36)

45



36. Body less than 4 mm long; abdomen black and pale yellow or white, head and thorax brown (Fig 46A)(Southern Chinch bug nymph)
Yellow, green or gray body less than 7 mm long; triangular, sometimes elongated head (Fig 46B)(Leafhopper nymph)

46



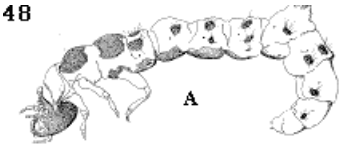
37. Insect with three pairs of thoracic legs and five pairs of prolegs on abdomen (Fig 47) (43)
Insect with three pairs of thoracic legs or no thoracic legs and one or no prolegs on abdomen (38)

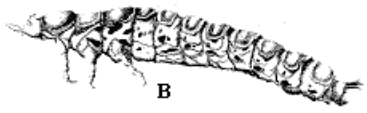
47

38. Insect with three pairs of thoracic legs and one abdominal proleg (anal)(fig 48A,B)(39)
Insect without even an anal proleg (40)

39. Inhabiting vertical burrow; with hooks on top of fifth abdominal segment (Fig 48A) (Tiger beetle larva)
Crawling in thatch; no hooks on top of fifth abdominal segment (Fig 48B)(Ground beetle larva)

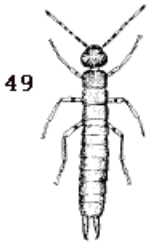
48





40. Insect with forceps or pinchers at end of abdomen (Fig 49)(Earwig)
Insect without forceps at end of abdomen (41)

49



41. Insect with 3 pairs of thoracic legs (Fig 50)(Ataenius spretulus, Green June beetle, Japanese beetle and May Beetle grub)
Insect without legs (42)

50

42. Feeding on turfgrass, head dark (Fig 51)(Billbug larva)
In nest in turfgrass; head usually pale to medium brown (Ant, Cicada killer wasp, flea, velvet ant, wild bee, yellow jacket larvae)

51

43. Hairy, spotted caterpillar, 6-19 mm when fully grown, with a yellowish- to light brown body (Fig 52)(Sod webworm)
Caterpillar smooth or with only a few sparse hairs (44)

52

44. Caterpillar basically one color (45)
Caterpillar with multicolored strips or designs (46)

45. Fat caterpillar light gray to nearly black; as long as 46 mm when mature (Fig 53A)(Black cutworm)
Caterpillar dirty white or light gray with brown head; only 20 mm long when fully grown (Fig 52B)(Burrowing Sod webworm)

53

46. Dark brown to gray caterpillar with pale, longitudinal stripes and black, conical granules of various sizes; head brown; mature length 38.5 mm (Fig 54A)(Granulate cutworm)
Skin smooth or sparsely-haired but not granular (47)

47. Smooth-skinned, pale gray or light brown caterpillar mottled with dark brown; first abdominal segment marked with a pair of yellow or orange dots; mature length 40 mm (Fig 54B)(Variegated cutworm)
Caterpillar not as above; primarily striped (48)

54

48. Green, brown, or black caterpillar with dark head capsule often marked with an inverted "Y"; longitudinal, black stripe on each side of body; yellowish-gray stripe down back; mature larva 35-50 mm; most common in late summer or autumn, two pairs of dark spots on each abdominal segment; body uniform diameter throughout (Fig 55A)(Fall armyworm)
Pale green to yellowish- or brownish-green caterpillar; body widest at middle, tapering slightly toward each end; mature length 35-50 mm (Fig 55B)(Armyworm)

APPENDIX D

KEY TO IDENTIFICATION OF COMMON TURFGRASS DISEASES
(Adapted from the Texas Agricultural Extension Service Publication no. B-5087)

Grass affected in distinct patches

Individual patches 2-3" in diameter, leaf lesions present

Diseased spots are light tan or straw colored. Light tan lesions may be found near the top of the grass blade. Fine, cobwebby, mycelial growth can be seen covering the spots in the early morning when dew is present.....Dollar Spot

Individual patches usually larger than 2-3" in diamtere, leaf lesions not present

Dark green "halo" or circular or crescent-shapes patches present; mushrooms may be present in circular pattern outside of dark green "halo", grass appears normal in the center of the patch....Fairy Ring

Dark green "halo" or mushrooms not present in circular pattern.

1. Grass blades matted together in affected area; greasy, water-soaked appearance, fading to a light tan as grass blades dry and shrivel; cottony appearance in early morning hours; blighted areas may merge to form large irregular areas or long streaks....Pythium Blight

2. Outer edge of circular patch may be yellowish-brown in color occasionally giving it a "smoke-ring" appearance; grass blades at the margin of patch can be easily pulled from the stolon; green grass may appear within the patch.....Brown Patch

3. Outer edge of irregular patch is chlorotic to straw-colored, grass within the patch is straw-colored and "crisp"; leaves not easily pulled from the stolon.....Take-all Patch.

4. Circular, doughnut-shaped patches of chlorotic, tan or straw-colored grass; patches no more than 3 feet in diameter with green grass in the center producing the "frog-eye" pattern, chiefly on cool season grasses.....Fusarium Blight

5. Circular patches of grass appear brown in early spring, grass does not recover from winter dormancy (bermudagrass only).....Spring Dead Spot

Grass not affected in distinct patches

Spots Distinct on Leaf Blades

1. Orange or red bumps on leaf surface, rust-colored spores readily rub off the leaf surface....Rust

2. Leaf blades show chlorotic mottling (St. Augustine grass and centipedegrass only).....St. Augustine Decline

3. Oval-shaped spots with tan or gray-colored center and brown margin surrounded by chlorotic tissue, spots apparent on leaves and stems.....Gray Leaf Spot

4. Small, elongated spots with dark brown or purple margins; spots increase in size and the centers fade to a brown or straw color; where leaf spots are numerous, leaves may be completely killed; spots apparent on leaves and stems....Bipolaris and Exserohilum Leaf Spots

5. Small superficial patches of white to light-gray dusty fungus growth on leaves, lower leaves often completely covered; leaf tissue under the mildew becomes yellow and fades to brown; heavily infected leaves gradually dry up and die....Powdery Mildew

Spots Not Distinct on Leaf Blades and Grass Appears Chlorotic

1. Affected areas appear yellow, thin and generally unhealthy; grass roots appear normal.....Curvularia Fading Out, Nigrospora Stolon Rot, Centipedegrass Decline

2. Affected areas appear yellow, thin, not responsive to treatment; grass roots stunted, swollen or blackened....Nematodes

3. Grass appears chlorotic, seedstalks abundant, growth rate noticeably slower than normal, no distinct boundaries to the affected area (except possible fertilizer distribution pattern), root system appears normal....Nitrogen or Iron Deficiency

Spots Not Distinct on Leaf Blades and Grass Not Generally Chlorotic

1. Leaf tips frayed, grass not wilted, turf has a brown appearance several days after mowing.... Mower blade dull or not properly adjusted

2. Grass wilted in localized spots, turf has a gray cast in wilted areas and turns brown as condition persists, leaves rolled, soil dry or compacted (sloping site)....Drought stress, soil compaction or hydrophobic soil (Common on sandy soils).

3. Grass wilted in localized spots, soil moist, water stands in places after rain or irrigation, weak root system.....Wet wilt, poor drainage

4. Grass appears burned in spots or streaks, leaf blades are first to turn brown, occurs shortly after application of soluble fertilizer....Fertilizer burns

5. Grass not wilted and has a brown appearance shortly after mowing; grass stems or crown exposed...Grass scalped, excessive thatch accumulation

6. Grass not wilted and has health color, but leaf tips appear burned; grass grows rapidly after mowing....Excessive nitrogen

8.7 FOREST, TREE AND SHRUB FOLIAGE PESTS

a. Introduction. A variety of arthropod pests periodically infest ornamental and shade trees. These pests differ in their life histories, feeding preferences and behavior. This section discusses the following pest groups: (1) defoliators, (2) bark beetles and borers, (3) conifer shoot and tip pests, (4) piercing and sucking insects and (5) meristem feeders and (6) miscellaneous pests.

b. Defoliators. Arthropods which feed on ornamental and shade trees are called defoliators. Some arthropods, such as the Japanese beetle, defoliate their host by skeletonizing the leaves. Others, such as webworms, leafrollers and tent caterpillars defoliate by consuming parts or all of the leaves. Heavy infestations may result in completely stripping the foliage.

(1) Conifer Insects

Bagworm (*Thyridopteryx ephemeraeformis*)

Importance

Bagworms are one of the most important pests of evergreen ornamentals. Arbovitae and juniper are particularly susceptible. If infestations are extensive, the insects will strip evergreen shrubs of their foliage and cause branch dieback or death. Some hardwood species-such as maple, oak, dogwood and willow- also are attacked, but rarely are they damaged as severely as conifers.

Identification

Bagworms are larvae and are rarely seen outside the bags they construct. The wingless female moth is grub-like and remains inside this though, silken bag throughout her life. Male are accomplished fliers and are often seen circling around infested tress in search of a mate during the fall.

Identifying the Injury

Bagworms consume the entire needle or leaf, leaving only the needle sheath or mid-rib. They usually feed on one branch at a time. An indication of damage is the presence of bags suspended from twigs and branches.

Life History

Bagworms overwinter as eggs, inside the bag that contained the female. In the spring, the eggs hatch and the larvae crawl out in search of food. By using silk and bits of needles or twigs, they construct a bag around themselves. When fully grown, the bags are between 1.56 and 2.5" in length and the larvae permanently suspend their bags from twigs and pupate. In the fall, he male moth emerges, flies to a female's bag and mates. The female lays between 500-1500 eggs within her bag. There is one generation annually.

Male

Female

Management

In most cases, bagworm infestations are reduced by low winter temperatures and a complex of several parasites. On ornamentals, it is often practical to control bagworm by picking and destroying the bags. Chemical control is also effective, but only in the spring an d fall when vulnerable larvae are feeding and exposed without bags. Bacillus thuringiensis sprays are also effective against bagworms.

Blackheaded Pine Sawfly (*Neodiprion excitans*)

Importance

This sawfly, which ranges from Virginia to Texas, prefers loblolly and shortleaf pines but also feeds on slash, longleaf and pond pines. Because heaviest defoliation occurs during late summer and fall, trees may go through the winter stripped of their needles. The resulting loss in vigor may pre-dispose slow growing pines to bark beetle attack.

Identification

Older larvae are about 1" long and olive green with a glossy black head. Two longitudinal black stripes run along the top of the body, and a conspicuous row of black spots occurs on each side.

The adult female is about 0.5" long with a light brown body. She lays her eggs singly at the bases of needles on the tips of shoots.

Identifying the Injury

Defoliation during the spring and summer is not serious because larvae tend to feed on the older foliage. In the fall, however, defoliation may exceed 90% of the total crown and result in a considerable growth reduction during the following season. Heavily defoliated trees, especially overmature sawtimber, may be killed following secondary attacks by bark beetles.

Life History

The larvae overwinter in light brown cocoons spun principally in duff, topsoil and bark crevices at the base of the trees. Pupation is completed in the spring and both adults and larvae are sometimes present throughout the summer and fall. There are 3-4 generations per year in the Gulf coastal region.

Management

Outbreaks of the blackheaded pine sawfly occur periodically and usually subside rapidly. Natural enemies are usually helpful in preventing or ending outbreaks. Insecticides may be necessary on valuable trees.

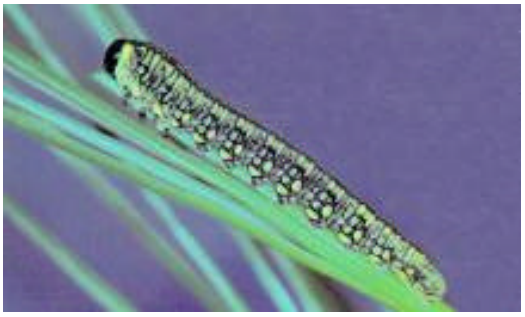
Introduced Pine Sawfy (*Diprion similis*)

Importance

The introduced pine sawfly occurs from Canada to North Carolina and in the central and lake states. Eastern white pine is its favored host, but it also infests Scotch, red, jack, and Swiss mountain pines. Infestations of this insect can be very serious in young trees.

Identification

A full grown larva is about 1" long, with a shiny, black head. The body has a black stripe on the back and numerous yellow and white spots on the sides. Larvae spin light brown, tough, leathery cocoons on the host tree, other vegetation, and ground litter. Adults resemble flies and are about 3/10" long and have four transparent wings.



Identifying the Injury

Defoliation first occurs in the upper crown, giving it a thin appearance. First generation larvae feed on old needles, and later generations feed on both old and new needles and sometimes on the bark of twigs. Trees in the most exposed locations and in the overstory suffer the most defoliation. Repeated heavy defoliation can cause branch and even tree mortality.

Life History

First generation adults emerge in early spring. Eggs are laid in rows in the needles and covered with a light green material. Hatch occurs in about 14 days. The larvae feed until cocoons are spun in late June through July. Second generation adults emerge in late July, and most larvae have finished feeding and spin cocoons by late September. There are two generations and sometimes a partial third per year. As a result of overlapping generations, all life stages can be observed in midsummer.

Management

Introduced and natural enemies play an important role in control. Insecticides are effective in protecting ornamental plantings from defoliation.

Loblolly Pine Sawfly (*Neodiprion taedae linearis*)

Importance

This species is one of the most important defoliators of loblolly and shortleaf pine in the south-central states. In heavily infested areas, trees may be completely defoliated in the spring before new shoots have developed. Periodic outbreaks over large areas cause substantial growth loss and reduced tree vigor, but mortality rarely occurs.

Identification

Larvae are dull green with black stripes along each side and often two lighter stripes below heavy ones. They are about 1 inch in length with brown heads. The adult female has a brown body with black markings and is about 2/5" long with a saw-like apparatus for depositing eggs.

Identifying the Injury

Newly hatched larvae feed in groups on the old growth. They consume the soft outer tissue of needles, leaving the remainder to turn reddish brown. Twigs with damaged and discolored needles can be easily seen, and are called "flags." Older larvae feed singly or in pairs and consume the entire needle, leaving short stubs on the branch.

Life History

There is only one generation per year. The overwintering eggs hatch during March and April. Larvae feed for 3-4 weeks before dropping to the ground and spinning cocoons in the litter and soil. Pupation takes place in October or November, just prior to adult emergence. After the female mates, she lays a row of 2-10 eggs in the middle portion of each needle, laying between 90-120 eggs overall.

Management

Natural enemies and a polyhedrosis virus are very effective at controlling outbreaks. Chemical control would be necessary only after several consecutive years of defoliation.

Pine Colaspis (*Colaspis pini*)

Importance

Pine colaspis beetles are commonly found throughout the southeast, but are more prevalent in the Gulf states. They prefer slash pine but have been found on other southern pines, baldcypress and ornamental spruce. Pine colaspis beetles are not serious tree pests, however, feeding damage caused by large beetle populations can cause a spectacular browning effect.

Identification

Adults are elongate, oval, convex and rusty yellow or brown with green reflections. These moderate sized beetles are about 1/4" long. Full grown larvae are sparsely covered with short hairs. Small clusters of longer hairs occur at the lower outer edges of each body segment.

Identifying the Injury

Adult beetles chew the edges of needles, producing irregular, sawlike edges that turn brown. Later the entire needle may die, causing the whole tree to become brown as though scorched by fire. Occasionally, only the tips of the needles show signs of injury. Trees do no die and little or no growth loss results. Attacks usually occur in early summer. By late summer the trees appear green and healthy again.

Life History-

There is only one generation per year. Eggs are laid on herbaceous undergrowth during the summer. Larvae emerge, feed on roots of grasses and other vegetation and overwinter in this stage. The larvae pupate in the spring, adults emerge in early summer.

Management

On ornamental and shade trees, insecticides are often used to prevent damage. In forest stands, no control measures are recommended.

Pine webworm (*Tetralopha robustella*)

Importance-

The pine webworm occurs throughout most of the eastern half of the United States and attacks pitch, Virginia, white, slash, shortleaf, longleaf, and loblolly pines. The pine webworm usually attacks one and two year seedlings, but will infest saplings and large trees. Rarely is defoliation severe enough to kill the seedlings, but it may have some growth impact.

Identification

The adult moth is dark to medium gray with dark gray to black forewings on the basal third and outer half. Wingspan is approximately 1". The larvae are light gray with darker tan stripes along the body. They are approximately 3/4" in length when fully grown. The pupae are reddish in color and approximately 1/2" long.

Identifying the Injury

The most noticeable sign of attack and usually the first, is a large mass of frass entangled in a network of silken webbing. Close examination of this material will usually reveal one or more larvae.

Life History

Eggs are usually laid on seedlings, or occasionally on large trees, between May and September. After the eggs hatch, the caterpillars live in silken webs surrounded by masses of frass and feed on the needles. After feeding is completed, the caterpillars drop to the ground and pupate in the soil. IN the South, there are usually two generations per year.

Management

Hand picking is an effective method of control. When high value ornamentals are infested, chemical control may become necessary.

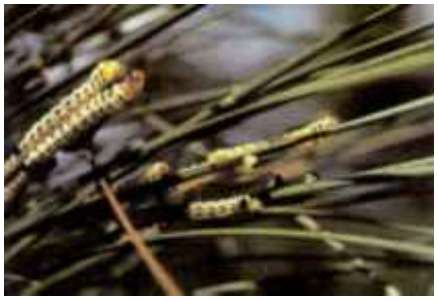
Redheaded Pine Sawfly (*Neodiprion lecontei*)

Importance

The redheaded pine sawfly is an important pest in young, natural pine stands. Heavy defoliation can lead to growth loss and tree mortality. The sawfly occurs throughout the eastern and southern United States. Loblolly and longleaf pines are preferred hosts, although shortleaf, pitch and slash pines are also attacked.

Identification

The mature larva is easily identified by its bright red head. The body is about 1" long and pale whitish yellow to bright yellow in color, with 4 to 6 rows of black spots on the body. The cylindrical cocoon is reddish brown and about 1/2" long. The adults resemble flies. They have four transparent wings and vary from 1/5-2/5" in length.



Identifying the Injury

Larvae feed in colonies containing a few to over a hundred larvae. Larval feeding generally occurs on the outer portion of the needles. The unconsumed portions of needles have a straw-like appearance. Older larvae strip branches of all foliage and sometimes feed on tender bark when foliage is scarce.

Life History

This sawfly overwinters in the larval stage within cocoons located in the soil or duff. Adults emerge in the spring. The female lays approximately 120 eggs in rows on the needles of a single twig. Each egg is deposited in a small pocket sawed into the edge of the needle. Eggs hatch in about 2-4 weeks and larvae feed gregariously for about 4 weeks. Larvae then drop to the ground and spin their cocoons.

Management

Outbreaks occur periodically and tend to subside after 1-2 years of heavy defoliation. Natural factors and climatic conditions help control populations. A polyhedrosis virus is being used to control outbreaks. Insecticides may also be used.

Virginia Pine Sawfly (*Neodiprion pratti pratti*)

Importance

Heavy defoliation by the Virginia pine sawfly for two or more years can weaken trees and make them more susceptible to other insects and diseases, particularly when associated with drought. This sawfly is found from New Jersey to North Carolina. The insect prefers Virginia and shortleaf pines, but will occasionally feed on pitch and loblolly pines.

Identification

Larvae are pale green, with black head capsules and about 1/10" long when newly hatched. Full-grown larvae are spotted or marked with longitudinal black stripes and are from 3/5-9/10" long. The adults have four membranous wings.

Identifying the Injury

Young larvae feed gregariously on the previous year's foliage. They consume the outer portion of the needle, causing the remaining part to take on a straw-like appearance, which is characteristic of early sawfly feeding. Mature larvae consume the entire needle and may feed on the buds and tender bark.

Life History

Adults emerge from cocoons in late October and early November. After mating, the female cuts a slit at the edge of the needle and inserts a small, white oval egg. Several eggs are usually laid at evenly spaced intervals in each needle. Each female lays about 30-100 eggs. The eggs overwinter and hatch the following April. Around mid-May, the full-grown larvae drop to the ground and spin cocoons in the litter or surface soil. They pupate in late September. There is one generation per year.

Management

Natural enemies, including a polyhedrosis virus, and adverse weather condition seem primarily responsible for fluctuations in sawfly populations. Insecticides may also be used.

(2) Hardwood Insects

Cottonwood Leaf Beetle (*Chrysomela scripta*)

Importance

Willows, poplars, aspens and alders are affected. Stunting and multiple-forked tops have been especially severe in intensively managed cottonwood plantations. Damage is most critical during the first 3 years after planting and may cause mortality.

Identification

Adults are about 1/4" long. The head and thorax are black and the margins of the thorax are yellow or red. The wing covers are usually yellowish with broken black stripes, but are sometimes almost pure golden to black. Young larvae are black, but become light to dark brown with prominent white scent gland spots along their sides. Mature larvae reach about 1/2" in length. The larvae emit a pungent odor when disturbed.

Identifying the Injury

The young larvae are gregarious and skeletonize the leaves. Later, they feed separately and consume the entire leaf, except for larger veins. Adults chew holes in the leaves, may attack tender shoots, sometimes killing the terminals, causing reduced growth, stem deformity or even tree mortality.

Life History

The adults hibernate under bark, litter and forest debris. Beetles may be collected in large numbers under or near cottonwood or willow trees in the winter. In the spring, after leaf growth begins, they fly to host trees to feed on the leaves and twigs. In a few days, the female beetles begin to lay their lemon-yellow eggs in clusters of 25 or more on the undersides of leaves. The larvae reach full size and pupate in less than 2 weeks. The pupae attach to leaf surfaces, the bark or to weeds and grass beneath the tress. The adult beetles emerge after 5-10 days. There are six to eight generations per year in the South.

Management

Under forest conditions, they are often held in check by lady beetle predators which feed on the eggs and pupae. Insecticide treatments have been successful in certain situations.

Eastern Oak Looper (*Phugalia titea*) and Linden Looper (*Erannis tiliaria*)

Importance

The linden and eastern oak loopers cause defoliation in the spring. Host species attacked include the red and white oak groups, maples, elms, hickories, ash and cherry. Heavy defoliation usually occurs in May and June and can cause growth loss and mast reduction. If coupled with other stresses, this defoliation may cause mortality. The greatest impact of these insects is often felt in public use areas where defoliation reduces the aesthetic value and larvae and their droppings create a nuisance.

Identification

Male moth wings are light gray to tan, with wavy lines and a span of 1-1.5". Linden looper females are wingless and the eastern oak looper female has wing pads, but cannot fly. Mature larvae of these loopers are about 1.5" long. The eastern oak looper has a tan head and body, with many lengthwise, black wavy lines. The larval segments have small, hairy tubercles. The linden looper has a rusty brown head, a tan back with numerous wavy black lines, and yellow sides. Coloring of both loopers varies with population densities.

Identifying the Injury

Early evidence of feeding are small holes in the leaf produced by the young larvae.

Life History

Adults emerge and females lay their eggs in early spring. Eggs hatch at about the time of bud break, and the larvae begin feeding on the expanding foliage. Feeding continues for approximately 6 weeks, then the mature larvae enter the soil to pupate.

Management

The eggs and larvae are attacked by insect parasites and predators. Other natural enemies also help in control. Sticky bands placed around the trunks of tress can trap females as they climb to lay eggs. Chemical control may be needed in certain situations.

Eastern Tent Caterpillar (*Malscosoma americanum*)

Importance

The eastern tent caterpillar is primarily an aesthetic problem and has little adverse effect on the host trees. Species of the genus *Prunus* are preferred hosts, with black cherry being the primary, uncultivated host.

Identification

Full-grown larvae are between 2-2.5" in length. Caterpillars have black heads with long, light brown body hairs. The back has a light stripe, bordered on each side with yellowish-brown and black wavy lines. The sides are marked with blue and black spots. Moths have a wingspan of about 2-2.5" and are yellowish-brown, with two narrow, light lines across the front wings.

Identifying the Injury

The larvae construct a white web or tent in the crotch of a small branch. They consume the entire leaf, except the midrib.

Life History

Overwintering eggs hatch about the time black cherry buds open in the spring. Young larvae begin to construct a tent and enlarge the structure as they grow. Full-grown larvae construct tough, silken cocoons. Moths emerge in early summer and lay eggs in shiny, dark brown masses around small twigs or branches of host trees.

Management

Control is not normally necessary. Defoliated trees usually refoliate after being attacked. Insecticides can be used to protect fruit trees, or tents containing caterpillars may be picked off and destroyed.

Elm Leaf Beetle (*Pyrrhalta luteola*)

Importance

The elm leaf beetle attacks all species of elm. However, in most of its range, the beetle prefers the Siberian elm. When defoliation is severe for several consecutive years, limbs and sometimes the tree may be killed. The beetles may become a nuisance in the fall when they move into homes searching for overwintering sites. The adults may be a problem in spring when they congregate in windows as temperatures increase.

Identification

The larvae are green to yellow, with a black head and two black stripes on the back. Pupae are about 1/4" long and bright orange-yellow. The adults are approximately 1/4" long and yellowish to green with a black stripe on each wing margin.

Identify the Injury

Adults chew holes in leaves, particularly new growth. The larvae feed on the under surfaces of leaves, leaving the upper surfaces and the veins intact. Leaves shrivel and turn brown when damage is severe.

Life History

In the spring, the adults fly to elms and eat small holes in the newly developing leaves. Eggs are laid in a cluster on the undersides of leaves. The eggs hatch and the larvae feed for 2-4 weeks. The larvae crawl to sheltered places on the tree or ground to pupate. In one to two weeks new adults emerge and again feed and lay eggs. There are two to four generations per year, depending on location.

Management

No chemical controls are recommended in forest stands. Shade trees may be protected by using insecticides. Sprays should be directed at the undersides of the leaves beginning in early spring.

Elm Spanworm (*Ennomos subsignarius*)

Importance

The preferred hosts of elm spanworm are red and white oaks and a few other hardwood species, especially hickory, pecan and related trees. This is a destructive forest pest, particularly in the southern Appalachians, where widespread severe outbreaks have occurred. Repeated defoliation can cause growth loss, dieback, reduction in mastcrops and even mortality.

Identification

Larvae are slate gray to brownish black with yellowish body markings (yellow or green at low population densities) and 40 to 50 mm long. The adults are snow white moths. The small, barrel-shaped, olive green eggs are laid in masses on the underside of small branches in the Southeast. To the north, they are found more commonly on the bole.

Identifying the Injury

Young larvae feed on the edge and undersides of leaves, causing a shothole appearance at low population levels. When populations are high, they consume the entire leaf, except the main veins, giving a feathered appearance to the tree.

Life History

Overwintering eggs hatch in early spring when the buds break, usually in late April. The larvae feed for 4-6 weeks and then pupate in net-like cocoons on the host tree or understory. Six to 10 days later, in late June or mid-July, the moths emerge and deposit their eggs. There is one generation per year.

Management

Insect parasites attack the eggs of the elm spanworm. Other natural enemies are also important in keeping infestations in check. Chemical controls may be needed to protect ornamental trees.

Fall Cankerworm (*Alsophila pometaria*)/Spring Cankerworm (*Paleacrita vernata*)

Importance

The fall and spring cankerworms defoliate a variety of hardwood species in the spring. Hosts include the red and white oak groups, maples, elms, hickories, ash and cherry. Heavy defoliation usually occurs in May and June, and can cause growth loss, mast reduction and if coupled with other stresses, may result in mortality. Their greatest impact is often felt in high public use areas where defoliation reduces the aesthetic value, and larvae and their droppings create a nuisance.

Identification

The wings of male moths are light gray to tan, with wavy lines, and span about 25-37 mm. Females are wingless. Mature larvae of the fall cankerworm are about 25 mm long and vary from light green to black, with light yellow lines on the sides and a dark dorsal stripe. Mature larvae of the spring cankerworm are 18-30 mm long and range in color from reddish to yellowish brown, yellowish green or black. The head is light and mottled with a yellow stripe along each side of the body. Coloring of both species varies with population density.

Identifying the Injury

Small holes in the leaves are early evidence of young larvae feeding on expanding foliage. Older larvae consume the entire leaf, except the midribs and major veins.

Life History

Fall cankerworm adults emerge in the fall following a hard freeze. They overwinter in the egg stage. The spring cankerworm adults emerge in February and March to lay their eggs. For both species, the eggs hatch at about the time of bud break and the young larvae begin feeding on the new foliage. Feeding continues for approximately 6 weeks after which the mature larvae enter the soil and pupate.

Management

The eggs and larvae are attacked by insect parasites and predators. Other natural enemies also help in control. Sticky bands places around tree trucks can trap females as they climb.

Fall Webworm (*Hyphantria cunea*)

Importance

The fall webworm is not considered an important tree pest. However, webs can seriously detract from aesthetic values. The preferred hosts are persimmon, pecan and sourwood.

Identification

The adult moth has a wingspan or 25 -30 mm and is snowy white, usually with dark spots in the wings. The larvae are 25-30 mm long and covered with silky hairs. The color varies from pale yellow to green with a black stripe on the back and a yellow stripe on each side. The pupae are found inside a gray cocoon constructed of silk, frass and debris. The eggs are small, yellow or light green and turn gray before hatching.

Identifying the Injury

Usually the first signs of attack are the large, silken web and skeletonized leaves. The silken web usually contains large numbers of caterpillars.

Life History

The moths emerge in the spring. After mating, females lay eggs in masses (400-500) on the undersides of host leaves. The eggs hatch in approximately 2 weeks and the larvae immediately begin to feed and construct webs. The enlarge the web as feeding continues for 4-8 weeks.

Then they spin a pupal cocoon in a sheltered place or in the duff or soil. There are at least two generations per year in the south.

Management

Biotic agents and unfavorable weather provide population control. Occasionally, chemical control may be necessary.

Forest Tent Caterpillar (*Malacosoma disstria*)

Importance

Outbreaks occur periodically on oaks, tupelo gum and other hardwoods over wide areas of the eastern half of North America. Growth loss and dieback occur, but trees are seldom killed unless they sustain 3 or more successive years of complete defoliation.

Identification

The larvae have pale bluish lines along the sides of a brownish body, and a row of key holes shaped white spots down the middle of the back. They are sparsely covered with whitish hairs and reach 50 mm at maturity. Adult moths are buff-brown with darker oblique bands on the wings. Egg masses of 100-350 eggs encircle the twigs and are covered with frothy, dark brown cement.

Identifying the Injury

The first noticeable signs of attack are sparse crowns and falling frass. Caterpillars often cluster on the lower trunks of infested trees. Single trees of complete stands may be completely defoliated during the spring.

Life History

Eggs hatch in early spring. Caterpillars feed for 4-6 weeks on the opening buds, foliage and flowers. Despite its name, this species does not form tents. Pupation occurs in yellowish cocoons and last 10-14 days. Moths emerge from late May to July, mate and deposit their eggs. There is one generation per year.

Management

Natural control agents include insect parasites of eggs. larvae and pupae. Predators, viruses, fungal diseases as well as environmental factors result in caterpillar mortality. Starvation is common when populations exceed the food supply. Several insecticides and a microbial agent are registered for control.

Gypsy Moth (*Lymantria dispar*)

Importance

The gypsy moth, which came from France, is considered one of the most important pests of red and white oaks in the Northeast. It has spread southward into Virginia and is continuing to move. Favored host species include oak, apple, alder, basswood, birch, poplar, sweetgum, willow and hawthorn. Less favored are hickory, maple, cherry, cottonwood, elm, blackgum, larch, sassafras and hornbean. Some mortality even occurs in white pine. It causes widespread defoliation, resulting in reduced growth, loss of vigor, mortality and reduces aesthetic, recreational and wildlife values. Gypsy moth larvae can be a serious nuisance in urban and recreational areas.

Identification

Older larvae are brownish-gray, with tufts of hair on each segment and a double row of five pairs of blue spots, followed by six pairs of red spots on the back. Mature larvae are from 40-60 mm long. Adult male moths are dark brown with wavy dark bands across the forewings. Females are white and cannot fly.

Identifying the Injury

Young larvae chew small holes in leaves. Older larvae feed on leaf edges, consuming entire leaves except for the larger veins and midribs. The entire tree is often defoliated.

Life History

Larvae emerge in late April or early May from overwintering eggs and feed through June and into early July. Pupation occurs in sheltered places and lasts 2 weeks. Adults emerge in July and August. Females deposit egg masses (100-800) covered with buff-colored hairs, under rocks and on tree trunks, limb, houses, picnic tables, trailers, campers, mobile homes, cars and other sheltered places.

Management

Natural controls, including introduced insect parasites and predators, viral diseases and adverse weather conditions, help control gypsy moth. Chemical and microbial insecticides have been used, primarily in urban ad recreation areas, to prevent defoliation and the nuisance effect of the pest.

Damage during summer months

Locust Leafminer (*Odontata dorsalis*)

Importance

Outbreaks of the locust leafminer are generally more spectacular than destructive. In combination with other stress factors, infestations can contribute to growth loss and even mortality. The major hosts are black locust and honeylocust. Other tree species (apple, birch, cherry, elm, oak and hawthorn) are occasionally attacked.

Identification

The adult is a small, elongated, flattish beetle about 5-6 mm long. The head is black and the thorax and most of the wing covers are orange. The full-grown larvae are yellowish, flat and slightly larger than adults.

Identifying the Injury

Adults skeletonize and eat holes in the leaves, whereas larvae mine the leaves (the latter damage is more destructive). When outbreaks occur, tree stands turn gray or brown.

Life History

Adults overwinter in bark crevices or in the leaf litter and emerge about the time leaves begin to unfold in the spring. Eggs are deposited on the undersides of locust leaflets. They overlap like

shingles in groups of three to five and are cemented together. Upon hatching, the larvae first feed collectively in a common, blisterlike mine. Then, the larvae disperse, excavating their own individual mines. Pupation occurs within the translucent blisters in July. There are two generations annually.

Management

Control of the locust leafminer is generally not necessary.

Orangestriped Oakworm (*Anisota senatoria*), Pinkstriped Oakworm (*Anisota virginiensis*), Spiny Oakworm (*Anisota stigma*)

Importance

These oakworms occur throughout the eastern United States. They are voracious feeders and where abundant, quickly strip the trees of their foliage. Since defoliation takes place in late summer to fall, however, forest stands of white and red oak are generally able to survive with only minimal growth loss or crown dieback. The greatest damage is the aesthetic impact and nuisance the caterpillars create in urban areas.

Identification

The larvae of the orange striped oakworm are black with eight narrow yellow stripes, the pinkstriped oakworm larvae are greenish brown with four pink stripes and the spiny oakworm larvae are tawny and pinkish with short spines. Larvae are about 50 mm long and have a pair of long, curved "horns." The adult moths are a similar yellowish red with a single white dot on each

Orangestriped

Pinkstriped

Spiny

of the forewings.

Identifying the Injury

Young larvae feed in groups, skeletonizing the leaf. Later they usually defoliate all but the main veins and usually defoliate one branch before moving on to another. Older larvae are less gregarious and can be found crawling on lawns and the sides of houses.

Life History

Adult moths appear in June and July and deposit clusters of several hundred eggs on the underside of leaves. The eggs hatch within a week and the larvae feed during July through September. The pupae overwinter in the soil. The orangestriped and spiny oakworms have only one generation per year, while the pinkstriped oakworm has two generations.

Management

Natural enemies generally prevent widespread defoliation. Chemical control may be needed for ornamental trees.

Poplar Tentmaker (*Clostera inclusa*)

Importance

The poplar tentmaker occurs from New England to Georgia and Colorado. Endemic populations may defoliate small groups of poplar and willow, especially trees growing in the open. Epidemic populations may completely defoliate large cottonwood stands. Complete defoliation twice during the same growing season will result in growth loss, crown dieback and in some cases, tree mortality

Identification

Full grown larvae are light brown to nearly black and up to 42 mm long. They have four light yellow lines in the back and a bright yellow and several indistinct lines on each side. Adults are bownish gray with three whitish lines crossing each forewing. The hindwings are crossed by a wavy band.

Identifying the injury

Newly emerged larvae skeletonize the leaf; older larvae devour all except the leaf stalk. Severe defoliation occurs during summer and early fall. Many one or two-leaf webbed tents hang from the branches.

Life History

Moths appear from March through September and lay cream to pink colored eggs in clusters of 150-300 on the leaves. The larvae are gregarious and live in tents or webs constructed by pulling together the edges of one or more leaves and lining them with silk. They feed from May through October and pupate in loose cocoons. There are four generations per year in the South.

Management

Natural controls include parasites of the egg and larvae. Predators and virus and fungal diseases also kill the poplar tentmaker. Chemical control may be necessary.

Slug Oak Sawfly (*Caliroa quercuscoccinae*)

Importance

The slug oakfly is usually an endemic pest of red and white oaks. This pest has been reported from Massachusetts through North Carolina, Kentucky and Tennessee. Repeated defoliation reduce growth, vigor, mast crops and kill some trees.

Identification

Larvae are sluglike, yellowish green and shiny with black heads and thoracic legs. They are 12 mm long and feed in groups. The adult is a typical sawfly about 6 mm long and light brown.

Identifying the Injury

Leaves are skeletonized. Larvae consume the lower surfaces of the leaves, making the leaf transparent and revealing a fine network of veins. Defoliation starts in the upper crown in early summer and progresses downward. By late summer, heavily infested trees may be completely defoliated or have a light red appearance.

Life History

Larvae overwinter in cocoons and pupate in the spring. Adults and larvae are present throughout the summer. Eggs are deposited in single rows of slits on the lower leaf surface along main veins. There are two to three generations per year.

Management

Microbial diseases, parasites and other natural enemies generally keep the slug oakfly under control. Insecticides may be needed on high value shade and ornamental trees.

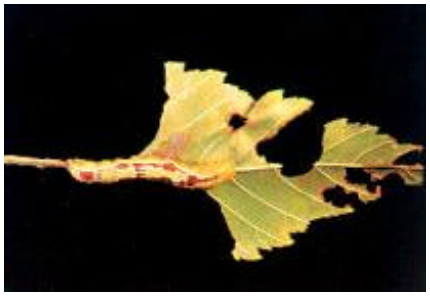
Variable Oakleaf Caterpillar (*Heterocampa manteo*)

Importance

This defoliator is common throughout eastern North America. It attacks a wide variety of hardwoods including all species of oaks, but prefers the white oak. Some infestations have covered millions of acres, retarding tree growth and reducing vigor. Outbreaks occur periodically and usually subside after 2-3 years, before serious tree mortality occurs.

Identification

The larval color is variable, but is generally yellowish green with a narrow white stripe down the center of the back, and one or two yellowish stripes on the sides. The head is amber, with one dark and one light band on each side. Mature larvae may reach 37 mm in length. The adult moth is ashy gray with three dark wavy lines across each forewing. The wingspan is approximately 37 mm.



Identifying the Injury

Young larvae skeletonize the leaf, while older larvae consume the entire leaf except the leaf stalks and main veins. There are two periods of defoliation-early May to late June and mid-August to late September.

Life History

There are tow generation in the south and one generation in the north. In the south, the larvae feed from early May until late June and pupate in the soil. Second generation larvae feed from mid-August until late September, then move to the ground to spin cocoons and over winter. Adult moths emerge from cocoons by early spring.

Management- Insect parasites and predators destroy eggs, larvae and pupae. Winter mortality also helps to keep population levels at a minimum. Chemical control is occasionally needed to protect high value ornamentals.

Walkingstick (*Diapheromera femorata*)

Importance

The walkingstick attacks oaks and other hardwoods. In the South, severe outbreaks have occurred in Arkansas and Oklahoma. Branches are killed or die back in heavily defoliated stands, but continuous defoliation for several years can result in mortality. The insects create a nuisance in high use areas.

Identification

Nymphs and adults are slender and have long thin legs and antennae. While motionless, they closely resemble their surroundings. Adults are about 60-75 mm long and their body color varies from brown to green and may even be multicolored.

Identifying the Injury

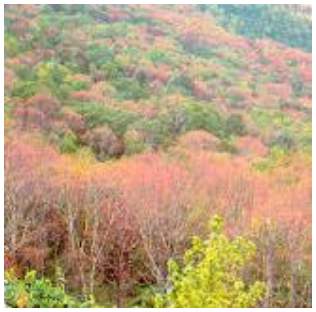
The entire leaf blade, except the base of the stout veins, is eaten. During heavy infestations, large stands are often completed defoliated. Because the walkingstick does not fly, infestations tend to be localized and spread only a few hundred yards.

Life History

Overwintering eggs in leaf litter hatch in May or June. Nymphs become adults during the summer and fall. Females deposit up to 150 eggs, which are randomly dropped to the forest floor. There is one generation per year in the South, while 2 years are required farther North.

Management

Natural enemies, particularly birds, are often effective. Chemical control may be used in recreation sites.



Walking Stick Damage

Walnut Caterpillar (*Datana integerrima*)

Importance

The walnut caterpillar feeds only on black walnut, pecan, hickory and butternut. Defoliation may weaken the tree and make it susceptible to damage by wood borers. Tree mortality is rare, but may occur after 2 years of heavy defoliation.

Identification

Eggs are spherical and pale green with white caps. They are laid in clusters of 120-800 on the underside of leaves. All larvae have black heads. Newly hatched larvae are light green and change to reddish brown with white stripes. Fully grown larvae are nearly black with white hairs. They are 25-50 mm long. Pupae are 20 mm long and shiny, dark, reddish brown. The wing-span of moths is about 45 mm. The front wings are dark tan with four rust colored lines. The hind wings are light tan.

Identifying the Injury

Young larvae skeletonize the upper leaf surface. As they grow, they feed on the entire leaf except the petiole. Individual branches, entire trees or groups of trees may be completely defoliated.

Life History

Moths emerge in May and lay eggs. Eggs hatch in 8-10 days, and larvae feed until mature and pupate in the soil. Adults emerge in July and begin the second generation, which is the largest and most destructive. Larvae cluster together on tree branches or trunks and molt simultaneously, leaving a large mass of hairy cast skins adhering to the bark.

Management

Parasites, predators and diseases are major factors influencing population levels. Cultural control include: clipping foliage to destroy egg masses and larvae, removing clustered larvae as they gather to molt and destroying pupae by shallowly disking the soil after larvae have pupated. Chemical control is usually not necessary because tree mortality is rare.

Whitemarked Tussock Moth (*Hemerocampa leucostigma*)

Importance

The whitemarked tussock moth occasionally occurs in epidemic numbers and heavily defoliates several species of hardwood including live oak, water oak, red oak and white oak. It is not

considered a serious forest pest. However, it causes considerable damage to shade and ornamental trees. Trees are seldom killed, but growth loss does occur. Larvae often create a nuisance in urban and recreation areas due to dropping frass, allergenic hairs and migratory habits.

Identification

The larva is 25-40 mm long. It has a bright red head with a yellowish body, a pair of upright pencil tufts of black hairs on the prothroax and four white to yellowish brush-like tufts of hair on the back toward the head. The adult male moth is gray brown, with darker wavy bands and a white spot. The female is wingless and whitish gray.

Identifying the Injury

Young larvae chew small holes in leaves. Older larvae feed on leaf edges, consuming entire leaves, except for larger veins and midribs. Entire trees may be defoliated.

Life History

Overwintering occurs in the egg stage. Eggs are laid in small, white masses and hatch in early spring. Larvae feed until they pupate in May or June. Pupation occurs in a cocoon and adults emerge in about 2 weeks. Adults live 2-4 weeks. In the South there may be as many as three generations per year. The female adult emerges from a beige cocoon and mates, laying her eggs in a mass on her cocoon.

Management

Parasites, predators, microbial diseases, starvation and unfavorable weather normally bring epidemics under control. Control is not necessary in forest stands. In urban and recreational areas, insecticides may be used to avoid defoliation.

Yellownecked caterpillar (*Datana ministra*)

Importance

This caterpillar is a defoliator of oaks and many other hardwoods throughout the United States. Infestations have been most common in the Appalachian and Ozark Mountains and their foothills. Damage is more severe among shade and ornamental trees than forest stands.

Identification

The larvae are yellowish, black striped and moderately covered with fine, white hairs. The head is jet black. The segment behind the head is bright orange-yellow. Full grown, larvae are about

50 mm long. When disturbed, the larvae lift their heads and tails in a distinct U shape. This is a defensive measure to prevent parasitism by various wasps and flies.

Identifying the Injury

Newly hatched larvae skeletonize the leaf, older larvae consume the entire leaf except the stalk. Individual trees or even stand may be defoliated during late summer and early fall. Since defoliation is confined to the late part of the growing season, little damage is caused to the tree.

Life History

Moths appear during June and July and deposit white eggs in masses of 50-100 beneath leaves. Larvae feed in groups, maturing in August and September, Mature larvae drop to the soil and pupate at a depth of 50-100 mm, where they spend the winter. There is one generation per year.

Management

Natural enemies generally keep infestations under control. Chemical controls may be occasionally needed.

c. Bark Beetles and Borers

(1) Conifer Infesting Insects

Ambrosia Beetles (*Platypus* spp.)

Importance

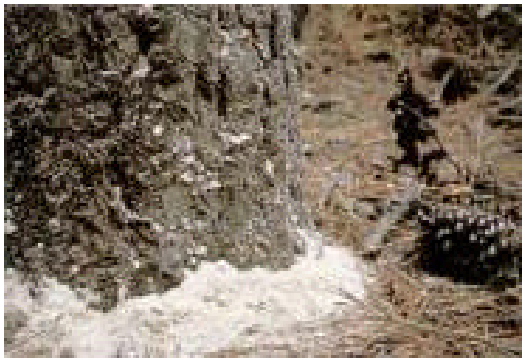
Ambrosia beetles of the genus Platypus attack most species of pine and hardwood trees. They severely infest weakened and dying trees, green logs and unseasoned lumber. Trees cut during the summer and left unmilled for more than 2 weeks are often severely damaged. This is especially true of gum, cypress and oak trees.

Identification

The adult beetles are elongate, dark reddish brown, about 6 mm long and usually have sharp spines at the rear.

Identifying the Injury

In pines, large piles of a fine white granular dust accumulate below entrance holes or at the base of standing trees. In lumber, the galleries are darkly stained.



Life History

The adults and larvae do not feed on the wood but on a fungus the beetles carry into the tree and culture in galleries. The adults bore into sapwood or heartwood, making pinsized holes which are stained by fungus. The females lay eggs in small clusters in the tunnel and the developing larvae excavate tiny cells extending from the tunnel parallel to the grain of wood. There may be several generations per year. Timber is not attacked unless the moisture content of the wood is at least 48%. Seasoned lumber is never infested

Management

No chemical controls are recommended under forest conditions. Rapid utilization of cut timber and fast drying of lumber will prevent damage.

Black Turpentine Beetle (*Dendroctonus terebrans*)

Importance

The black turpentine beetle is found from New Hampshire south to Florida and from West Virginia to Texas. Attacks have been observed on all pines native to the South. This beetle is most serious in urban areas.

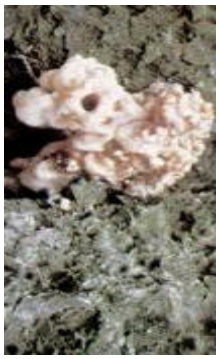
Identification

The insect is dark brown to black in color and 10 mm in length. The posterior is rounded. Full grown larvae are white with a reddish brown head and about 8 mm long. Pupae are about 6 mm long and yellowish white.

Larvae

Identifying the Injury

Black turpentine beetles attack fresh stumps and the lower trunk of living pines. Initial attacks are generally within 60 mm from the ground. Attacks are identified by white to reddish-brown pitch tubes about the size of a half dollar. The pitch tubes are located in bark crevices on the lower tree bole, usually below a height of 3 meters. Infested pines are often attacked by other bark beetles.



Life History

Adult beetles bore into the cambium and construct galleries which usually extend downward. Eggs are laid in clusters and hatch in 10-14 days. Larvae feed side by side, excavating a large continuous areas. The life cycle takes from 2.5-4 months, depending on the season. There are two to four generations per year.

Management

Natural enemies and good tree vigor generally keep black turpentine beetle populations at low levels. Newly attacked trees can often be saved by spraying the base to the highest pitch tube on the trunk with an approved insecticide. The prompt removal of infested trees also helps to control outbreaks. Forest management practices which promote tre vigor and minimize root and trunk damage help prevent infestations.

Ips Engraver Beetles (*Ips avulsus, I. grandicollis, I. calligraphus*)

Importance

Ips beetles usually attack injured, dying or recently felled trees and fresh logging debris. Infestations are particularly common in trees weakened by drought or lightening strikes.

Identification

Adult beetles are red-brown to almost black and 3-5 mm long. They are distinguished from other bark beetles by their scooped out posterior with 4-6 spins on each side.

Larvae have white bodies with orange-brown heads and are legless. Pupae are waxy-white and similar to adults in size.

Identifying the Injury

The first signs of attack are reddish-brown boring dust in bark crevices or reddish-brown pitch tubes about the size of a dime on bark surfaces. If the bark is removed, there are Y-or H-shaped egg galleries with short larval galleries extending perpendicular to them. egg galleries will usually be free of boring dust. The foliage of Ips-killed pines will eventually turn yellow and then red about the time the beetles complete development under the bark. Often only the top portion of the crown is killed, leaving lower branches green. Blue-stain fungi, introduced when the beetles attack the tree, is visible in the sapwood and hasten the death of the trees.

Life History

The female constructs an egg gallery and lays her eggs beneath the bark of attacked trees. The larvae make individual feeding galleries in the inner bark and pupate at the end of their galleries. New adults emerge after 21-40 days during the summer or after several months during the winter.

Management

The best control is prompt removal and utilization of actively infested trees, making sure that the bark and slabs are destroyed. Insect parasites, predators and weather conditions provide controls. Chemical control is seldom warranted under forest conditions, but may be used to protect pines in urban or high value areas. Preventive control practices include minimizing logging damage to residual stands and quick removal of felled trees.

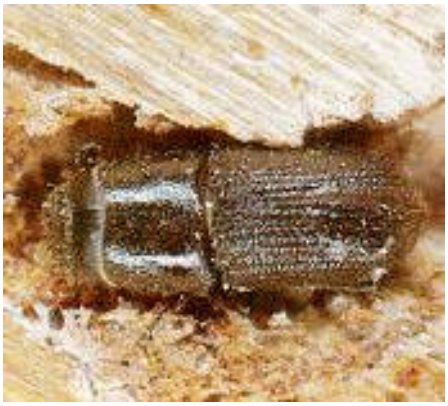
Southern Pine Beetle (*Dendroctonus frontalis)*

Importance

The southern pine beetle is one of the most destructive pests of pine in the southern United States. The beetle occurs from Pennsylvania to Texas, New Mexico and Arizona. It attacks and can kill all species of pines but prefers loblolly, shortleaf, Virginia, pond and pitch pines.

Identification

The adult is short legged, about 3 mm long and dark reddish brown to black in color. The front of its head is notched and the hind end of its body rounded.



Identifying the Injury

The adults bore directly through the outer bark into the living tissue. At each point of attack, the tree usually exuded resin which forms a small pitch tube about the size of a small piece of popped popcorn. Adult beetles construct winding, S-shaped galleries, which cut across one another and girdle the tree. Blue-stain fungi in the sapwood, introduced by the beetles, hasten the death of the tree. The first indication of tree mortality is discoloration of the foliage. Needles become yellowish, change to a red color and finally turn brown. Trees may be killed singly or in groups, ranging from a few trees to several hundred acres.

Life History

Adults construct winding galleries inside the bark, where eggs are deposited in individual niches on each side of the gallery. The eggs hatch into small larvae within 4-9 days. The larvae mine for a short distance before boring into the outer bark where they pupate. One life cycle may be completed i about 30 days. There are from 3-7 generations per year

Management

Diseases, parasites, predators and weather help maintain beetle populations at low levels and bring cyclic outbreaks under control. IPM may be achieved through any one or al of the following suppression techniques; rapid salvage and utilization of infested trees, pilling and burning of infested materials, chemical control in high value resources. Good forest management is the most effective method of preventing losses.

(2) Hardwood Infesting Insects

Carpenterworm (*Prinonxystus robiniae*)

Importance

In eastern and southern states, oaks are the most heavily damaged. Other hosts include green ash, black locust, elm, maple, willow, cottonwood and sometimes fruit trees and ornamental shrubs. The damage (wormholes) causes unsightly scars on ornamentals.

Identification

Newly hatched larvae are 6 mm long and reddish pink. They gradually become greenish white and are 50-75 mm long at maturity. Brown pupal skins protruding from entrance holes are common in early summer. Adults are grayish, stout bodies moths. The hindwing in the male has an orange spot.

Identifying the Injury

Earliest signs of attack are sap spots on the trunk. Later, frass is ejected from entrance holes. Burrows 50 mm in diameter under the bark, and galleries 12 mm in diameter and 12-22 cm long in the wood are typical. Galleries are open or loosely plugged with frass. Holes in lumber are dark stained.

Life History

Adult moths appear in April to June and deposit 400-800 eggs in bark crevices. Eggs hatch in 10-12 days and young larvae tunnel into the bark and wood. Pupation occurs within the gallery during spring and lasts 3 weeks. A life cycle requires 1-2 years in the South and 2-4 years in the North.

Management

Management practices such as maintaining high tree vigor, removing brood trees, preventing bark injuries and using insecticides when necessary help to minimize damage.

Cottonwood Borer (*Plectrodera scalator*)

Importance

The cottonwood borer ranges throughout the eastern United States, but highest populations and greatest damage occur in the South. It attacks cottonwood and willow. Trees weakened by severe infestations may be broken off by the wind.

Identification

Adult beetles are 25-40 mm long and about 12 mm wide. They are black with lines of cream-colored hair forming irregular black patches. Larvae are seldom seen.

Identifying the Injury

The adults may cause serious damage in cottonwood by feeding on tender shoots of young trees, causing them to shrivel and break off. The larvae bore into the inner bark and wood at the root collar and tunnel downward into the roots. Light brown, fibrous frass is sometimes ejected from bark openings at or slightly above the ground line, accumulating in piles at the base of the tree. The root collar and roots of infested trees may be riddles by larval tunnels.

Life History

The adults appear in midsummer. After feeding briefly, they descend to the bases of host trees where the female deposits her eggs in small pits gnawed in the bark. Eggs hatch in 16-18 days. The larvae bore downward in the inner bark, entering a large root by autumn. Pupation occurs in the gallery from April to June and lasts about 3 weeks. The new adults chew exit holes through the sides of the pupal chambers and emerge through the soil. Some larvae complete development in 1 year, while others require 2 years.

Management

Planting unifested cuttings, removing and destroying infested rootstock to minimize damage. Application of insecticide at the proper time (soon after emergence) also offer adequate control.

Cottonwood Twig Borer (*Gypsonoma haimbachiana*)

Importance

The cottonwood twig borer is widely distributed throughout the eastern United States. It is one of the most destructive insects of young cottonwood. Terminal shoot injuries cause serious stunting, forks, crooks, and other malformations. This leads to a reduction in the quality and quantity of lumber.

Identification

The adult is ash gray and has a wingspan of 13-17 mm). The basal portion of the forewing is darker than the apical. Full grown larvae are pale, with a brown-yellow head. They are from 10-13 mm long.

Identifying the Injury

Larvae bore into the terminals and branch ends of the host. They frequently kill the bud and up to 25 cm of the terminal. Often the old dead terminal remains intact on the tree for several months after the larvae have emerged. A stunted, deformed tree is a good indication of cottonwood twig borer damage.

Life History

The female moth lays eggs of the upper surface of leaves along the midrib, alone or in groups of two-eight. Hatching occurs in about 5 days. The young larvae cover themselves with silk mixed with debris, then bore into the midrib. After about 3 days, the larvae abandon their midrib galleries and move to tender shoots where they tunnel in an complete their larval development. Larvae reach maturity in about 23 days and move down the trunk, where they spin cocoons in sheltered bark crevices or litter or between leaf folds. Adult moths emerge in about 9 days. It takes from 40-45 days to complete the life cycle in summer.

Management

The most effective natural control is a potter wasp, which opens the cottonwood shoots and removed twig borer larvae from their galleries. Other wasps also parasitize twig borer larvae. Direct control can obtained through the use of soil-applied systemic insecticides.

Hickory Bark Beetle (*Scolytus quadrispinosus*)

Importance

The hickory bark beetle is reported to be the most serious pest of hickory in the United States. Several states have reported instances where thousands of trees were killed. Pecan and butternut are also hosts.

Identification

The adult is short, stout, black almost hairless and 5 mm long. The ventral side of the posterior is concave and has spines. The larvae are typically white or cream-colored, legless grubs, about the same size as the adults.

Injury Caused by Hickory Bark Beetle

Identifying the Injury

Dying leaves and twigs and trees with red foliage are the first evidence of attack. Short, vertical egg galleries with radiating larval galleries etched in the sapwood are good indicators of damage.

Life History

Adults appear in early summer and feed for a short time at the bases of leaf petioles and on twigs before attacking the trunks. Twenty to 60 eggs are deposited in egg galleries in the phloem. When nearly full grown, the larvae gradually angle away from the adult gallery. Before reaching maturity, they leave the phloem to pupate in the bark. Winter is spent in the larval stage and pupation occurs in the spring. There are usually two generations per year in warmer climates.

Management

Control practices include felling infested trees over large areas and destroying the bark during winter months. Chemicals may also be used,

Locust Borer (*Megacyllene robiniae*)

Importance

This is the most serious insect pest of black locust. It provides infection courts for the fungus, *Fomes rimosus*, which causes substantial defect, growth loss and some mortality. The only host is black locust.

Identification

The adult is a colorful longhorned beetle, often seen feeding on goldenrod in late summer and early fall. It has bright yellow bands expanding across a jet black thorax and wing covers and the third band on the wings forms a "W" design. Legs are yellow-orange and long. Full-grown, larvae are large, pale and about 25 mm long.

Identifying the Injury

The first sign of attack occurs in the spring, around the time of bud burst. Oozing sap at the point where the larva bores into the tree causes a wet spot on the bark. Eventually, the larva begins to tunnel into the wood, pushing granular frass out of the entry hole. Wood infested by locust borers can be virtually "honeycombed" by the larvae. Sometimes stems are so weakened that they become wind broken.

Life History

Eggs are deposited in rough bark surfaces and around wound of living trees. Newly hatched larvae excavate a small hibernating cell in the inner bark and overwinter. In the spring, they bore into the wood, enlarging the tunnel to the exterior. About mid-July, they emerge at the original attack point. There is one generation annually.

Management

Since the heaviest attack occur in stressed trees, most preventive recommendations are designed to encourage or maintain health and vigor. This includes planting superior trees, avoiding pure locust stands and removing low vigor and overmature trees.

Red Oak Borer (*Enaphalodes rufulus*)

Importance

This is a major pest of red oaks. Valuable shade trees in parks and urban areas are sometimes attacked, but rarely destroyed.

Identification

Adult borers are longhorned beetles. Their antennae are very long, almost doubling their 25 mm body length. Their rust brown color blends well with bark surfaces and they are rarely observed. The pale, robust larvae have very small legs of the thorax.

Identifying the Injury

The first signs of attack resemble the fine frass produced by ambrosia beetles. As the larvae bore into the tree, sap begins to extrude from the hole. Within the tree, tunnel diameters gradually increase from pinhole size to about 12 mm as larvae grow. Tunnels are 15-25 cm long and are often accompanied by discolored and decaying wood. They are usually within 15 cm of the pith.

Life History

The red oak borer has a 2 year life cycle. Eggs are laid in mid-summer in roughened areas or near wounds and larvae tunnel under the bark for the first year. In the second year, the more damaging wood tunneling occurs. Prior to pupation, the larvae chew round exit holes through which they later emerge as adults.

Management

Removal of brood trees significantly reduces the pest population. Measures aimed at encouraging stand vigor will discourage attack. Infested, shade trees and ornamentals may be treated with insecticides.

Smaller European Elm Beetle (*Scolytus multistriatus*)

Importance

This beetle is the prime vector of the Dutch Elm disease fungus which has destroyed millions of American elms since its introduction into the United States. The beetle attacks all native and introduced species of elm.

Identification

Adults are reddish-brown beetles about 3 mm long. The ventral posterior area or the body is concave and displays a prominent spine. The larvae are typically white or cream-colored, legless grubs, about the same size as the adults.

Identifying the Injury

Beetles excavate a 25-50 mm straight egg gallery parallel with the wood grain. Larval mines are roughly perpendicular to the egg gallery. The result is a design resembling a long-legged centipede on the inner bark and wood surface.

Life History

Smaller European elm bark beetles overwinter as larvae under the bark and develop into adults in the spring, emerging after the leaves expand. Adults feed at twig crotches of healthy elms, infecting the tree with Dutch elm disease. Then they fly on to other elms to breed. These attacked trees have usually been weakened by drought, disease or other stress factors. After boring through the bark, the beetles excavate their egg galleries, grooving the inner bark and wood surface in the process. When larvae are full-grown, they construct pupal cells at the end of their larval mines. New adults emerge by boring directly through the bark, leaving it peppered with tiny holes. There are two generations annually.

Management

The most effective method of reducing losses is through removal of dead and dying elms and the pruning of dead and dying limbs. Several chemical insecticides may be applied as preventive sprays or to kill beetles before they spread to unifested trees.

d. Piercing and Sucking Insects

(1) Conifer/Hardwood

Aphids

Importance

Aphids infest hardwoods and conifers throughout the United States. They may be found almost anywhere on a tree, particularly on new growth. Heavy infestations distort foliage, cause terminal dieback, reduce tree vitality, weaken the tree and cause branch and crown dieback. In young trees and seedlings, mortality can occur from heavy infestations. Aphids are usually of greatest concern in nurseries, seed orchards and shade and ornamental trees. Honey dew and sooty mold, associated with aphids, often reduce the aesthetic value of these plants.

Identification

Aphids vary in body covering and range in size from 0.5-6 mm long. However, they are all soft-bodied insects. Most aphids are pear-shaped, with a pair of cornicles at the posterior of the abdomen. They may be transparent, yellow, green, pink, brown, almost black or spotted. Some may be covered with a white woolly wax. Some are winged.

Identifying the Injury

Aphids feed on various parts of a tree. Some feed on the underside of leaves, causing stunting, curls, and folds in the leaves. Other symptoms include: leaf discoloration, dieback or "flagging" of newly formed terminals, branch ends, and new leaves, early leaf drop and ringlike swellings or knots at nodes and buds. Trees with poor vigor or with branch and crown dieback should be examined closely for aphids. Sooty mold and ants frequenting a tree are good indicators of an active or recent aphid infestation.

Life History

Overwintering can occur in any life stage, but the most common is the adult or egg. Eggs hatch and live births usually occur in the spring, and nymphs begin feeding on selected parts of the plant. Some aphids migrate as nymphs; others spend their life in one place. Some aphids have only one generation per year; other aphids have several. Some aphids require alternate hosts in alternate generations.

Management

Parasites and predators (ladybugs, lacewings and flower flies) are effective in controlling aphid outbreaks and maintaining low populations. However, insecticides are often used to protect high value trees and are most effective against the nymphs.

(2) Hardwood Infesting Insects

Lace Bugs (*Corythucha* spp.)

Importance-

Adults and nymphs of lace bugs feed on the leaves of many species of hardwoods. Some of the more common species affected are sycamore, oak, elm, hackberry and basswood. By the end of August, leaves attacked by these insects may be discolored and fall from the tree.

Identification

Nymphs are usually dark colored and covered with spines. Adults have broad, transparent, lace-like wingcovers. They are flattened and about 6 mm long. Some species are beautifully colored.

Identifying the Injury

Infested leaves have chlorotic flecks or tiny chlorotic spots on top. Heavily infested trees may be partially or fully defoliated, especially during dry weather.

Life History

Adults overwinter in bark crevices and similar protected areas of their host. The adults become active during the spring and lay eggs on the underside of leaves. After the eggs hatch, the nymphs begin feeding by inserting their mouthparts into leaf tissue and sucking the plant juices. A complete life cycle may take 30-45 days; several generations may occur each year.

Management

Natural enemies are usually effective in maintaining populations at low levels and bringing outbreaks under control. Chemical controls are usually only used on shade and ornamental trees.

Scales

Importance

Many different types of scales effect hardwood and conifers throughout the United States. A large scale population may reduce growth, weaken the tree and cause branch or crown dieback. Scales are usually of greatest concern on ornamental trees.

Identification

Scale insects vary in shape and form. There are softbodied, hardbodies or armored scales. They may resemble a small turtle or oyster shell or even part of the bark of a tree. Some scales are white and very obvious; others dull and perfectly match their host's color. They can range from 0.5-7 mm in length. Scale insects may be found in any part of the tree.

Identifying the Injury

Trees with poor vigor or with branch and crown dieback should be examined closely for scales. Scale feeding may cause some abnormal plant growth at the point of attack, such as stunting of leaf or shoot growth, leaves turning yellow or red and branch gouting. Other symptoms include early leaf drop or dieback or newly formed terminals and branch ends. Ringlike swellings or pits in the bark cause a rough appearance. Heavy infestations will kill trees. Sooty mold and ants frequenting a tree are good indicators of scale infestations.

Life History

Eggs are usually produces underneath the female scale in the spring. The eggs hatch and the nymphs seek feeding sites. Some nymphs migrate to different sites to overwinter; others complete their life in one place. Some scales have only one generation per years, others multiple generations.

Management

Parasites and predators are effective in controlling infestations. Insecticides are often used to protect ornamentals.

e. Meristem Feeders

(1) Conifer Infesting Insects

Nantucket Pine Tip Moth (*Rhyacionia frustrana*)

Importance

This bud and shoot borer occurs throughout the East and South. Most species of pines are attacked, except longleaf and eastern white pine. Greatest economic losses result from retarding growth and deforming the main stems of trees.

Identification

Young larvae are cream colored with black heads. Mature larvae are light brown to orange and about 9 mm long. The head,. body and appendages of the adult are covered with gray scales, while the forewings are covered with patches of brick-red and copper colored scales.

Adult

Larva

Identifying the Injury

Tip moths injure the growing shoots of young plants. Larvae bore into and feed on inner tissues of buds and shoots. Shoot injury occurs primarily during the first 5 years and decreases as crowns close.

Life History

This pest overwinters as a pupa, and adults emerge in late winter or early spring. Mating and egg laying occur shortly after emergence. Young larvae feed on needles and surfaces of new growth, while later instars move to shoot tips and begin boring into buds or stem tissues. Pupation occurs within damaged shoots. There are 2-5 generations per year.

Management

Control by insecticides is usually not recommended except for high value tress.

White Pine Weevil (*Pissodes strobi*)

Importance

The white pine weevil is the most serious insect pest of eastern white pine. Weevil larvae kill the last two years terminal growth and repeated attacks cause trees to become stunted and deformed. Trees up to 3 feet tall may be killed. The weevil also attacks Norway spruce and jack pine and to a lesser extent, pitch pine, red pine , Scots pine and red spruce.

Identification

Adult white pine weevils are brown beetles about 6 mm long. They have a long snout with antennae attached. White and tan spots of various sizes cover the body. The most conspicuous spots are toward the posterior of the wing covers. Full-grown larvae are legless grubs with reddish brown heads. They are about 12 mm long.

Identifying the Injury

In the spring, resin droplets ooze from feeding punctures on the terminal shoot, especially near the terminal bud. The most conspicuous sign of current infestation is a drooping of the terminal shoot caused by larval feeding. The terminal shoot dies and one or more branches in the uppermost live whorl will assume dominance. This gives the tree a forked, crooked or bushy form.

Life History

Adults overwinter in the litter beneath host trees and emerge in the spring to feed. females deposit eggs in small punctures in the bark. The young larvae bore downward, side by side in a ring. after feeding for 5-6 weeks, the larvae construct pupal chambers in the wood or pith of the terminal shoot, and cover themselves with shredded wood and bark. New adults leave the tree by late summer and do some feeding before overwintering. There is one generation per year.

Management

Control of the white pine weevil is difficult. It is possible to reduce damage by making conditions in a young stand unfavorable for egg laying. Pine grown under a canopy or hardwoods is relatively free of weevil damage. Under certain circumstances, insecticides may be used to protect the tree tops.

f. Common Arthropod Pests of Ornamental and Urban Trees

Introduction- Keeping trees healthy in an urban setting is often challenging. Urban surroundings, with compacted or disturbed soils, limited growing space, air pollution and human pressures are all important factors which must be considered.

Trees are valuable resources that require long-term care. Insects and diseases pose two of the most serious threat to tree health. The early diagnosis of problems before long-term injury occurs is a crucial step and can depend on the observation of several signs and symptoms at once or in sequence. For example, the conclusion that a particular insect is effecting a plant depends upon evidence of characteristic feeding activity, time of season the damage has occurred, observation of the pest itself and knowledge of the host/insect history.

The following provides information concerning common arthropod pests of urban/ornamental plants.

(1) Balsam Fir

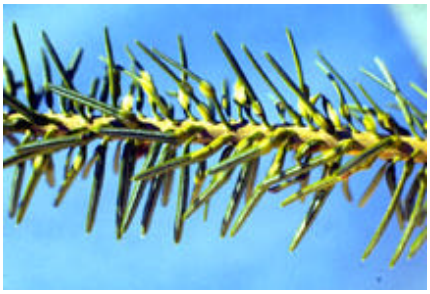
Balsam Gall Midge (*Paradiplosis tumifex*)

Hosts

Balsam and Fraser firs

Identification of Injury

Larvae initiate the formation of galls which appear as swollen oval growths about 3 mm in diameter at the base of needles mid-June. Galled needled turn yellow and begin to drop from the twigs in October.



Life History

There is one generation per year. The gall midge overwinters as a larva in the soil under an infested host tree. Pupation takes place in May and soon adult flies emerge, mat and lay eggs in developing needles. Newly-hatched larvae settle and feed on immature needles, initiating the almost immediate growth of gall tissue which encloses the larvae. In late fall, larvae leave the galls and drop to the ground for the winter.

Management

Outbreaks of balsam gall midge are likely to be episodic, lasting for only 2-3 years before returning to very low levels for the following several years. Significant reductions in gall midge

populations have been attributed to insect parasites. Where chemical control is warranted, treatments should be made when new shoots begin to flatten.

Balsam Shootboring Sawfly (*Pleroneura brunneicornis*)

Hosts

Balsam, Fraser and white fir

Identification of Injury

Larvae tunnel into the center of new shoots, causing the needles to turn red and die. Initially, the affected shoot has a flattened appearance and just the center turns red. As the shoot elongates, the dead tip becomes more obvious and looks much like frost damage. Unlike with frost, the dead tip is easily pulled off, revealing a white larva or hollowed out shoot. After the larvae leave the shoots (by mid-June) the affected part usually drops. Damage tends to be heaviest in even years.

Damage

Larva

Life History

The sawflies overwinter as either larvae or pupae in earthen cells in the soil. Adults, which emerge in early spring, lay eggs through the bud sheath before buds swell. Upon hatching, the young larva feeds toward the tip of the shoot in the needle cluster. Later, it burrows into the shoot and tunnels toward its base. When mature (7-8 weeks), the larva crawls out of the shoot, burrows into the ground and spins a thin cocoon. In more northerly regions, the insect may spend nearly two years in the cocoon.

Management

Keeping trees healthy and tightly sheared, where appropriate, will help minimize the damage caused by this insect. This pest is most prevalent in areas adjacent to native balsam fir stands

Balsam Twig Aphid (*Mindarus abietinus*)

Hosts

Balsam, Fraser, grand, Siberian, subalpine and white firs, Colorado and white spruce and juniper

Identification of Injury

Curling and twisting of needles, distortion of twigs and presence of aphid colonies covered with white waxy material. Infested tips may be sticky and shiny with honeydew or black with sooty mold. In early spring. look for tiny pale (milky) green wingless stem mothers often on needle undersides. In fall and winter, the tiny flattened black eggs covered with bits of whitish wax may be seen with a hand lens near buds.

Life History

The balsam twig aphid, like many aphids, has an unusual and complex life cycle, with five distinct stages. Twig aphids overwinter on twigs as eggs that hatch in late April or early May. First generation nymphs feed on needles near the buds, before developing into mature wingless stem mothers. These produce living young which feed on flushes or new needles. These individuals molt three times, producing and covering themselves with white waxy material after each molt. They become winged adults which can migrate to other trees. The winged forms produce the final form of aphid, males or egg-laying females. After mating, the females lay one or two eggs on the twigs.

Management

Natural enemies, such as lady beetles and syrphid flies, help control balsam twig aphid. Look for hatched aphids when buds show green just before budbreak to determine need for control. Application of insecticides can be made in the spring around budbreak.

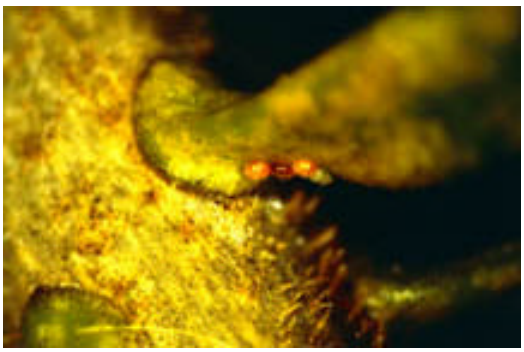
Spider Mites on Conifers (*Oligonychus ununguis*)

Hosts

Spruce, fir, juniper, pine, hemlock and others

Identification of Injury

Foliage may appear mottled, stippled, flecked or off-color. Conspicuous basal needle discoloration is often the first sign of a problem. Infested trees may appear brownish-gray and needle loss may occur. Look for mites, starting in May and continuing on a periodic basis, by sharply beating branches over white paper and examining the paper for reddish-brown mites. A hand lens will help you identify them. You may also be able to see eggs with a hand lens, which appear as tiny, shiny red or brown balls laid singly on the twigs and needles. In heavy infestation, webbing may also be conspicuous.



Life History

Winter is spent in the egg stage in needle axils, under webbing on stems or branches or under bud scales. Hatching occurs in the spring. Under optimum conditions, mites can complete their life cycle in ten days. Each adult lays 40-50 eggs and there can be several generations per year.

Management

Control is generally recommended if an average of 5-10 mites are found. If many eggs are found, a superior oil spray in early spring when the buds are still dormant (Hard and resinous) will provide control. Otherwise, spray with a registered insecticide in the spring and/or summer as soon as active mites are discovered. Frequently, a second application 7-10 days later will be necessary unless the product is ovocidal. Early treatment, before populations build up, is most effective. Some chemical sprays are injurious to predatory mites.

Whitespotted Sawyer (*Monochamus scutellatus*)

Hosts

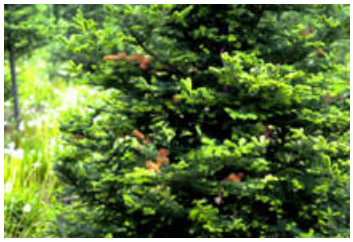
Balsam fir, spruces and white pine

Identification of Injury

The damage of most concern to urban tress is that caused when the adult beetle feed on the bark on the underside of twigs, causing the tips to turn red and die. Otherwise, the beetle is usually considered a secondary pest, attacking the trunks of weakened, dying or dead trees. Small piles of sawdust may be present near the base of trees where larvae have been tunneling.

Life History

There is a one or two year life cycle. Adults emerge through circular exit holes in the wood and are present during the summer. They feed on tender bark or twigs, causing tips to flag. Eggs are laid in the bark crevices of weak, recently killed or newly cut trees. When eggs hatch, young larvae bore a tunnel through the phloem into the cambium. Young larvae mine beneath the bark. Later instars tunnel toward the heartwood. Prior to pupation, the larva turns its tunnel toward the surface where it pupate behind a chip plug.



Management

Reducing the presence of dead and dying trees in the vicinity or ornamental conifers can help reduce the numbers of whitespotted sawyer beetle adults in an areas. Logs that have been cut can be debarked or put out in the sun to reduce the availability of egg-laying sites.

(2) Pine Insect Pests

Pine Bark Adelgid (*Pineus strobi*)

Hosts

Primarily white pine

Identification of Injury

White woolly material on trunks, branches and at the bases of needles in early spring. Heavy infestations may give the bark a white appearance. Under the wax, you may find the dark-colored adelgids. The wax-covered brown eggs are clustered near females.

Life History

There are several generations per year. After overwintering as immatures on the bark, adelgids begin feeding and secrete large amounts of waxy material over their bodies. Crawlers and winged individuals emerge from eggs. Wingless forms settle o the trees and reproduce rapidly.

Management

Healthy trees are not usually affected by he pine bark adelgid and light to moderate infestations don't usually warrant control. If unsightly, the adelgids and woolly secretion can be washed away with water, using a strong stream from a garden hose.

Pine Leaf Adelgid (*Pineous pinifoliae*)

Hosts

White pine, red and black spruce

Identification of Injury

Beginning in mid-summer, drooping or discolored new lateral shoots on pine may be observed. Crawlers will be present on the shoots and remnants of the winged adults may be found lined up on old pine needles, heading toward the needle base, from July to August. This shoot droop may persist on the tree into the following year. Heavy populations occur on pine and spruce in alternate years.

Life History

The pine leaf adelgid has a complex life history which occurs over a two year period and involves two hosts and five distinct life stages. From the discolored shoots, a winged form of the adelgid is produced which flies to spruce and causes production of leafy, cone-like galls at the tip of the new growth in the spring. Heavy production of galls on spruce may indicate that there is a threat of high populations on pine the following year.

Management

The mortality of young shoots during infestations appears to become a limiting factor, contributing to population collapse. On ornamental spruce, control may be effected by hand-collecting and burning galls before mid-June. Insecticidal treatments seem to be ineffective.

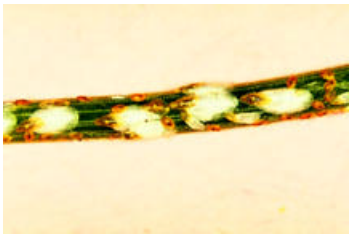
Pine Needle Scale (*Chionaspis pinifoliae*)

Hosts

Almost all needle bearing conifers, but especially Mugho and Scots pine.

Identification of Injury

White or yellowish oyster shaped scales on needles. Lower branches tend to have heaviest populations of the scale. Yellowing and dieback can occur when populations are heavy or trees may look gray.



Life History

There are two generations per year. The red eggs, which overwinter beneath the dead female scale, hatch in spring. Reddish-brown nymphs crawl out and move to a new area of the host tree. Nymphs reach maturity in mid-June and begin to lay eggs. The second generation of nymphs is found from July to September. These nymphs reach maturity in mid-August, and lay eggs which will hatch the following spring.

Management

Low populations of pine needle scale do not usually pose a problem. When numbers reach several scales per needle, yellowing, stunting and eventual dieback may result. Evaluate the number of white flecks which appear in early spring. Natural enemies such as parasitic wasps and lady beetles, feed on the scales and are often present in large numbers. Dormant oil may control scale while minimizing harm to the beneficial insects. Crawlers may be treated with summer oil.

European Sawfly (*Neodiprion sertifer*)

Hosts

Red, Scots, White and Austrian pines

Identification of Injury

Look for defoliation that results from gregarious feeding on old foliage only. Only fascicle sheaths may remain or you may see tufts of curled, strawlike needles from early feeding. Larvae which are 18-24 mm when full grown, tend to eat all foliage on one branch before moving to another. They are grayish-green with black heads and thoracic legs, and a pattern of light and dark green or black stripes.

Life History

There is one generation per year. Overwintered eggs hatch from April to mid-May. Larvae are present until mid-July. Then they may drop to the ground or remain in the tree to pupate in golden-brown cocoons. Adults emerge from late August through September. Sawfly adults lay eggs in slits in needles during late September through October.

Management

The European pine sawfly limits its feeding to old foliage and seldom kills trees, though shoots may die or be deformed and losses in diameter growth and height may occur. Bark of new shoots may also be eaten. Numerous parasites and disease pathogens are associated with these sawflies and can be effective control agents. Bacillus thuringeiensis cannot be used successfully, but various chemical insecticides are effective against larvae.

Introduced Pine Sawfly (*Diprion similis*)

Hosts

Preferred hosts are white and Scots pines, but jack, red and Swiss mountain pines may be attacked.

Identification of Injury

Larvae are marbled yellow green with black stripes down the back and yellow and white spots on the sides. They may be found between late May and early July (first generation) and between late July and early September (second generation). Young larvae feed in groups, while older larvae feed singly.

Life History

There are two generations per year. The larvae overwinter in cocoons in foliage, on twigs, other trees, shrubs or other understory objects. Pupation takes place in early spring and adults emerge during May and early June. Eggs are laid in slits in needles.

Management

Trees of all ages are attacked, but the insect seems to prefer ornamental, nursery or plantation trees. First generation larvae prefer previous year's needles but second generation larvae will feed on old and current year foliage. Very low or rapidly shifting temperatures or heavy rainfall can reduce egg and early larval numbers. Natural enemies include birds, which feed on pupae, and several parasitic wasps. *Bacillus thuringiensis* cannot be used effectively, but various chemical insecticides are effective against larvae.

Redheaded Pine Sawfly (*Neodiprion lecontei*)

Hosts

Preferred hosts are red, Scots and jack pines. Also attacked are shortleaf, loblolly, slash, pitch, Swiss mountain, Japanese black, mugho pines, white pine, larch, deodar cedar and Norway spruce.

Identification of Injury

Sites where eggs have been laid in current or previous years' needles. Larvae, which have reddish heads and whitish-yellow bodies with 6 rows of black dots, are present from May through September. Defoliation caused by larvae feeding gregariously on old and new foliage and tender bark. They tend to defoliate an entire branch before moving on to another area of the tree. Fascicle sheaths or tufts of curled, strawlike needles may remain after larvae feed.

Life History

There is one generation per year. Winter is spent as a pupa in topsoil or duff. Adults emerge in early spring and lay eggs in slits in current or previous years' needles. Eggs hatch in 4-5 weeks. A range of larval age groups may be present throughout the summer. Young larvae feed on the

edges of needles, leaving a central spine, but large larvae consume entire needles. Damage tends to be worse in years with warm, extended falls. From July through September, larvae reach maturity and drop to the soil to overwinter.

Management

Larvae may defoliate an entire tree from the top downward. Young or stressed trees are preferred and small ornamental pines may be completely defoliated and killed in heavy infestations. Trees that are growing in poor sites or under stress are attacked more readily than healthy trees. Damage can sometimes be reduced by getting rid of competing vegetation, planting in high-quality sites and promoting early closure by close plantings. If infestations are light, manual removal of larvae may effectively control the pest. When infestations are heavy, or many trees are involved, trees may be sprayed with a residual insecticide.

White Pine Sawfly (*Neodiprion pinetum*)

Hosts

White pine is the primary host, with pitch, shortleaf, red and Swiss mountain pines attacked occasionally.

Identification of Injury

Pale yellow larvae with black heads and four rows of black dots may be present. Larvae are present from July through August. Look for defoliation caused by gregarious feeding on old and current foliage.

Life History

There is one generation per year. Insects overwinter as pupae in cocoons in the topsoil. Pupation occurs in spring. Adults emerge and lay eggs and larvae feed through September.

Management

Ornamental trees of all sizes are attacked ad maybe completely defoliated because this sawfly feeds on current and previous years' foliage. I some cases, natural control has been attributed to a wasp that parasitizes eggs. Bacillus thuringiensis cannot be used successfully, but various chemical insecticides are effective against larvae.

White Pine Aphid (*Cinara strobi*)

Host

White pine

Identification of Injury

The bark of infested trees and branches will have black aphids with a central white stripe, white spots on the sides and long, stiff hairs on the body. During the winter, examine needles for rows of black eggs. Hineydew, sooty mold, yellow jackets and ants may be seen on twigs and branches with aphids. Look for branch flagging and discoloration of needles.

Life History

Like many aphids, the white pine aphid has several generations and life forms each year. Winter is spent in the egg form on needles. These eggs are laid end to end in rows of 5-25. Eggs hatch in spring to yield the first of several generations of wingless females. In the fall, both winged and wingless females are produced. Mating occurs and new overwintering eggs are laid.

Management

Small trees may be killed by the white pine aphid, while branch dieback and discolored needles are common in larger trees that are infested. Needles on which eggs are found can be removed in the winter, or, if present in large numbers, eggs can be destroyed with dormant oils.

White Pine Weevil (*Pissodes strobi*)

Hosts

White pine, Norway spruce, other spruce and pine species, Douglas fir.

Identification of Injury

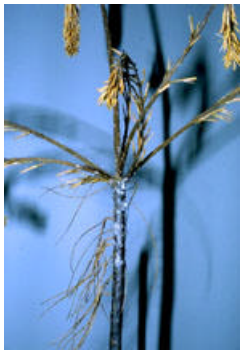
On sunny days in early spring, look for adults near terminal buds. Pitch flow from feeding and egg-laying punctures is common in the leaders of infested trees. Tops may be stunted, drooping or dead by mid-summer. Dead terminals sometimes take on the appearance of a shepard's crook. Two or more whorls can be affected and occasionally smaller trees killed.

Life History

Adults overwinter in the duff under infested trees. They emerge in very early spring to begin feeding and egg-laying in last year's terminal shoot. Upon hatching, larvae tunnel downward beneath the bark, girdling the leader. Pupation takes place in the oval chip-lined cells beneath the bark in the feeding channel. Adult emerge in July and August and drop to the ground.

Management

Flagged terminals should be pruned out below the larval tunnels and destroyed as soon as they are discovered. When infestations are heavy, treatment of terminals in early spring with a residual insecticides can eliminate adults as they are feeding, but before they begin oviposition.



(3) Spruce Insect Pests

Spruce Gall Adelgids (Cooley, Eastern and Ragged: *Adelges cooeyi, A. abietis, Pineus similis)*

Hosts

Cooley: Primarily white spruce, Douglas fir and Colorado blue spruce; Eastern and ragged: spruce only

Identification of Injury

Look for characteristic, sometimes unsightly galls that may disfigure shoots on spruce only. Cooley spruce galls are pineapple-shaped and form on the end of new growth, particularly on

lower branches of blue spruce. White woolly flocculence is associated with some adelgid life stages and feeding may result in discoloration and distortion. Needles on Douglas fir, the alternate host, develop yellow blotches at adelgid feeding sites and may appear twisted. Eastern spruce galls are pineapple shaped but can be found at the base of new shoots. These galls turn brown and open in late August. Ragged spruce galls are formed on the end of new growth, but are shorter and thicker than Cooley galls and chambers inside are joined. Needles may cover the gall surface, making twigs appear scraggly.


Damage Caused by Cooley Galls

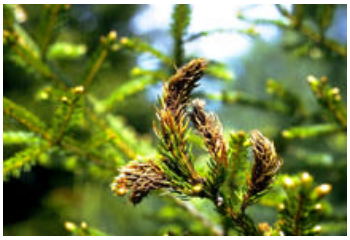
Life History

These adelgids have complex life cycles, involving alternation of hosts (Cooley) and multiple generations. Adelgids overwinter as exposed immatures and become reproductively active in the spring. Feeding during shoot elongation induces the development of galls, which are succulent at first but turn woody and dry in summer, opening to release adelgids,

Management

Green galls produced by these adelgids can be pruned out and destroyed in the spring. It may be desirable to rogue out particularly susceptible individual trees in a spruce planting to reduce populations. Horticultural soaps or oils can be applied to adults, eggs or nymphs. Overwintering nymphs can be killed with dormant oils applied to twigs (Cooley) or


Damage Caused by Eastern Gall



terminals (eastern). Chemical insecticides can be applied in April before bud break or in September to early October.

Yellowheaded Spruce Sawfly (*Pikonema alaskensis*)

Hosts

White, black, red, blue, Norway and Engelmann spruces

Identification of Injury

In July, look for groups of olive green larvae with reddish-yellow to chestnut brown heads on branches of open-grown spruce. Look for defoliation of current years' foliage; older foliage may be eaten when new foliage is completely gone. The ground beneath trees may be littered with partially consumed needles and frass. When disturbed, larvae have a tendency to rear up both their head and posterior ends, and they may give off a viscous fluid from the mouth. After larvae complete feeding, their droppings may still be seen and dark brown cocoons with bits of soil around them will be present in the litter.

Life History

Winter is spent as a pupa in a cocoon in the litter. Adults emerge in early to mid June. Eggs are laid singly in sits at the base of new needles in the crown of the tree. Newly-hatched larvae begin feeding on the edges of new needles and later when half grown, begin to consume entire current year needles before moving to older foliage. Larval feeding lasts for about a month. Then larvae drop to the ground and spin cocoons.

Management

Parasites and predators are known to kill significant proportions of yellowheaded spruce sawfly populations, but control using insecticides is frequently necessary. Insecticides should be applied as soon as the larvae begin to feed (about 10 days after bud caps have been shed). Young, open-grown and ornamental trees seem to be preferred. Defoliation often begins on single branches but may spread to the entire tree. Trees may be killed if completely defoliated for more than one season. Trees that experience severe needle loss may survive, but lose branches and radial growth as a result. If there are just a few, young trees infested, larvae can be handpicked.

(4) Beech Insect Pests

Oystershell Scale (*Lepidosaphes ulmi*)

Hosts

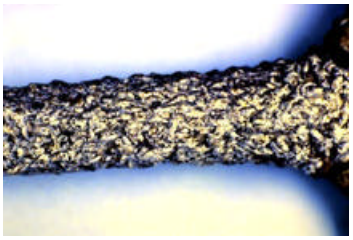
Beech, birch, maple, ash, poplar, willow, elm, lilac, apple, pear, cherry and many others.

Identification of Injury

Look for tiny brown to gray oystershell-shaped scales, usually densely packed on the bark. Foliage may appear thin and chlorotic and there may be areas of the crown that lack leaves or where there are scattered clumps of leaves.

Life History

The life cycle varies with the host tree species. In general, insects overwinter in the egg stage in groups of 50-100 under the scale covering. Crawlers emerge in May and move to feeding sites on twigs and branches. Adult females are present in July. By late July, they have formed a scale covering beneath which the white eggs are laid.



Management

This insect tends to cover entire branches before populations spread to a new area of the host tree. If scales are heavy enough to cover branches, host dieback is likely to result. Branches that are heavily infested should be pruned. Known enemies include lady beetles, parasitic wasps and mites. Additional control measures are often needed. Dormant oils are effective against overwintering populations, and systemic or contact insecticides can be used to control crawlers. Summer oils may also be effective.

(5) Birch Insect Pests

Birch Lace Bug (*Corythuca pallipes*)

Hosts

Yellow and white birch, beech, maple, willow, mountain ash

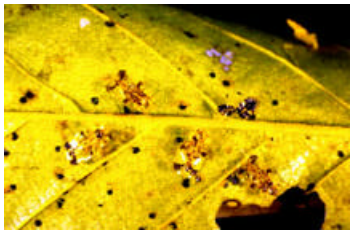
Identification of Injury

These small, flattened insects live and feed on the underside of leaves. While the upper surface of infested leaves becomes mottled and discolored, the undersurface is littered with excrement,

cast skins and eggs. Heavily infested leaves turn brown and fall off. Nymphs and adults reach their highest numbers in August.

Life History

There are two generations per year. Winter is spent in the adult stage among the leaf litter. In the spring, eggs are laid in groups of 4-10 on the lower surfaces of leaves in the axils of veins. Nymphs, which are dark brown, molt five times before becoming an adult. Adults are about 4 mm long and have lacelike forewings.



Management

Control measures are not usually required. If horticultural oils or other insecticides are used, the lower surface of the leaves must be sprayed thoroughly.

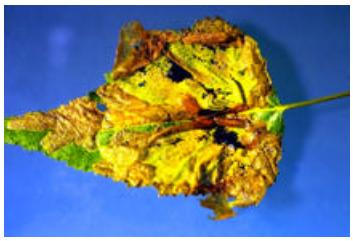
Birch Leafminer (*Fenusa pusilla*)

Hosts

Gray and paper birch are preferred, but yellow, black, European, white and river birch may also be attacked.

Identification of Injury

The most obvious sign of infestation is severe browning and distortion of foliage beginning in mid-May. Larval feeding causes irregular blotch mines that are translucent green at first, turning gray and eventually brown. Mines contain black waste material. Larvae are flat and light greenish-yellow with four black spots on the underside near the front. Eggs are laid singly in slits made in developing leaves. Both eggs and larvae show up as translucent spots when the leaf is held up to the light. Browning may increase as damaged leaves dry out over the growing season, or defoliation may occur.



Life History

There are 3-4 generations per year. The insects overwinter as pupae in soil under infested trees. The small black sawfly adults emerge in May and early June and lay eggs in individual slits cut in

the upper surface of developing leaves. Adult females require newly developing foliage for successful oviposition. Larvae eat the tissue between the upper and lower leaf surfaces, and eventually chew through the leaf surfaces and drop to the ground to pupate. New adults emerge and lay eggs to continue the cycle.

Management

Damage tend to be more serious on open-ground ornamental birches than on trees in forest stands. Trees weakened by birch leafminer may be more susceptible to attack by other insets and pathogens. Control of the first generation greatly reduces damage by subsequent generations. Prevention of egg-laying at budbreak may be accomplished using systemic pesticides. This insect may also be controlled by applying pesticides as the new leaves emerge.

Birch Skeletonizer (*Bucculatrix canadensisella*)

Hosts

Principle host is white birch but other native and exotic birches may be attacked.

Identification of Injury

Look for late season browning of foliage and premature leaf drop. By mid-summer, narrow, serpentine mines are visible and white silken molting webs may be found on the undersurface of the leaf. By late summer, skeletonizing by the light green larvae causes conspicuous browning.

Life History

Insects overwinter as pupae in the ground litter. Moths appear from late June to late July. Eggs, which are laid singly on either surface of a leaf, hatch in about 2 weeks and young larvae enter the leaf and feed as miners. In 3-4 weeks, they emerge through the lower surface of the leaf and spin webs in which they molt. For the next 3-4 weeks, the larvae feed externally as skeletonizers, molting twice in silken molting webs. Full grown larvae (about 6 mm) drop to the ground to pupate.

Management

Defoliation occurs in late summer, when most growth is completed. Large-scale control is not usually warranted, though population levels on ornamental trees can be reduced by raking and burning leaves.

Bronze Birch Borer (*Agrilus anxius*)

Hosts

White, cutleaf and yellow birch are preferred but other birches are also attacked.

Identification of Injury

Look for top dieback, with first symptoms including sparse, chlorotic foliage. Welts appear on the surface of the stem above borer galleries. Adult emergence holes are D-shapes and about 7 mm long. Adults are dark green-bronze or copper-bronze and about 10 mm long. Larvae are flat headed borers with two spines at the posterior end.

Life History

It takes one to two years to complete development. Winter is spent in the larval stage in tunnels beneath the bark. Depending on location, adults emerge from early spring through August. They feed on leaves for several weeks before laying eggs on unshaded bark. Newly hatched larvae bore into the cambium and then make galleries hat are tightly packed with frass and zig-zag across the wood grain.

Management

Weakened or injured trees are preferred by this pest, but healthy trees are also attacked. Trees which have been recently transplanted or those on stress-prone sites are especially susceptible. Numerous galleries can girdle the tree, causing branch dieback. Infestation and dieback tend to start at the top of the tree and move down. Prune off dead and dying branches before adults emerge in early spring. Maintaining or improving vigor of trees through proper fertilization, watering , and control of defoliators can help reduce attack. Chemical controls are generally not effective by the time a problem is detected.

(6) Crabapple and Cherry Insect pests

Eastern/Western Tent Caterpillar (*Malacosoma americanum, M. constrictum*)

Hosts

Primarily ornamental cherry, wild cherry and apple but also other shade, forest and fruit trees.

Identification of Injury

Spindle-shaped egg masses which encircle twigs and are covered with hardened varnish-like material can be seen from late summer until early spring. In spring, look for silken tens in crotches of trees. Caterpillars are furry and bluish with black heads and a white stripe down the back. Defoliation is usually complete by mid-June. When damage is severe, only larger veins and leaf petioles remain. The chunky, chocolate brown moths have narrow white bands on their

wings and are attracted to light.

Life History

Winter is spent in masses of 100-300 eggs. Hatching occurs in early spring and the newly emerged, gregarious larvae construct tents. They leave the nest on warm sunny days to feed on nearby foliage. When full grown, larvae wander in search of pupation sites. Pupation takes place in silken, yellow-dusted cocoons on trees and other vegetation, and on fences, building and other structures. Adults emerge in July.

Management

Reduced growth and branch damage may result from heavy or repeated defoliation. Natural enemies such as birds, parasites and pathogens and adverse weather conditions often control the eastern ten caterpillar effectively. From July until early spring, twigs containing egg masses can be pruned off and destroyed. Mechanical removal and destruction of tents as they appear in early spring is a control option. Bacillus thuringeiensis and various chemical insecticides can be used to control larvae.

Japanese Beetle (*Popillia japonica*)

Hosts

Apple, cherry, maple (especially Norway), littleleaf linden, birch, elm and many other hardwood species of trees; foliage and flowers of many shrubs are also attacked.

Identification of Injury

From early July through September, the adults, with metallic green bodies can be found on leaves, sometimes several per leaf. Young tender leaves are preferred and may be completely skeletonized by adults. The C-shaped larvae can seriously damage grass roots and can be found under dead patches of lawn.

Life History

There is one generation per year. Most of the year is spent as larvae in the soil. Larvae overwinter in earthen cells 4-12" below the surface. From early spring until June, they continue to feed on roots. Then the insects pupate near the soil surface. Adults fly in the daytime and are active on sunny, warm days over 6-12 weeks, beginning the first week of July. Eggs are laid in the soil and larvae feed on roots into the fall.

Management

Feeding on underground stems and roots of grasses may go unnoticed until plants fail to grow or die. Eggs and newly hatched larvae are killed by extremely dry weather, while wet summers are usually followed by seasons of increased numbers. Predators of grubs include birds, moles, skunks and occasionally raccoons. Beetles can be handpicked and destroyed if there are a few. Chemical insecticides, in the form of granules or sprays can be effective in controlling larvae in soil and turf. If there are more than 8-15 per square foot in blue grass, treatment is suggested. Chemical treatments can also be made to foliage of susceptible trees and shrubs.

(7) Honeylocust Insect Pests

Honeylocust Plant Bug (*Diaphnocoris chlorionis*)

Hosts

Honeylocust

Identification of Injury

As leaves unfold in the spring, look for deformation, chlorosis and stunting.

Life History

There is one generation per year. Winter is spent in the egg stage in the bark of 2- to 3-year old twigs. Eggs hatch at budbreak and green nymphs may be found on new growth. Adults, which are similar in appearance but have fully formed wings, are present in June.

Management

Insecticidal control may be warranted if early monitoring indicates that high numbers of immatures are present. Monitor by vigorously shaking a branch over a sheet of paper and counting the nymphs.

Honeylocust Pod Gall (*Dasineura gleditchiae*)

Host

Honeylocust

Identification of Injury

Look for the development of pod galls as leaflets expand. From a distance, leaflets may appear deformed or dried up, but closer examination reveals swollen, globular galled tissue.

Life History

There are several generations per year. The small adult flies become active a budbreak, laying their eggs in developing leaflets. The larvae (maggots) initiate pod gall development on leaflets, which turn brown and drop from the tree. New adults emerge from the galls, laying eggs of subsequent generations.

Management

Destruction of pod galls that fall to the ground can reduce the midge population. When midges are present in high numbers, a residual insecticide application applied at budbreak may be effective.

(8) Locust Insect Pests

Locust Leafminer (*Odontota dorsalis*)

Hosts

Black locust is preferred, but apple, birch, beech, cherry, elm, hawthorn and oak may also be attacked.

Identification of Injury

The overwintering flat, red and black adult beetles appear on leaves in May and those of the next generation appear in July. Larval feeding results in blotch mines which eventually coalesce, causing leaves to turn brown.

Life History

There are two generations per year. Winter is spent as an adult in leaf litter under host trees or in bark crevices. As new leaves develop, adults emerge and lay eggs in small clusters on the undersurfaces. Newly hatched larva form a common mine at first, but later separate and each larva mines several leaflets before pupating inside the last mine. Adults emerge and skeletonize lower leaf surfaces before seeking overwintering sites.

Management

Most trees can survive continued infestations with only minor damage. However, reduced aesthetic value is a problem. Parasites and predators can cause significant reductions in leafminer populations.

(9) Maple Insect and Mite Pests

European Snout Beetle (*Phyllobius oblongus*)

Hosts

Sugar and mountain maples, yellow birch, elm and serviceberry are particularly damaged, but the beetles also feed on many other hardwoods and softwoods.

Identification of Injury

In spring, look for notch feeding along leaf edges. Adult weevils, which are brown and 4-5 mm long, may appear in large numbers at that time. They are sometimes quite active, dropping from foliage onto other surfaces and entering homes.

Life History

There is one generation per year. Eggs are laid in the soil during mid-summer and larvae feed and develop on roots. Winter is spent in the soil as a mature larva. Adults appear in spring and feed along leaf margins.

Management

Weevils disappear by midsummer. Control is not usually warranted.

Forest Tent Caterpillar (*Malacosoma disstria*)

Hosts

Sugar maple, birch, oak, aspen and many other deciduous trees but never red maple.

Identification of Injury

Shiny brown egg masses are present from July until early spring of the following year. They differ from those of eastern tent caterpillar in having square edges and they completely encircle the twigs of host trees. Larvae, which are present in early spring, have distinctive keyhole-shaped white spots on the middle of the back of each segment. Defoliation of all except larger veins and petioles of the leaf occurs in May and June. The large chocolate-brown moths which appear in July do not have white bands on their wings. Their occurrence and density can be monitored with pheromone and light traps.



Life History

Insects overwinter in masses of 150-200 eggs. Larvae emerge about the time leaves unfold in the spring and may feed at first on opening buds. Later they consume whole leaves. Unlike the eastern tent, forest caterpillars do not construct tents. They spin mats on which they rest and make pathways of silken threads to feeding sites. Pupation takes place in white, silken cocoons often within rolled leaves. Adults emerge in July, mate and lay eggs.

Management

Loss of woody growth and death of branches may result from heavy or repeated defoliation. Repeated defoliation, along with other stress factors, can kill trees or predispose them to disease or other pests. Bacillus thuringiensis and various chemical insecticides can be used to control larvae. The collapse of large outbreaks which occur periodically have been attributed to depletion of food supplies, unfavorable weather conditions, and natural enemies such as predators, parasites and pathogens.

Gall Mites and Midges -Bladdergall, Spindlegall and Erineum Mites, Gouty Vein Midge
Bladdergall-*Vasates quadripedes*, Spindlegall-*Vasates aceriscrummena*, *Erineum-Eriophyes* sp., Gouty vein midge-*Dasineura communis*

Hosts

Bladdergall; silver and red maples; Spindlegall: sugar maple; Erineum: many species of maple; Gouty vein midge: sugar and red maples


Identification of Injury

In spring as leaves expand, look for characteristic gall formations on the upper surfaces of leaves.

Life History

For gall mites, there are several generations per year. Adults overwinter in cracks in the bark. Gall development is initiated as adults feed on developing buds in spring. The female becomes enclosed in the abnormal growth, and lays eggs within. Eggs hatch and mites reach adulthood and leave the galls quickly. These adults may initiate the development of more galls. The gall midge probably has one generation per year, with the winter spent in a cocoon in the soil. Adults emerge in spring and lay eggs in developing buds.

Management

Though these mites and midge cause galls that may be aesthetically undesirable, they are not a serious threat to the host trees. Handpicking infested leaves, which tend to be most common on lower branches, can help reduce populations. Systemic insecticides can be applied in spring or early summer to kill mites.

Loopers - Linden looper, Bruce Spanworm, Spiny Looper and Fall Cankerworm: *Erannis tillaria, Operophtera bruceata, Phigalea titea* and *Alsophila pometaria*

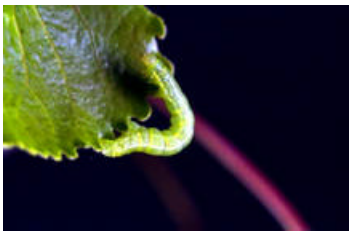
Hosts

Maple, oak, linden, beech, apple, birch, elm, hickory and other hardwoods.

Identification of Injury

In the spring, look for larvae that move in typical inchworm fashion. Linden loopers are dull to brightly colored, yellow-sided. Bruce spanworm larvae are variable in color, ranging from vivid green to dark brown with three yellow lines on each side of the body. Spiny loopers are pinkish with hairy tubercles and black lines running their length and fall cankerworm larvae range from very light green to dark brownish-green. The head and anal segments are also variable in color, ranging from pale green to black or mottled. Darker larvae may have a longitudinal black stripe, while lighter color forms have white lines running their length. Though larger loopers tend to feed voraciously, consuming all but the mid rib and larger veins, younger larvae may work as skeletonizers (e.g. fall cankerworm) or gives the appearance of Swiss cheese (e.g. Bruce spanworm).


Linden Looper


Bruce spanworm


Spiny Looper

Fall cankerworm

Life History

Each of these loopers has one generation per year. Winter is spent in the egg state with the exception of the spiny looper, which overwinters as a pupa beneath litter. The adult female moths of all four loopers are wingless and with the exception of the spiny looper, moths are active into the fall, when females may be seen crawling up the base of trucks. With the spiny looper, adults emerge and mate in the spring.

Management

These species of loopers are often found in association with each other. Parasites and disease are credited with keeping them in check, though periodic epidemics occur. Urban trees appear to be especially susceptible to heavy feeding by some species of loopers. Sticky bands around tree trunks will protect isolated trees by preventing females from crawling up to lay eggs. Insecticides, including Bacillus thuringiensis, are effective once larvae begin to feed on leaves.

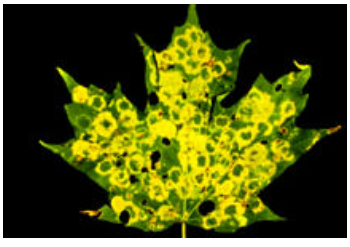
Maple Leafcutter (*Paraclemensia acerifoliella*)

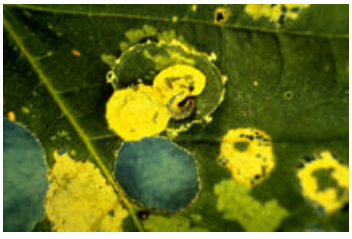
Hosts

Preferred host in sugar maple, but will also feed on red maple, birch, beech and other hardwoods.

Identification of Injury

First signs of maple leafcutter feeding are small mines which appear in June. As summer progresses, look for oval-shaped holes of various sizes and defoliated rings with green centers. You will also see oval shaped disks cut from leaves and used as larval cases on the upper leaf surface. Leaves brown prematurely.





Life History-

The insect overwinters as a pupa. Moths appear at about the time that maple leaves are opening and begin laying eggs within a couple of days. Eggs, laid singly, hatch in 2-3 weeks. Larvae feed as leafminers for about 2 weeks. After they emerge from the mines, they begin to construct cases, using leaf disks fastened together by silk. Using the case as a shelter, the larva feeds

around the edges, leaving ring-like patterns of the leaf. As the larva molts, it builds a case of larger leaf disks. Larvae drop to the ground in the end of September, spin cocoons and pupate.

Management

Natural control factors are thought to play an important role in the decline of populations because the maple leafcutter drops to very low levels between outbreaks. The maple leafcutter is a late season defoliator, and may be of little consequence unless present in extremely high numbers year after year. In ornamental plantings, raking and destroying infested leaves can reduce or eliminate overwintering populations. Larvae may also be killed with chemical or biological insecticides as they begin to feed on the leaf surface around July. Burning of fallen leaves can be effective in reducing populations.

Maple Webworm (*Tetralopha asperatella*)

Hosts

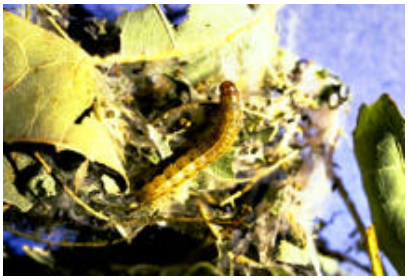
Sugar, red and mountain maples, oak, elm, beech, quaking aspen and willow.

Identification of Injury

Look for tattered leaves that are webbed (nested) together in a clump. Within the leaves, you may find mottled and striped larvae, varying in color from pale yellow to greenish or brown. Leaves may be brown covered with frass and skeletonized.

Life History

There is one generation per year. Winter is spent as a pupa in a cocoon in the duff. Moths emerge in the spring to lay eggs on leaves that are already partially rolled by other insects. Young larvae feed as skeletonizers on these leaves, while older larvae web groups of leaves together as they feed.



Management

Trees that are more exposed, such as those in urban settings and portions of the crown that are more open tend to have heavier infestations. Many parasites and predators have been found associated with the maple webworm and are thought to be significant control agents. Chemical control is not usually necessary.

Pear Thrip (*Taeniothrips inconsequens*)

Hosts

Maple, birch, beech, ash and cherry

Identification of Injury

Foliage that has been severely injured by pear thrips appears distorted, tattered or stunted and may resemble foliage damaged by late frost or strong winds. Close examination of the midvein and petiole may reveal swollen blister-like scars where egg laying occurred.

Life History

There is one generation a year. Insects spend the winter in the ground as pupae and adults emerge in early spring to feed on opening vegetation and flower buds. Eggs are laid in the midvein or in petioles. The emerging larvae, which are pale white and translucent, feed on foliage until early June, then drop to the soil to pupate.

Management

Control of pear thrips is difficult because adults emerge and enter developing buds before trees leaf out. The damage done by thrips takes place over a short time span, and insects are concealed in buds for much of that time. Results of research on the effects of fungi on pear thrip populations may provide new control options.

Woolly Alder Aphid (*Paraprociphilus tessellatus*)

Hosts

Silver maple and alder

Identification of Injury

Throughout early summer, look for white, wool-like waxy filaments on branches and stems of host

trees along with conspicuous curled leaves. The presence of honeydew, ants feeding on honeydew or development of sooty mold are commonly associated with aphid infestations.

Life History

The insect overwinters on maple bark in the egg stage or on alder in tightly-clustered, wool-covered aphid colonies. Newly emerged aphids settle on the midvein of new maple leaves. These aphids reproduce asexually, producing very large colonies. The winged generation that develops flies to alder in July. Several generations may develop on alder, accompanied by production of large amounts of white waxy material. Some of the migrants fly back to the trunk and branches of maples, where they mate and produce eggs, one per aphid. Others remain on the alder in the adult stage.

Management

The insect is usually of little significance, although the amount of white waxy material that accumulates may be troublesome and some of the infested leaves drop prematurely. The associated honeydew and sooty mold may also be annoying. Many predators or woolly alder aphids are known, including lady beetles, lacewings and, on alder, one of the few predaceous butterfly larvae, known as the Harvester (Feniseca tarquinius).

(10) Oak Insect Pests

Gypsy Moth (*Lymantria dispar*)

Hosts

Preferred hosts include oak, apple, birch, boxelder, hawthorn, linden, poplar, sweet gum and willow

Identification of Injury

The distinctive felt-like, tan egg masses may be seen on bark, branches, and in other sheltered locations throughout the winter. In early May, shot hole damage to leaves by young larvae is apparent. Large larvae, which are hairy and gray with five pairs of blue dots and six pairs of red dots, consume all but the larger veins and midvein. They tend to feed at night and gather in protected areas during the day. They may even gather in nests of the eastern tent caterpillar.

Life History

There is one generation per year, with winter spent in the egg stage. Eggs hatch at the time that shadbush (serviceberry) begins to bloom and larvae feed until July. Pupation takes place in sheltered locations on tree trunks or branches, or under other objects. Adults emerge about 2 weeks later to mate and lay eggs. Although the heavier white females do not fly, the smaller brown males are very active fliers and often become a nuisance in infested areas.

Management

Gypsy moth outbreaks occur periodically. Egg mass counts can be used to predict spring infestation levels, with 10 or more masses per tree indicating that severe defoliation may follow. As egg masses remain somewhat intact for several years, be sure that the count includes only viable eggs. Viable eggs should be firm to the touch and "pop" when crushed. The eggs masses may be removed by hand for some measure of control. Bacillus thuringiensis applied to very young larvae in May can provide good control. Residual insecticides are necessary if applications are made after mid to late May. Although barrier bands can afford some protection to individual ornamental trees, they should be used with great caution. Any materials applied directly to the bark may be toxic to thin-barked trees. Diseases and starvation become important control agents when populations are high.

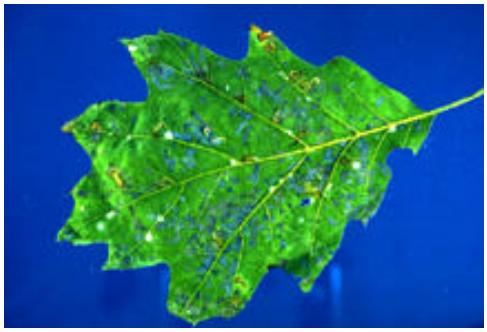
Oak Skeletonizer (*Bucculatrix ainsliella*)

Hosts-

Oak and chestnut

Identification of Injury

In winter, look on the bark or fallen leaves for the characteristic white cocoons. During the growing season, examine leaves for caterpillars, molting webs along veins on the underside of leaves and skeletonized patches. The tiny pale-yellow larvae tend to hang from leaves on silken thread.



Life History

There are two generations per year. Winter is spent as pupae in white cocoons on trunks and leaves. First generation moths emerge in April and May and lay eggs on undersides of fully-grown leaves. Newly emerged larvae feed as miners, but later instars (full-grown larvae are about 25 mm long, feed externally on the lower leaf surface. Molting takes place in small silken webs. Second generation adults appear in July and August.

Management

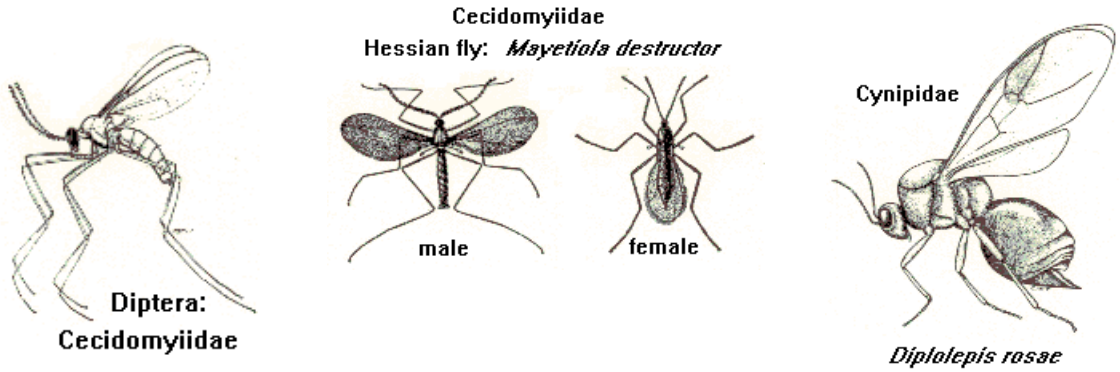
Ornamental trees are especially vulnerable to attack. Repeated infestations may result in weakened trees with thinning crowns, dieback and increased susceptibility to attack by wood boring beetles. Fallen leaves should be raked and burned to destroy cocoons. Population levels can vary widely from one year to the next.

g. Miscellaneous Pests

Gall-Making Insects and Mites

Importance

Galls are the result of the abnormal growth of plant cells. They are caused by insects, mites, nematodes, bacteria or fungi. Insects that cause galls include certain small wasps (cynipids),



jumping plant lice (psyllids), aphids, thrips, moth caterpillars and beetles. The most common galls on ornamental/forest plants are those caused by insects and mites.

Life History

The biology of gall-making wasps can be complex. Some wasps form different types of galls in alternating generations. In some species, the adults and galls are similar in the first and third generation, while very different in the second generation. The two generations of mealy oak gall wasp are described as an example of a common gall making insect.

Asexual generation: Spherical galls, 25 -75 mm in diameter, appear on branches and twigs of live oak in late summer or early fall. When first formed, they are pink to pinkish brown and the yellow-green tissue inside is moist and soft. Adults emerge by chewing holes in the bases of galls. All adults are female, they do not mate before laying eggs on swollen leaf buds.

Sexual generation: Eggs laid by adults of the asexual generation hatch in early spring as leaf buds begin to open. Larvae develop quickly in leaf tissue and stimulate the development of small, beige-colored galls resembling kernels of wheat. Adults of both sexes emerge from these galls after a few weeks. After mating, females lay eggs in post oak twigs and branches. These eggs remain dormant for 3-5 months. They then hatch and stimulate the formation of galls of the asexual generation.

Gall Formation

Gall tissue is formed when a plant reacts to some stimulus from insects and mites. This stimulus might be: 1) a fluid injected by adults laying eggs; 2) the presence of the insect or mite in plant tissue; 3) insect or mite saliva; 4) insect excretions. Genetic changes in the plant tissue also may occur during gall formation. After a brief period of growth gall development stops completely. The insect or mite inside the galls become surrounded by their food source and are protected by the gall.

Damage

The biggest problem with gall infested plants is that they seem unsightly. Galls usually do not damage plants, although leaves with insect-induced galls may fall from the plant earlier than non-infested leaves. Twig and stem galls usually persist for more than a year. They can weaken stems and twigs and cause them to drop during storms.

Management

Prevention: To avoid gall forming insects, choose plants that are not known to be hosts to these pests. If planting a susceptible plant. Select a good site and plant properly. Should a susceptible plant already be in place, good horticultural practices will keep it healthy. Gall forming insects must attack the host plant at a very precise stage of plant development in order to form galls. Occasionally, certain trees will bear more galls than adjacent trees of the same species. Studies have shown that oak trees whose buds opened earlier than those of nearby trees had many more galls, because the wasp creating the galls needed open buds in which to lay its eggs.

Tolerance, hand picking and pruning: Since most galls and gall-forming insects are not a threat to plant health, attempts to suppress them are not usually warranted. If galls are unsightly, they can be hand picked or infested plant parts pruned and discarded. However, this may not prevent infestations the following season. Removing the host plant and replacing it with a non-susceptible plant is the only sure method of control.

Biological control: Several kinds of wasps parasitize gall-forming insects and limit the number of galls formed. These wasps are natural biological control agents and should be encouraged. To protect these beneficial wasps, do not use insecticides when they are searching for their hosts. (late spring through early summer).

Newly planted susceptible plants may have galls for a year or so before parasites find the galls and begin their attack on gall forming insects.

Chemical Control: Although some pesticides are registered for controlling gall-making insects, their use is generally unwarranted and ineffective. Unless these products can be applied when adults are actively laying eggs, they provide no control. Once galls begin to form, the insects and mites inside are protected and cannot be killed with either a surface-applied pesticides or a systemic pesticide.

Common Gall Making Insects and Mites

Host plant	Type of gall	Pest
Apple	galls on roots and twigs	wooly apple aphid
Cypress	swellings on growing tips	gall midge fly
Elm	bladder or finger-type leaf galls	Mite (eriophyes ulmi)
Ficus	leaf folding and rolling	Cuban Laurel thrips
Grape	Galls on roots	grape phylloxera
Hackberry	blister, nipple, petiole, bud gall top shaped galls on underside of leaf	Pachypsylla spp. cecicdomyid fly
Oak	petiole and leaf stipule gall	Phylloxera spp.
	leaf vein pocket gall	fly gall
	woody twig gall	gouty oak and horned oak gall wasps
	leaf galls with orangish "hair"	hedgehog gall wasp
	sticky, spongy galls on twigs	wool sower gall wasp
Live Oak	woody twig and stem galls	mealy oak gall wasp
	Leaf gall	wooly leaf gall wasp
Red Oak	spherical, spongy-filled galls	oak apple wasp
Poplar, cottonwood	pocket galls on leaves, leaf bases and petioles	aphid
Willow	Cone-like gall on terminal	willow cone gall fly

Sowbugs and Pillbugs (*Porcellio* spp. and *Armadillidium vulgare*)

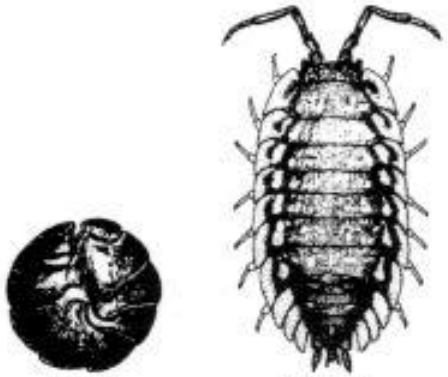
Identification

Sowbugs are oval or slightly elongate with a flattened body and up to 3/4" long. They are wingless, brownish or slate gray and possess well-developed eyes, seven pairs of legs and overlapping "armored" plates that make then look like little armadillos. Sowbugs have two tail-like structures on the posterior end. Pillbugs are similar, except they lack the tail-like appendages and can roll up into a tight ball. Both are slow-moving crustaceans related to crayfish, shrimps and lobsters but not insects. The young resemble the adults, except they are smaller and lighter in color.

Life History

Both sowbugs and pillbugs mate throughout the year, with most activity in the spring. The female carries the eggs, numbering from 7-200 in a brood pouch on the ventral side of her body. Eggs hatch in 3-7 weeks and the young are white-colored. They remain in the brood pouch for six to eight weeks until they are able to care for themselves. There may be one to two generations per year, with individuals living up to three years depending on weather conditions.

These creatures live outdoors, feeding on decaying organic matter and occasionally young plants and their roots. They may become pests is and around homes where flower bed mulches, grass clippings, leaf litter, rotting boards, trash, rocks and pet droppings are present. Adequate moisture is essential for their survival and they group in masses to reduce water loss. On a hot day, they remain under objects on the damp ground and are active only at night due to lower temperatures and more humid conditions. They become inactive during the winter months.



Management

Remove hiding places such as piles of leaves, grass clippings, mulch in flower beds, fallen fruit, boards, stones and other debris from foundation walls, doors, basement windows and other entry points. Properly ventilated basements and subfloor crawl spaces to eliminate excess moisture. Repair and seal cracks and openings in the foundation wall, around doors, and around basement windows with caulking compound and weather stripping. Drain standing water and moist areas.

Indoors, the use of fans and dehumidifiers will help dry out the basement and other damp rooms. These creatures can be collected with a brooms and dustpan, vacuum cleaner or other mechanical means and discarded. Insecticide sprays usually are not needed indoors since sowbugs and pillbugs dry out quickly.

Outdoors, apply a residual treatment (protective barrier) to the soil in a three to six foot band around the foundation walls, especially damp areas, surrounding the house and even underneath crawl spaces, at doorways, window wells and other potential entry sites. It is helpful to rake mulch, leaves, etc. away from the house foundation before treatment. Sprays or dusts of benicarb (Ficam), chlorpyrifos (Dursban), diazinon, pyrethrins or resmethrin are effective. Treatment of peat moss, leaves and bark used as plant mulches is important. Subsequent sprinkling with water will carry the pesticide down into the soil where these crustaceans hide. Materials such as fluvalinate (Mavrik, Yardex) are used outdoors.

Book/Barklice/Psocids (*Liposcelis corrodens*)

Identification

Booklice (psocids) are minute, soft-bodies, transparent to grayish-white insects about 1-4 mm long, usually wingless and may go unnoticed. It is helpful to use a hand lens and flashlight for detection. They resemble lice in size, but are not in the same order as true lice. The head and abdomen appear large, while the thorax is narrow. The antennae are long, threadlike, and segmented. Some have chewing mouthparts and large eyes that protrude from the sides of the head. The young appear almost colorless, becoming more opaque with age. They run along exposed surfaces in a "jerky" manner and sometimes appear to hope. Outdoor psocids may be winged or wingless. If winged, they are weak fliers and hold the wings in a roof-like position over the body when at rest.

Life History

Psocids are all females and development occurs from unfertilized eggs (parthenogenesis). Females deposit an average of 60 eggs that are white, oval and covered with a crusty coating. Eggs are laid singly or in clusters near a food source where young white nymphs hatch and feed on molds and mildews. There are four to six nymphal stages with the immatures resembling the adults in form and structure. The life cycle, from egg to adult, takes four weeks to two months or more depending on environmental conditions. There may be 7-8 generations per year with adults dying in cold weather and eggs hatching the following spring. Psocids avoid light and prefer temperatures of 75-85F with relative humidity of 75-90%. Long periods of humid weather, accompanied by warmth favor outbreaks.

These insects feed on microscopic molds, fungi, dead insect fragments, pollen and other starchy foods found in humid environments such as houses, warehouses, libraries and structures where green lumber is stored or used. Sweating and high humidities may form in wall voids when new lumber becomes enclosed, encouraging psocid outbreaks. Damp basements, crawl spaces,

leaky and sweating plumbing, potted houseplants, cereal, flour, bird nests, furniture stuffing of natural plant fiber, paste on book bindings, grains, wallpaper, etc. may harbor psocids.

Management

Reducing the relative humidity hinders development or causes death due to desiccation. Effort should be made to reduce the relative humidity in rooms and buildings to less than 50%, drying out infested materials and eliminating the food source such as mold and mildews.

Use a vacuum cleaner with proper attachments to remove debris from cracks and corners of storage areas. Clean up spilled food stuffs such as cereals and flour. Foods stored for six months or more sometimes become infested especially in damp, warm, undisturbed sites.

Infested cereals or stored foods should be discarded or supercooled in a deep freeze at 0F for 7 days. Books, paper or upholstered furniture can be dried in sunlight. Ventilate and dry areas with a dehumidifier or fan or simply open the doors of a damp room. Infestations will usually disappear during late fall when rooms are artificially heated and kept dry.

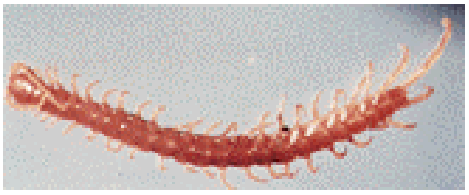
Store cardboard boxes, books and papers off the floor and repair plumbing leaks and drains to eliminate standing water. Install a vapor barrier in crawl spaces or add additional ventilation. Regrade wet areas around buildings and install a drainage tile system to handle runoff in problem areas. Seal cracks in interior and exterior foundation walls and repair leaking rain gutters, down spouts, roof vents and roofs.

Normally chemical control is not needed if strict sanitation is practiced. They are a nuisance by their presence, crawling over areas in large numbers. Some apply mothballs in infested closets of file cabinets. Household products that control mold and mildew will reduce a food source. Household pressurized aerosol cans containing pyrethrins applied on psocid habitats are useful indoors, while treatments of diazinon, propoxur or chlorpyrifos may be applied to structure foundations, rotting logs, grass piles, tree bark, etc.

Centipedes

Identification

Centipedes are reddish-brown, flattened, elongated animals with many segments, most of which have 1 pair of legs. The first pair of legs is modified into poisonous jaws located below the mouth. Antennae have 14 or more segments. The house centipede is grayish-yellow with 3 dark, long stripes down the back with the legs encircles with alternating dark and white bands. The actual body length is an inch or slightly longer, surrounded with 15 pairs of very long legs making the creature appear much larger. The last pair of legs is more than twice the body length of the female. a pair of very long slender antennae extends forward from the head. They move quickly and are sometimes mistaken for long-legged spiders. Other centipedes, found outdoors, often are more elongate with shorter legs and antennae.



Life History

Centipedes are long-lived, sometimes with a span up to 6 years. They overwinter as adults and lay eggs during the warm months. Usually eggs are laid in the soil and protected by the adults. Some species give birth to living young.

Centipedes need moist habitats and those living outdoors are found in rotting wood, compost piles, mulch, wood chips, leaves, etc.

The house centipede can complete its life cycle indoors, as it prefers dampness. They mate and breed in dark cracks and crevices. Eggs hatch into larvae which have 4 pairs of legs. There may be 5 or more larval stages with the number of legs increasing with each molt. Following larval growth are 4 adolescent stages, each with 15 pairs of legs. Centipedes prey on insects, spiders and other small animals, being considered beneficial to humans. The last pair of hind legs are modified to lasso and hold the prey until they are paralyzed from the jaws connected to the poison glands.

The house centipede runs swiftly when disturbed and can climb walls easily. Some are found around sump pumps in basements or bathrooms and other humid places where they are most active at night. They usually occur in small numbers and, in spite of their fearful appearance, they are considered harmless to humans.

Management

Centipedes, related to lobsters, crayfish and shrimp, require moist habitats and areas of high humidity. It is important to keep areas as dry as possible.

Keep old boards or rotting wood, compost piles, grass clippings, leaves, and stones way from the house foundation. Remove, if practical, trash or leaf litter in a strip 3 feet wide surrounding the house foundation, exposing the soil surface to drying from the air and sunlight. Repair and seal cracks and opening in the foundation wall and around door and window frames with caulking compound and weather stripping.

Properly ventilate basements and subfloor crawlspaces to eliminate excess moisture. Indoors, control nuisance insect populations to reduce the food source of centipedes. These creatures can be collected by broom ad dustpan, vacuum cleaner or other mechanical means and discarded.

Try to locate the infested area or cause of infestation. Outdoors, if necessary, spray a protective insecticide barrier thoroughly soaking the soil in a five to fifteen foot band around the house. Also, thoroughly spray the sides of the house up to a level of the first story windows, especially across doorways and other openings. The carbamate insecticides such as propoxur, bendiocarb or carbaryl give the fastest knockdown compared to other groups of insecticides. Wettable powder formulations provide the best soil residual control. If foundation planting are heavily mulched, insecticides may have to be rodded down to the soil beneath the mulch. repeat applications at weekly intervals may be needed.

Treatment of the peat moss, mulch, wood chips and leaves used in landscaping is important. Subsequent water sprinkling will carry the insecticide down into the soil where these creatures hide.

Crickets
House Cricket (*Acheta domesticus*)
Field Cricket (*Gryllus* spp.)
Ground Cricket (*Gryllus abbreviatus*)
Snowy Tree Cricket (*Oecanthus niveus*)
Camel Cricket (*Ceuthophilus* spp.)
Northern Mole Cricket (*Neocurtilla hexadactyla*)

Identification

Crickets get their name from the high-pitched sound or "chirp" produced when the male rubs his front wings together to attract a female. Different crickets may be identified by listening to their song.

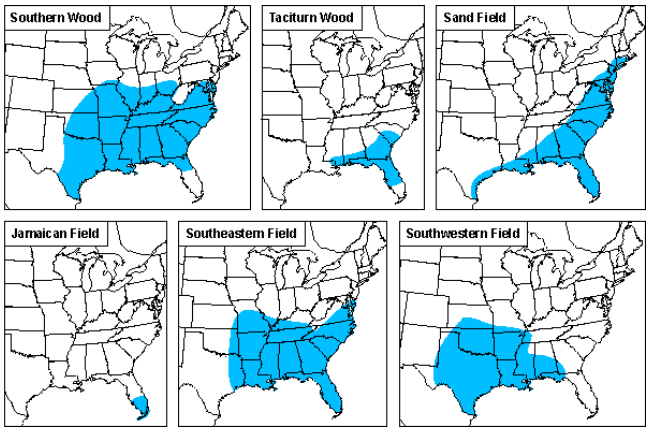
The "True Crickets" (House, Field, Ground, Tree) resemble longhorned grasshoppers in having long tapering antennae, striculating (singing) organs on the front wings of the male and auditory (hearing) organs on the front tibiae (4th leg segment).

House Cricket

Adults are about 3/4-7/8" long, light yellowish-brown (straw colored), with three dark bands on the head and have long, slender antennae much longer than the body. Wings lay flat on the back but are bent down abruptly on the sides. Females have a long, slender, tube-like structure (ovipositor) projecting from their abdomen for egg laying. Both males and females have two antenna-like (cerci) attached to the sides at the end of the abdomen.

Field Cricket

Adults range in size from 1/2" to 1 1/4" long depending on the species, are usually black-colored (sometimes brown), have long, slender antennae and a typical stout body (more robust than the house cricket) with large "jumping" hind legs. The ovipositor may be up to 3/4" long. Females have three easily seen appendages coming out of the tip of the abdomen, whereas males have only two. Most chirp and may sing both day and night.



Field Cricket: Long Wings

Field Cricket-Short Wings

Ground Cricket

Adults resemble house and field crickets but are much smaller, usually less than 1/2" long and brownish. Spines on the hind tibiae are long and movable. Their songs are often high-pitched, pulsating trills or buzzes.

Snowy Tree Cricket

Adults are about 5/6-7/8" long, pale yellowish-green or whitish shaded pale green and have a single black spot on the front side of each of the first two antennal segments. Male wings are broad, paddle-like, and lay flat on the back at rest, whereas the female forewing is narrow, and wrapped closely about the body. They chirp at a regular rate varying with the temperature. A good approximation of the temperature is degrees Fahrenheit is to add 40 to the number of chirps in 15 seconds. These are the crickets commonly heard in the background noises of TV and movies. Most deliver loud trills.

Camel Cricket

Adults, sometimes called cave or cellar crickets, are a little over 3/4" long, light tan to dark brown (darker bands on some segments), wingless, with head bent downward, back arched (humpbacked appearance), large hind legs and long antennae.

Northern Mole Cricket (Neocurtilla hexadactyla), Southern Mole Cricket (*Scapteriscus borelli*), Tawny (*S. vicinus*) Mole Cricket

Adults are 1/2" to 1 1/4" long, brownish to blackish-brown with bead-like eyes. Their broad front legs are adapted for digging. They have rather short antennae a large head and can fly.

Life History

House crickets normally live outdoors especially in garbage dumps, preferring warm weather, but will move indoors when it gets colder usually in late summer. Overwintering occurs outdoors in the egg stage. Each female can lay an average of 700 eggs with the immatures (nymphs) resembling the adults except being wingless. Nymphs molt seven to eight times and reach adulthood in about 60 days. Also, these crickets can live indoors, completing their life cycle with eggs laid in cracks, crevices and other dark areas such as behind baseboards.

Adults are very attracted to lights and become active at night (hide during the day) to crawl, jump or fly sometimes in countless numbers up the sides of houses, entering openings of even second and third story windows. They will feed on silk, woolens, nylon, rayon and wood. They can bite when handled carelessly. They are found in fields, pastured, lawns, and in the woods.

Field crickets overwinter as eggs or nymphs in moist, firm soil. Each female lays between 150-400 eggs which hatch in the spring. Nymphs resemble adults except are smaller and wingless, molt eight to nine times and reach adulthood in about 90 days. They are serious agricultural pests feeding on many crop plants. They become household pests in late summer and early fall when they move out of fields and into buildings. They can damage furniture, rugs and clothing and the chirping of adult males can be irritating. They are readily attracted to lights, can fly and are often found around dumpsters. Large swarms may invade well lighted areas covering streets and the sides of buildings. They feed on nylon, wood, plastic fabrics, thin rubber goods and leather. Outbreaks occur when rainfall follows a period of drought.

There are many different kinds and sizes of field crickets, none of which are able to survive and reproduce in buildings. They are found outdoors in similar places as are house crickets, especially under stones or boards, entering cool, moist basements in hot summers.

Ground Crickets act similar to field crickets except are smaller, overwinter as eggs, are largely active at night and attracted to lights. They occur in pastures, lawns and wooded areas.

Snowy Tree Crickets occur in trees, shrubs, weeds and high grass and are excellent singers, chirping at a regular rate varying with the temperature. Eggs are laid in the bark or stems of fruit and ornamental plants, often seriously damaging the twigs during the process of egg laying. Eggs are laid in pin-size holes (usually in single rows), sometimes injuring brambles of bush fruits. Overwintering eggs hatch in the spring with nymphs maturing in late summer. Apple, peach, plum, prune, cherry and berries are food hosts.

Camel Crickets are active at night in cool, damp, dark areas occasionally invading damp basements or crawlspaces. They are not attracted to lights nor produce a song. Overwintering occurs as nymphs or adults in protected areas. They may be found living in large numbers, causing alarm. Some textiles may be damaged. Some hide under hay bales, feeding on other insects seeking shelter there. Most are found in caves, hollow trees, under logs and stones and in other dark, moist places. They can live and reproduce indoors.

Northern Mole Crickets spend most of their lives burrowing in the soil, coming to the surface as the soil is wet or flooded. They are not often pests, but sometimes enter basements or homes. They fly to lights during their spring mating period. Females lay eggs in the soil (35 eggs per cell). Eggs hatch in 10-40 days with adulthood reached by autumn. They feed on roots, tubers and underground stems of grasses, strawberries, vegetables, etc. They overwinter as adults in the soil.

Management

Crickets are usually active at night (nocturnal), prefer shelter in cracks and crevices and invade homes seeking moisture. An occasional cricket usually presents no serious problems.

Sanitation is the most important means of eliminating nuisance crickets. Keep all areas in and around buildings free of moisture, dense vegetation and weeds (1 foot band next to foundation). Mow lawns, cut weeds and clean up garbage collection areas. Remove harborage sites such as piles of brick, stones, rotting wood and other debris. Caulk and seal all cracks and crevices, especially near the ground level at basement windows and doorways.

Make sure that all windows and doors are tight-fitting with proper screening in place. Exclusion is an important factor as well as light discipline. Avoid bright mercury vapor lights in entryways and along structure perimeters since crickets will be attracted from far distances. Convert to sodium vapor yellow lights.

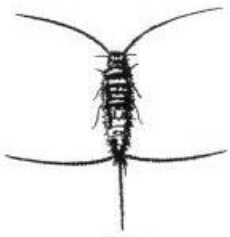
Never store firewood next to buildings. Raise refuse containers off the ground if practical. Trash and dumpsters should be placed as far away from buildings as possible. Crickets are attracted to food in these areas. Crickets can be killed with a fly swatter, collected by vacuum cleaner or broom and discarded.

Heavy cricket migrations are hard to control. It may be necessary to use insecticides both inside and outside. Indoors, apply to cracks and crevices, baseboards, in closets, under stairways, around fireplaces, in basements and other hiding places. Outdoors, when populations are large, treat a 5-20 foot swath around buildings.

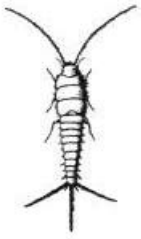
Silverfish and Firebrats
Silverfish (*Lepisma saccharina*)
Four-lined Silverfish (*Ctenolepisma quadriseriata*)
Long-tailed or Gray Silverfish (*C. longicaudata*)
Firebrat (*Thermobia domestica*)

Identification

Silverfish and firebrats have flat, elongated bodies 1/3-3/4" long and broad near the head, tapering toward the posterior, somewhat carrot shaped. These fragile, wingless insects are covered with scales and have two long, slender antennae at the head and three long, antennae-like appendages at the rear. These three appendages, one directed straight back and the other two curving outward, plus the two antennae, are nearly as long as the body. Sometimes these insects are known as "bristletails."



Firebrat



Silverfish

The silverfish adult is about 1/2" long with a uniform silvery or pearl-gray color, whereas the four-lined silverfish is about 5/8" long and the back displays four dark lines the length of the body. The gray silverfish is about 3/4" long and uniform light to dark gray. The firebrat is about 1/2" long,

grayish and mottled with spots and bands of dark scales. Young resemble the adults except they are smaller. Eggs are whitish, oval and about 1/32" long.

Life History

Silverfish and firebrats are active at night and hide during the day. When objects are moved where they are hiding, they dart out and seek new hiding places. The silverfish lives and develops in damp, cool paces (prefers 75-95% relative humidity), often in the basement, bathroom and kitchen. Large numbers may be found in new buildings where walls are still damp from plaster and green lumber.

The firebrat is quick moving and lives in dark places above 90 F such as around ovens, furnaces, boiler rooms and fireplaces or insulation around hot water and heat pipes. These insects follow pipelines from the basement to rooms on lower floors, living in bookcases, around closet shelves, behind baseboards and behind window or door frames. They are hardy and can live without food for many months. Bristletails prefer to eat vegetable matter. Indoors, they will feed on rolled oats, dried beef, flour, starch, paper and paper sizing, gum and cereals. Outdoors, they can be found under rocks, bark and leaf mold, and in ant, termite and animal nests.

Silverfish females may lay over 100 eggs during a lifetime. Eggs are laid singly or two to three at a time in small groups, hatching in three to six weeks. Young silverfish and firebrats resemble adults except being smaller, white and take on the adult color in four to six weeks. Adults may live two to eight years. Firebrats lay about 50 eggs at one time in several batches. Eggs hatch in about two weeks under ideal conditions.

Silverfish and firebrats, depending on the species, may reach maturity in three to 24 months. These insects normally hitchhike into the home in food, furniture, old books, papers and old starched clothing. Unlike other insects, they continue to molt after becoming adults. Forty-one molts have been recorded for one firebrat. Populations do not buildup fast. A large infestation in a building usually indicates a longtime infestation.

Management

Sanitation is important but not entirely effective in reducing populations because insects often reside between wall partitions, in insulation materials, in books and papers, among book shelves and in other protected places. Often reducing available water and lowering humidity is helpful. Repair leaking plumbing and eliminate moisture. Lighting a dark, sheltered area may force these insects to move. Once the infestation has been eliminated, sanitation will help prevent reinfestation.

Insecticide treatments need to be applied thoroughly to all potential hiding places such as cracks, crevices, inside floor molding, around steam and water pipes, i and behind seldom moved furniture, and closets. Control may not be immediate since bristletails in wall voids must move out and contact the insecticide.

Boxelder Bug (*Boisea trivittatus*)

Identification

Adult boxelder bugs are flat-backed, elongate, narrow , about 1/2", 1/3" wide and dark brownish-black with three lengthwise red stripes on the pronotum (area behind the head). The head is black with the "beak" or proboscis reddish-orange and the long, thin, four-segmented antennae, half as long as the body. Wings are thick and leathery at the base and membranous at the tip. There are red veins in the wings and the abdomen is bright red under the wings. The nymphs or immatures resemble the adults in shape except they are smaller, more rounded, wingless and bright red. Eggs are dark reddish-brown.

Life History

During the autumn months (around October 1), adult and large nymph boxelder bugs congregate in large numbers primarily on the bark of boxelder trees and then begin migrating to a place for overwintering. Only full-grown adults overwinter, moving to hibernation sites either by crawling or flying. They may crawl from a nearby tree or fly about two miles to find shelter. These bugs hide in cracks and crevices in walls, in door and window casings, around foundations, in stone piles and other protected places. On warm days during the winter and early spring, they sometimes reappear on light-painted surfaces outdoors on the south and west sides, resting in the sun.

Overwintering adults leave their hibernation with the coming of warm weather and females begin laying eggs in crevices of tree bark, stones, leaves, grasses and on other objects hear host plants. Eggs hatch in 11-20 days, with bright red nymphs appearing about the same time new tree leaves develop. There are five nymphal instars. The instars get progressively darker red with each stage. In July, new adults lay eggs that result in a second generation by early autumn. Boxelder bugs feed primarily on the seed-bearing boxelder trees by sucking sap from the leaves, tender twigs and developing seeds. Occasionally, they have been observed feeding on ash, maple, plum, cherry, apple, peach, grape and strawberries, causing some scarring or dimpling of fruits. However, boxelder bugs seldom develop large enough populations to become a nuisance, unless able to feed on seed-bearing boxelder trees. Apparently they do little actual feeding damage to boxelder trees. There may be one to two generations per year.

Management

Since boxelder bugs feed and reproduce on pistillate (female) boxelder trees, removal of these trees, especially around the house, would eliminate nuisance populations. However, adults are capable of flying two or more miles for suitable hibernation sites. If boxelder trees are desirable for shade, ornamental or other purposes, use only propagation (cuttings) from staminate (male) trees. Eliminate potential hiding places such as piles of boards, rocks, leaves, grass and other

debris. Rake leaves and grass away from buildings in a six to ten foot wide strip, especially on the south and west sides. Be sure to caulk and close openings where boxelder bugs can enter the house such as around light fixtures, doors and windows, unscreened vents, holes in walls around utility pipes or conduits, air conditioners, etc. They are also attracted to lights and can fly in open doors and windows.

Should boxelder tree removal be impractical, treat the young, exposed boxelder bug nymphs on the trees during spring and early summer to prevent potential large populations and indoor migrations in the autumn. Spray a soap mixture on the nymphs and adults as they begin congregating in late summer. The spray consists of about 1/2 cup of laundry detergent in one gallon of water applied by a hand sprayer or squirt bottle directly on the boxelder bugs as often as necessary. The soap mixture kills only the bugs sprayed, but does not prevent others from coming to the site. Applications of insecticides may be used as well.

Thrips
Grass Thrips (*Anaphothrips obscurus*)
Onion Thrips (*Thrips tabaci*)
Pear Thrips (*Taeniothrips inconsequens*)

Identification

Adult thrips are very active and usually less than 1/8" long, tan to dark brown bodies with four very thin, veinless, feather-like wings. The wing margins are fringed with close-set long hairs. Wings are laid back over the body while at rest. The head has compound eyes and less noticeable, simple eyes. Mouthparts are rasping sucking. Nymphs are creamy white and wingless. Eggs are laid on the tissues of plants or inserted into plants.

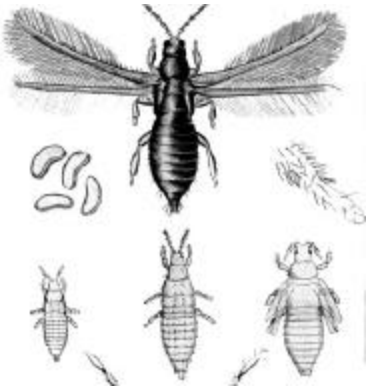
Life History

Thrips are serious pests on vegetables and flowers. Plant injury is caused by both nymphs and adults rasping the bud, flower and leaf tissues of the host plants, and then sucking the exuding sap. This causes distorted and discolored flowers or buds and gray or silvery, speckled areas on the leaves.

After successful mating, eggs are laid on plants with the young developing to maturity in about two or more weeks. The number of generations produced each year depends on the thrips species, temperature and other climatic factors. Most species produce many generations in a season. Females may lay fertilized or unfertilized eggs, the latter developing into males only. There are four or more nymphal instars exhibiting gradual metamorphosis. Both nymphs and adults overwinter concealed in grass stems or other plant debris with activity continuous in warmer climates.

Management

Try to locate the source of infestation. Check for host plants such as potted plants, vegetables, flowers, fruit trees, etc. Thrips may feed between the leaves well down toward the plant base where it is difficult to see. Be sure to check swimming pools or ornamental waterfalls nearby.



To reduce and eliminate a thrips infestation, remove excess water from around plants and vacuum up thrips. Discard infested plants or treat with insecticides labeled for the host plant. Surface applications may aid in control efforts. Also, several species of lady beetles and the minute pirate bug are thrips predators and should be conserved.

Earwigs
European Earwig (*Forficula auricularia*)
Ringlegged Earwig (*Euborellia annulipes*)

Identification

Earwigs are elongate, flattened insects, ranging from light red-brown to black and are easily recognized by their forecep-like appendages (pincers) on the end of the abdomen. The forceps (cerci) are unequal in length in the males. Earwig female forceps are straight-sided, whereas the male forceps are strongly curved (caliper-like) and larger. They have chewing mouthparts and long, slender antennae and are either winged or wingless. If wings are present, the first pair are hard, short and beetle-like, while the second pair of wings usually protrude from under the first pair. The European earwig ranges from 1/2 to 3/4" long with banded legs and a reddish head. The ringlegged earwig ranges from 1/2 to 3/5" long and is black-yellowish underneath with legs having dark crossbands. Young earwigs (nymphs) are similar to adults. They are white to olive green and lack wings.

Life History

The name earwig is derived from a European superstition that these insects enter the ears of a sleeping person and bore into the brain. This belief is totally unfounded. Earwigs develop from egg to adult through gradual metamorphosis with four or five nymphal instars. During spring or autumn, females lay 20-50 smooth, oval, pearly white or cream colored eggs in a below ground chamber (upper 2-3" of the soil). The female moves, cleans and provides maternal care by protecting the eggs and young until the first molt. The young then leave the nest, fend for themselves and mature in one season. Both eggs and adults overwinter. Earwigs may dig as deep as six feet below ground to escape the cold. They are active at night and are often found around lights. During the day, they hide in moist, shady places. They are rapid runners and feed on mosses, lichens, algae, fungi, insects, spiders and mites, both living and dead. Some earwigs are predators, feeding on aphids and other feed on living plants, becoming pests on certain crops such as vegetables, fruits, ornamentals, forages and field plants.

Earwigs rarely fly and are unable to crawl long distances, but often hitchhike in laundry baskets, cut flowers, vegetables, etc. They prefer moisture and may migrate indoors during long periods of prolonged heat and drought. Forceps at the end of the abdomen are used to defend the nest, capture prey, probe narrow crevices and fold or unfold wings.

Earwigs require moist, cool places and are found in damp crawlspaces, flower gardens, near the home, compost piles and wood piles. After entering homes, they feed on sweet, oily or greasy foods and houseplants. They are attracted to lights.

Management

Earwigs need and are very attracted to moisture. High populations, practically invisible during the day, may be present around foundations, in landscaped yard, in mulch etc. Be sure to eliminate damp, moist conditions. Rain gutters and spouts should carry water away from buildings. Use caulking compound, putty and weather stripping around doors, windows, pipes and other entry sites, especially at ground level. Change landscaping by creating a clean, dry border immediately around the foundation wall. Gravel or ornamental stones can make an attractive barrier against earwigs and other pests.

Earwigs can be trapped outdoors in cardboard boxes baited with oatmeal or bran with pencil hole size entry sites punched in the sides near the bottom. Place burlap bags, canvass, boards, newspaper or other cover material in mulch, shrubbery and similar habitats to collect individuals the following day. Discard appropriately.

There are many insecticides labeled for earwig control. Indoor treatments should supplement outdoor treatments since earwigs do not become established indoors. Dusts and residual sprays

are effective when applied to baseboards, beneath cabinets and other hiding places at the floor level.

Spider Mites
Carmine spider mites (*Tetranychus cinnabarinus*)
Twospotted spider mites (*Tetranychus urticae*)

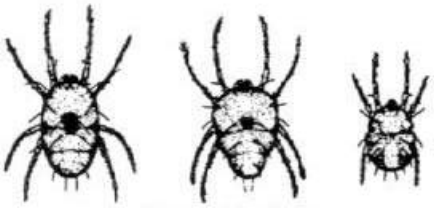
Identification

Adult carmine and twospotted spider mites are differentiated on the basis of live summer female forms. Carmine spider mite females are red; twospotted spider mite females are yellowish to dark green. Oval and about 0.4 mm long, females of both species have two or four dark, dorsal spots. Smaller than the females, males of these two species have slightly pointed abdomens. Adults of both species have eight legs.

Eggs are spherical and white to transparent when first laid. Just before hatching, they become straw colored and average 0.14 mm in diameter.

The larvae are not much bigger than eggs, the six-legged larvae are colorless except for carmine eye spots.

The two, eight legged nymphal instars are difficult to distinguish. Both instars are oval pale green to deep green, sometimes spotted and slightly smaller than adults.



Life History

The twospotted spider mite is cosmopolitan. The carmine spider mite has been reported in scattered areas throughout the world and is probably also a cosmopolitan species.
In view of recent taxonomic revisions which establishes the carmine spider mite as a species separate from the twospotted spider mite, it is often difficult to separate the host ranges of these two mites. Before the change, twospotted spider mites were recorded on over 180 host plants, including 100 cultivated species. Violets, chickweed, pokeweed, wild mustard and blackberry are probably common hosts of both species from which infestations spread to nearby crops.

Although these two species have been reported to infest grain sorghums since the early 1970's, forage sorghums appear to be resistant.

Spider mites usually feed on the undersides of leaves, where they pierce the epidermis and extract sap. Lightly infested leaves have a stippled appearance; heavily infested leaves turn completely pale and dry up. The entire plant may die. The undersurfaces of leaves usually have silken webs over which the mites crawl. A heavily infested plant, however, may have webs all over it. A rapid increase in spider mite damage is associated with drought conditions and symptoms are very similar from a distance.

F. Spider mites on corn.

As a general rule, these spider mites overwinter as fertilized females resistant to low temperatures. In mild winters, they may continue to feed and lay eggs. In summer, many generations develop; the number of eggs laid depends largely on temperature. Within 1-3 weeks, eggs hatch into six-legged larvae which develop into eight-legged nymphs. There are two nymphal stages. After the larval and each nymphal stage, a resting stage occurs.
Adults mate soon after emerging from the last resting stage. In warm weather, the females soon begin laying approximately 100 eggs each. Development is rapid in hot, dry weather. A generation requires 1-3 weeks to mature.

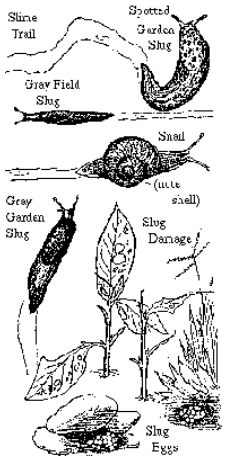
Management

On form of cultural control is the destruction of weeds around fields in the fall or early spring. This practice eliminates much of the overwintering mite population. Avoid destroying this habitat during the summer as it will force mites into ornamental plants. Chemical control may also be implemented, providing short-term relief.

Snails and Slugs

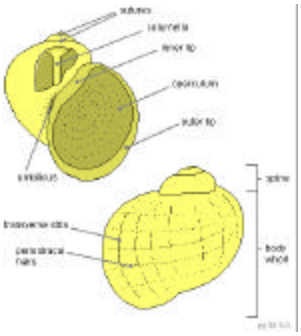
Identification/Life Cycle

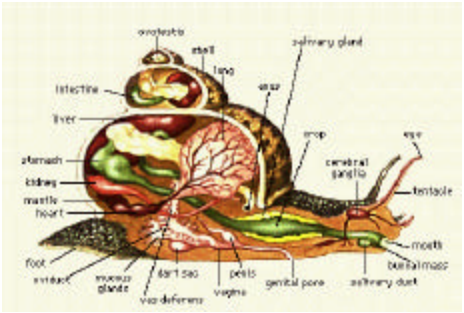
Snails and slugs are among the most bothersome pests in many landscape situations. The brown garden snail (*Helix aspersa*), gray garden slug (*Peroceras reticulatum*), the banded slug (*Limax poirieri*) and greenhouse slug (*Milax gagates*) are frequently are among many species which are frequently damaging. Both snails and slugs are members of the mollusk phylum and are similar in structure and biology, except slugs lack an external spiral shell (Appendix E).



Snails and slugs move by gliding along on a muscular "foot." This muscle constantly secretes mucus, which later dries to form a silvery "slime trail" that signals the presence of these pests. Adult brown garden snails lay about 80 spherical, pearly white eggs at a time into a hole in the topsoil. They may lay eggs up to six times a year. It takes about 2 years for snails to mature. Slugs reach maturity in about a year.

Snails and slugs are most active at night and on cloudy or foggy days. On sunny days they seek





hiding places out of the heat and sun; often the only clues to their presence are their silvery trails and plant damage. In mild winter areas, young snails and slugs are active throughout the year.

During cold weather, snails and slugs hibernate in the topsoil. During hot, dry periods, snails seal themselves off with a parchment-like membrane and often attach themselves to tree trunks, fences or walls.

Damage

Snails and slugs feed on a variety of living plants as well as on decaying plant matter. On plants they chew irregular holes with smooth edges in leaves and can clip succulent plant parts. They can also chew fruit and young plant bark. Because the prefer succulent foliage, they are primarily pests of seedlings, herbaceous plants and ripening fruits, such as strawberries, artichokes and tomatoes that are close to the ground. However, they will also feed on foliage and fruit of some trees; citrus are especially susceptible to damage.

Management

A good snail and slug management program relies on a combination of methods. The first step is to eliminate, to the extent possible, all places where snails and slugs can hide during the day. Boards, stones, debris, weedy areas around tree trunks, leafy branches growing close to the ground, and dense ground covers such as ivy are ideal sheltering spots. There will be shelters that are not possible to eliminate, e.g. low ledges on fences, undersides of wooden decks and water meter boxes. Make a regular practice of removing snails and slugs from these areas. Also, locate susceptible plants as far away as possible from these areas. Reducing hiding places allows fewer snails and slugs to survive. The survivors congregate in the remaining shelters, where they can more easily be located and controlled. Also, switching from sprinkler irrigation to drip irrigation will reduce humidity and moist surfaces, making the habitat less favorable for these pests.

Handpicking-Handpicking can be very effective if done thoroughly on a regular basis. At first it should be done daily; after the population has noticeably declined, a weekly handpicking may be sufficient. To draw out snails, water the infested area in the late afternoon. After dark, search them out using a flashlight, pick them up, place them in a plastic bag and dispose of them in the trash.

Traps- Snails and slugs can be trapped under boards or flower pots positioned throughout the infested area. You can make traps from 12 x 15" boards raised off the ground by 1" runners. The runners make it easy for the pests to crawl under. Scrape off the accumulated snails and slugs daily and destroy them. Snail and slug traps can also be purchased at garden supply stores.

Barriers- Several types of barriers will keep snails and slugs out of susceptible areas. The easiest to maintain are those made of copper flashing and screen. Copper barriers are effective because it is thought that the copper reacts with the slime that the snail or slug secretes, causing a flow of electricity. Vertical copper screens can be erected around planting beds. The screen should be 6" tall and buried several inches below the soil surface to prevent slugs from crawling beneath.

Copper foil can be wrapped around planting boxes, headers or trucks to repel snails for several years. When banding trunks, wrap the copper foil around the trunk, tab side down, and cut it to allow an 8" overlap. Attach one end or the middle of the band to the trunk with one staple oriented parallel to the trunk. Overlap and fasten the ends with one or two large paper clips to allow the copper band to slide as the trunk grows. Bend the tabs out at a 90 degree angle from the trunk. The bands need to be cleaned occasionally.

Instead of copper bands, Bordeaux (a copper sulfate and hydrated lime mixture) can be brushed on trunks to repel snails. One treatment should last about 1 year. Adding a commercial spreader may increase the persistence of Bordeaux mixture through two seasons. Sticky material (such as Stickem Green, which contains copper) applied to trunks excludes snails, slugs, ants and flightless species of weevils.

Barriers of dry ashes or diatomaceous earth heaped in a band of 1" high and 3" wide around a susceptible area have also been shown to be effective. However, these barriers lose their effectiveness after becoming damp and are therefore difficult to maintain.

Natural Enemies- Snails and slugs have many natural enemies, including ground beetles, pathogens, snakes, toads, turtles and birds, but they are rarely effective enough to provide satisfactory control.

Baits- Snail and slug baits can be effective when used properly in conjunction with a cultural program incorporating the other methods discussed previously.

Metaldehyde or metaldehyde/carbaryl snail baits can be hazardous and should not be used where children and pests cannot be kept away. Never pile bait in mounds or clumps, especially those baits that are hazardous, because piling makes a bait attractive to pests or non-target organisms. Placement of bait in a commercial trap reduces hazards and can protect bait from moisture, but may also reduce their effectiveness. Thick liquid baits may persist better under conditions of rain and sprinklers.

The timing of any baiting is critical; baiting is less effective during very hot, very dry or cold times of the year because snails and slugs are less active during these periods. Irrigate before applying a bait to promote snail/slug activity. Make spot applications instead of widespread applications. Apply bait in a narrow strip around sprinklers or in other moist and protected locations or scatter it along areas that snails and slugs cross to get from sheltered areas to susceptible areas.

Millipedes

Identification

Millipedes, or "thousand-legged worms", are brownish-black or mottled with shades of orange, red, or brown and are cylindrical or slightly flattened, elongated animals, most of which have two pairs of legs per body segment, except for the first three segments which have only one pair of legs. Antennae are short, usually seven-segmented and the head is rounded with no poison jaws. Their short legs ripple in waves as they glide over a surface. They often curl up into a tight "C" shape and remain motionless when touched. They range from 0.5-1.25" long depending on the species. They crawl slowly and protect themselves by means of glands that secrete an unpleasant odor.

Life Cycle

Millipedes can be long-lived, sometimes up to seven years. They overwinter as adults and lay eggs singly or in small groups in the soil. Some females lay between 20-300 eggs (fertilization is internal), which hatch in a few weeks with young reaching adulthood in the autumn. Some reach sexual maturity the second year, while others spend 4-5 years in the larval stage.

Millipedes are attracted to dark, cool, moist environments, usually going unnoticed in the summer due to their nocturnal habits and tendency to disperse. They feed on living and decomposing vegetation and occasionally on dead snails, earthworms and insects. Slight feeding injury can occur on soft-stemmed plants. They cannot tolerate water-saturated soil, which often forces them to the surface and higher ground. Likewise, dry, drought conditions can stimulate migration. In the autumn, it is believed they may migrate for better overwintering sites. If one or all of these conditions exist, sometimes hundreds or thousands of millipedes are found in garages and basements.

These creatures are usually abundant in compost piles and heavily mulched ornamental plantings, moving out shortly after sunset. Anyone handling millipedes will notice a lingering odor (hydrogen cyanide-like) and the fluid may be harmful if rubbed into the eyes. If crushed, millipedes may stain fabrics.

Management

Millipedes prefer moist, decaying organic matter and shade. Always keep compost piles, grass clippings, rotting wood, leaf piles, plant debris, stones, etc. away from susceptible areas to reduce moist, damp, dark places where feeding and reproduction can occur. Be sure to check for wood imbedded or buried in the soil.

Also, ivy beds and mulch are favored habitats. Rake and remove trash or leaf litter in a strip three feet wide surrounding susceptible areas if practical, exposing the soil surface to drying from the air and sunlight.

Chemical- Total control of millipedes during migration periods is difficult. Locate infested areas, spray (if needed) a protective barrier thoroughly soaking the soil in a five to fifteen foot ban. Wettable powder formulations provide the best soil residual control. Treatment of peat moss, mulch, wood chips, leaves, etc. used in landscaping is important. Subsequent watering will carry the insecticide down into the soil where the millipedes hide.

APPENDIX E
Key to Slugs and Snails

Key to Common and Potential Slug and Snail Pests of Flowers and Foliage Plants
Adapted from The Ohio State University Extension Service

1. **With** external shell (Fig. 127).....Snails, 2
   Without external shell (Fig.128).....Slugs, 5

2. **Shell** an elongate spire that is often broken off (Fig. 129); These snails mainly feed on other snails they are not considered pests..... *Rumina* sp.
   Shell not elongate spire.....3

3. **Shell** a flattened disc spiraling toward the center (Fig. 130); these snails mainly feed on other snails, they are not considered pests.....*Oxychilus* sp.

4. **Shell** oval, with a large teardrop-shaped aperture which is approximately two-thirds the total shell length (these snails feed on algae and soft vegetable matter, they are not considered pests, Fig 131).....*Succinia* sp.
   Shell globular, with the aperture approximately the shell diameter (Fig. 132)..... Brown garden snail.

Brown Garden Snail (Cantareus aspersus)

5. **Breathing** pore located in anterior half of mantle; back never keeled; posterior end rounded when viewed from above (Fig 133); these slugs can cause considerable damage.....*Arion* sp.
   Breathing pore located in posterior half of mantle; back keeled at least at posterior end which is pointed in dorsal view.....6

Arion Sp.

6. **Back** strongly keeled from the mantle to tip of tail; mantle grainy with center part bound by a groove (Fig 134); usually burrows in the soil and feeds on roots.....Greenhouse slug
   Back keeled only near posterior end; mantle wrinkled in concentric circles, without groove.....7

7. **Mantle** and body with black spots; large slug (up to 150 mm)(Fig 135).....Spotted garden slug.
   Mantle and back without well defined spots.....8

8. **Mantle** and back with well defined, dark stripes; breathing pore not surrounded by a pale ring (Fig 136); exudes watery slime when irritated.....Lehmannia slug

Mantle and back without well defined stripes; breathing pore surrounded by a pale ring.....9

Lehmannia

9. **Medium** sized slug (up to 50 mm)(Fig 137); gray to reddish brown; exudes milky adhesive slime when irritated.....Gray garden slug.
   Relatively small slug (up to 25 mm) (Fig 138) light gray to blackish brown; exudes clear, watery mucus when irritated.

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