Basic Entomology

Scales and Mealybugs

General Description. This is one of the most destructive groups of insects to ornamental crops. Scales are divided into three groups: (1) armored scales; (2) soft scales; and (3) mealybugs. The armored scales secrete a waxy covering over their bodies. This covering is not an integral part of the insect=s body, but the scale lives and feeds under this covering resembling a plate of armor, hence the name. They vary in size from 1/16" to 1/8" in diameter and can be almost any color, depending on the species. Armored scales may be circular, oval, oblong, threadlike or pear-shaped. The female=s armor is larger than that of the male, while the shape and color may be similar to distinctly different, depending upon the species.

Soft scales also secrete a waxy covering, but it is an integral part of their body. Soft scales vary widely in color, size and shape. They range from 1/8" to **2**" in diameter and may be nearly flat to almost spherical.

Mealybugs are soft-bodied insects that are covered with white, powdery or cottony, waxlike material. Short wax projections extend from the margin of the body, and some species have long filaments projecting from the rear of the body. They vary from 1/8" to 1/5" in length when mature. They tend to congregate together, appearing like fluffs of cotton on the foliage.

Important Species. Three hundred fifty species of armored scales occur in the United States, and about 175 species are present in Florida. Eighty-five species of soft scales occur in the United States with 60 species in Florida. Two hundred eight species of mealybugs occur in the United States and Canada.

Some of the more common armored scales on woody plants include magnolia white scale (false oleander scale, *Phenacaspis cockerelli*), latania scale (*Hemiberlesia lataniae*), tea scale (*Fiorinia theae*), obscure scale (*Melanaspis obscurus*), and the white peach scale (*Pseudaulacaspis pentagona*). Common soft scales found in Florida on woody plants include the brown soft scale (*Coccus hesperidum*), Florida wax scale (*Ceroplastes floridensis*), cottony maple scale (*Pulvinaria innumerabilis*) and the tuliptree scale (*Toumeyella liriodendri*).

Biology. A generalized armored scale life cycle is as follows: The eggs are laid underneath the waxy covering and hatch in one to three weeks. The newly hatched scales (crawlers) move about over the plant until they locate succulent new growth. They insert their piercing-sucking mouthparts into the plant and begin feeding. Female scales lose their legs and antennae during the first molt. They molt a second time before reaching maturity, and do not pupate. The cast skins (exuviae) are incorporated in the scale cover. Male scales go through two additional molts and pupate underneath the wax. Adult males are tiny two-winged, gnat-like insects without mouthparts. In some armored scales the adult stage is reached in six weeks, and there are several generations per year.

In the females of the soft scales the antennae and legs are not lost, but are reduced to such an extent that though the adults can move about somewhat, they seldom do. The wax when secreted, usually forms a sac at the rear end of the body enclosing the eggs, and the scale on the back of the insect becomes much thickened, forming a thick, fluffy mass. The life cycle is similar

to the armored scales except some soft scales require one year to reach maturity. Mealybug life cycle requires approximately 30 days at 80 F.

Host Plants. Virtually every woody plant is subject to attack by one or more species of scales. Some scales attack only a few species of closely related plants, while other species infest a wide variety of plants. Some common mealybug host plants are azalea, coleus, croton, cactus, rose, bedding plants and a large number of foliage plants. Mealybugs are one of the major problems affecting plants in greenhouses and interiorscapes.

Seasonal Abundance. Scales are present year-round. Many species overwinter in the egg stage and the crawler hatch is correlated with the flush of new growth in the spring. Other species overwinter in all stages. Populations build up throughout the spring and summer months.

Damage. On many ornamental plants, scale insects are the most serious pests, and most ornamentals are susceptible to one or more species of scales. Scales cause damage by sucking the juices from the plants. Heavily infested plants appear unhealthy and produce little new growth. Scales feeding on the undersides of leaves may cause yellow spots to appear on the top sides, and these spots progressively become larger as the scales continue to feed. If the scales are not controlled, leaves will drop prematurely, sometimes killing portions of twigs and branches. Scales also feed on trunks and stems of plants. Soft scales and mealybugs excrete large amounts of honeydew, which is rich in nitrogenous compounds and sugars. The honeydew excretion is an excellent medium for the growth of a fungus known as sooty mold. This black fungus coats the top side of leaves, interfering with photosynthesis and makes the plants unattractive. Armored scales do not excrete honeydew.

Sampling. Inspect plants closely at weekly intervals, especially plants where scale problems have occurred in the past. Since scale insects may occur on all plant parts, every part of the plant must be checked. Leaves should be examined on both surfaces, and particularly along the midrib of the underside. The use of a 10? hand lens or magnifying glass will aid in their detection. Stems should be checked around buds, leaf petioles and lenticels or other depressions which may afford a place for the scales to hide and feed. Pay particular attention to old wound scars where the bark is thin. Many times, the scale=s wax covering blends in with the bark and is difficult to see. The contrast between the bark and scale can be increased by wetting the bark with water before examining with a hand lens.

Dispersal of scales depends upon the movement of first instars (crawlers), which are motile in all species. Wind may blow crawlers to other plants. Crawlers are also moved about by birds or insects. The most important means is by movement of infested plants by man.

Aphids

General Description. Aphids or Aplant lice@ are soft bodied, pear-shaped insects generally less than 1/8" long. Their color varies according to species. However, the common ones are usually green, yellow or black. The most distinguishing feature in the identification of aphids is the two short cornicles, or tubes, which extend from the end of their body. These structures are partly responsible for secretions of a fluid thought to be a defense mechanism.

Important Species. There are approximately 1,375 species of aphids identified in the United States and Canada. The most common species encountered in Florida on woody plants are the black citrus aphid (*Toxoptera aurantii*), crape myrtle aphid (*Tinocallis kahawaluokalani*), cotton aphid (*Aphis gossypii*), green peach aphid (*Myzus persicae*), Oleander aphid (*Aphis nerii*),

podocarpus aphid (*Neophyllaphis podocarpi*), rose aphid (*Macrosiphum rosae*), yellow rose aphid (*Rhodobium porosum*) and the spirea aphid (*Aphis spiraecola*).

Biology. Most aphids are wingless, but when colonies become overcrowded or the host plant becomes undesirable, winged forms are produced that establish new colonies. Temperature and photoperiod also affect the production of winged and wingless forms.

Aphids are unlike most insects in two ways: (1) in Florida, almost all are females which reproduce without mating; and (2) they seldom lay eggs, but give birth to living young. Aphids have the ability to reproduce rapidly and there are many generations per year. Each female aphid produces 50 to 100 daughters during her life span and each daughter will begin reproducing in six to eight days.

Host Plants. Most species of aphids are specialists, feeding on one or a few closely related plants. Examples are crape myrtle, oleander, podocarpus and the rose aphid. A few aphids, such as the green peach and melon aphid, feed on a wide variety of plants. Some of the more frequently infested plants include camellia, crepe myrtle, gardenia, oleander, Photinia, podocarpus, rose and viburnum.

Seasonal Abundance. Aphids are present in largest numbers during the spring on the flush of new growth. Reproduction is augmented by nitrogen levels and this element is particularly high in portions of the plant that grow most rapidly. Also during the spring months, predators and parasites have not usually reached sufficient numbers to suppress the aphids. Some aphid species are present year-round, especially the green peach aphid, which also feeds on older leaves.

Damage. Aphids have piercing-sucking mouthparts and cause damage by sucking the plant juices. However, their ability to transmit plant virus diseases may be more harmful than any direct feeding damage. They are commonly found on the stems, undersides of leaves and on flower buds in colonies of individuals. They seem to be especially troublesome on plants that are in shaded areas. Their feeding causes the leaves to curl or crinkle, and flower buds may become hardened, causing the flowers to be distorted.

Aphids excrete large amounts of honeydew, which is a sugary liquid composed of unused plant sap and waste products. This provides an excellent medium for the growth of a black fungus called Asooty mold.@ Besides being unattractive, sooty mold interferes with photosynthesis and somewhat retards the growth of the plant. Sooty mold usually weathers away following control of the insect infestation.

Sampling. Examine the terminal stems and the undersides of leaves (especially the new growth) one to two times a week during the growing season. Finding tiny white cast skins deposited on the upper leaf surface is frequently the first indication of an infestation. Molting aphids inhabiting the undersides of leaves immediately above such deposits are the source of these cast skins. Ants feed on honeydew. Consequently, when ants are observed, plants should be examined closely for these sucking pests.

Whiteflies

General Description. Adult whiteflies resemble tiny white moths. However, they are not closely related to moths but are more related to scale insects. They are only about 1/16" to 1/8" and have four wings. The wings and body are covered with a fine white powdery wax. The immature stages (nymphs) are found on the underside of leaves and are flat, oval in outline, and slightly smaller than a pin head. They are lightgreen to whitish and somewhat transparent.

Important Species. Approximately 100 species of whiteflies occur in the United States and Canada. There are more than 1,150 species worldwide, mostly in the tropics. The most common whiteflies in Florida are the silverleaf whitefly (*Bemisia argentifolii*, formerly the sweetpotato whitefly), the citrus whitefly (*Dialeurodes citri*), the cloudy-wing whitefly (*Dialeurodes citrifolii*) and the wooly whitefly (*Aleurothrixus floccosus*).

Biology. The silverleaf whitefly deposits 100 to 300 eggs on the lower leaf surface of the host plant. Eggs hatch in five to seven days into the first nymphal stage known as a crawler. Crawlers are pale-green and move about the leaf seeking a suitable feeding site. They locate a site, insert their long, threadlike mouthparts into the lower leaf surface, become immobile, and soon molt, losing their legs and antennae. The resultant larvae are flat, oval, pale-green and nearly transparent. They resemble pale-green scales. After two additional molts, they pupate and the adult emerges. The life cycle from egg to adult requires 21 days at 80 F and more than 30 days at 65 F. They do not develop at temperatures cooler than 50 F. There are several generations per year.

Citrus whitefly development is similar, except they lay fewer eggs and there are three major generations per year. In the Gainesville area, these occur in late March, mid-June and late August (these are the times when adults will be noticed). In south Florida, they will be about two to three weeks earlier, and in north Florida, one week later.

Host Plants. Host range varies greatly with different species. The silverleaf whitefly feeds on approximately 700 species of plants, poinsettia being the most common host. The citrus whitefly commonly attacks citrus, allamanda, chinaberry, gardenia, ligustrum, poinsettia and many other annual, perennial and woody plants.

Seasonal Abundance. Some are present year-round. Largest numbers occur in late summer and early fall.

Damage. Both adults and immature whiteflies feed on the leaves of plants, but the larvae inflict the most damage. Their withdrawal of sap reduces plant vigor, and leaves display yellowing or chlorosis. Heavy infestations will cause the plant to wilt and eventually die. Larvae excrete large amounts of honeydew causing sooty mold.

Sampling. Observe for sooty mold. Tap plants to disturb adults. Inspect the undersides of leaves for larvae and pupal cases. Use a 10? magnifying glass if needed. Observe for evidence of predators or parasites.

Thrips

General Description. Thrips are very small, elongate, cylindrical, gregarious insects ranging from 1/25" to 1/8" in length. The nymphs are frequently pale-yellow and are highly active. The antennae and legs are relatively short. Adults are usually black or yellow-brown, but may have red, black or white markings and often jump when disturbed. They may have wings or may be wingless. If wings are present, they are long, narrow and fringed with hairs. Thrips are commonly referred to as fringed-winged insects.

Important Species. There are 264 species of thrips in the United States and Canada that are found on plants. Many other species are predaceous. The most common plant-feeding thrips in Florida are banded greenhouse thrips (*Hercinothrips femoralis*), Cuban laurel thrips (*Gynaikothrips ficorum*), flower thrips (*Frankliniella tritici*), greenhouse thrips (*Heliothrips haemorrhoidalis*) and red-banded thrips (*Selenothrips rubrocinctus*).

Biology. Thrips undergo gradual metamorphosis. A general thrips life cycle is as follows:

Female thrips deposit eggs in slits made in the leaf tissue by their sharp ovipositors. Each female lays 25 to 50 eggs which hatch in two to seven days into active nymphs. Immature thrips resemble adults; but immatures lack wings and are light-colored. The two nymphal stages are followed by two resting stages, the prepupal and pupal. The resting stages can be found either on the host or in the soil below the host. Under favorable conditions, the developmental period from egg to adult ranges from 11 days to three weeks, depending on the species. Hence, a population may increase quite rapidly. Parthenogenesis (reproduction without mating) occurs in many species. When male thrips are present, they are usually smaller than the females.

Host Plants. Thrips attack an extremely wide variety of woody plants including azalea, ardisia, avocado, dogwood, ficus species, gardenia, guava, hibiscus, magnolia, maple, palm, viburnum and many annual and perennial plants. Thrips occur throughout the growing season.

Damage. Thrips feed on the foliage, flowers, as well as young tissues in shoot apexes where the leaves are expanding. They puncture the plant cells with their raspingsucking mouthparts and withdraw cell sap. Feeding activities produce bleached, silvered or deformed leaves and necrotic spots or blotches on flower petals. Eventually the damaged foliage becomes papery, wilts and drops prematurely. Thrips produce large quantities of a varnishlike excrement that collects on leaves, creating an unsightly appearance.

Sampling. To aid in detecting thrips, place a sheet of white typing paper beneath the leaves or flowers and shake the plant. The thrips will fall onto the paper and can be more easily observed and identified than when on the plant. Also look for the small spots of varnishlike excrement on the leaves.

Because thrips are so small, use a 10? to 15? magnifying glass. Blue sticky traps have been developed for monitoring thrips and are available commercially. They appear to be somewhat more effective than yellow traps.

Lace Bugs

General Description. Adult lace bugs are approximately 1/8" long. Most species are gray or brown and somewhat rectangular. Some species have a broad hoodlike projection that extends over the head. Other species lack the projection and are elongate. The wings are sculptured, giving them a lacelike appearance. The nymphs are black or brown and have prominent spines.

Important Species. There are approximately 140 North American species. The most common species in Florida are the azalea lace bug (*Stephanitis pyrioides*), the hawthorn lace bug (*Corythuca cydoniae*), the lantana lace bug (*Teleonemia scrupulosa*) and the sycamore lace bug (*Corythucha ciliata*). The fringetree lace bug (Leptoypha mutica, the avocado lace bug (*Pseudacysta perseae*) and the oak lace bug (*Corythucha floridana*) are less frequently encountered.

Biology. Lace bugs have gradual metamorphosis (egg, nymphs and adult). Eggs are deposited in or on the tissue of newly developing leaves, usually along the midribs. Many species secrete a brownish substance that hardens over the eggs, which secures them to the leaf. There are five to six nymphal instars. Depending on the species and the weather, the life cycle requires four to seven weeks, and there are three to five generations a year.

Host Plants. Some of the more common host plants include azalea, fringetree, lantana, loquat, oaks, pyracantha and sycamore. Most lacebugs are host specific, feeding on one or a few species of host plants.

Seasonal Abundance. Lace bugs appear throughout the year, but are more prevalent in late summer and fall.

Damage. Nymphs and adults withdraw plant sap with piercing-sucking mouthparts. Infested leaves are stippled with brown, yellow or white blotches on the upper surface. Lower surfaces are disfigured by cast nymphal skins, stains from excrement, and from the brownish shields covering the eggs. Severe infestations cause leaves to become almost white and drop from the plants. Most species prefer sunny habitats.

Sampling. Most lace bugs have very specific host preferences, which aid in field identification. Examine the underside of leaves for adults and the spiny, dark nymphs. There will be dark-brown spots and stains present. When disturbed by pulling a leaf from a plant for observation, lace bugs exhibit a peculiar bouncing movement.

Mites

General Description. There are three major groups of mites that attack ornamental plants. They are the spider mites, the false spider or flat mites, and the gall or eriophyid mites. Mites are not insects, but more closely related to spiders and ticks. The body of spider mites and false spider mites is separated into two distinct parts: (1) the gnathosoma and (2) the idiosoma. The gnathosoma includes only the mouthparts. The idiosoma is the remainder of the body, and parallels the head, thorax and abdomen of insects. After hatching from the egg, the first immature stage (larva) has three pairs of legs. The following nymphal stages and the adult has four pairs of legs.

Spider mites are the most common mites attacking plants. False spider mites and eriophyid mites are less common. Eriophyid mites exhibit great modification of body structure. They have only two pairs of legs; the four rear legs are absent. They are microscopic, elongate, spindle-shaped and translucent, and the abdomen usually has transverse rings present.

Important Species. The most common spider mites found in Florida infesting ornamental plants are the two-spotted spider mite (*Tetranychus urticae*), southern red mite (*Oligonychus ilicis),* six-spotted spider mite (*Eotetranychus sexmaculatus*) and the spruce spider mite (*Oligonychus ununguis*). The predominant false spider mites are the privet mite (*Brevipalpus obovtus*) and *Brevipalpus phoenicis* (no common name). There are hundreds of species of eriophyid mites. Many species attack foliage plants, bedding plants and woody plants. Some of the most common are *Eriophyes buceras* on black olive, *Acaphylla steinwedeni* on camellia, *Trisetacus quadrisetus* on juniper, *Paracalacarus podocarpi* on podocarpus and *Phytoptus canestrinii* on boxwood.

Biology. Spider mite development differs somewhat between species, but a typical life cycle is as follows: The adult female can lay several hundred eggs during her life. Eggs are attached to fine silk webbing and hatch in approximately three days. The life cycle is composed of the egg, the larva, two nymphal stages (protonymph and deutonymph) and the adult. The length of time from egg to adult varies greatly depending on temperature. Under optimum conditions (about 80 F), spider mites complete their development in five to twenty days. There are many overlapping generations per year.

The majority of eriophyid mite species go through four stages of development **C** the egg, two nymphal instars and the adult. The length of life cycle is variable depending on the species, but it is usually approximately seven days.

Host Plants. Some of the more common plants attacked include azalea, camellia, citrus, eleaeagnus, hibiscus, ligustrum, Photinia, pyracantha, rose, viburnum, juniper, arborvitae, cedar, holly, pittosporum, and many foliage and annual plants. Eriophyid mites attack a wide range of plants including black olive, camellia, juniper, podocarpus, boxwood, maple and citrus.

Seasonal Abundance. The two-spotted spider mite prefers the hot, dry weather of summer and fall, but may occur anytime during the year. Southern red mite populations are at their peak during the winter months under mild, humid conditions. These mites can be found year-round in the landscape, especially on shaded or stressed pyracantha. Populations in the nursery usually disappear when the new spring growth develops.

The six-spotted spider mite is most abundant during winter and spring on azalea, especially after a cold winter. Spruce spider mites occur during the hot, summer months, especially on plants under water stress. False spider mites and eriophyid mites occur throughout the year, but predominantly during the summer and fall.

Damage. All mites have needlelike piercing-sucking mouthparts. Spider mites feed by penetrating the plant tissue with their mouthparts and are found primarily on the underside of the leaf. All spider mites spin fine strands of webbing on the host pant, hence their name.

When two-spotted spider mites remove the sap, the mesophyll tissue collapses and a small chlorotic spot forms at each feeding site. An estimated 18 to 22 cells are destroyed per minute. Continued feeding causes a stippled, bleached effect and later, the leaves turn yellow, gray or bronze. Complete defoliation may occur if the mites are not controlled.

Southern red mites first attack the lower leaf surface. As the population increases, the mites move to the upper surface. Injured leaves appear gray. Six-spotted mites feed along the midrib on the underside of the leaf. The upper surface has yellow spots. When heavy infestations occur, the entire leaf becomes yellow, distorted and drops prematurely. Spruce spider mite feeding causes the plants to appear off-color and eventually turn completely brown when high numbers are present.

False spider mites produce no webbing. Damage from these mites varies considerably, ranging from faint brown flecks to large chlorotic areas on the upper leaf surface to brown areas on the lower leaf surface, depending on the host.

Eriophyid mite feeding results in the following damage symptoms: (1) russeting of leaf and fruit (citrus); (2) leaf galls (juniper); (3) leaf blistering on top with hairy growth underneath (black olive); (4) discolored and stunted terminal growth (podocarpus); and (5) discolored bud scales, floral parts and leaves (camellia).

These mites are thought to possess chemicals in their salivary secretions that act as growth regulators. When the mites feed, these chemicals are injected into the plant. Leaves may become discolored or plant growth patterns may be changed. On foliage growth, modifications are initially more readily found on embryonic plant tissue. Russeting, which is discoloration, occurs on mature leaves and fruits.

Eriophyid mites induce plant galls developed from epidermal cells that are infected by injected growth regulators. Each species of mite has particular chemicals that cause galls to form which are of specific benefit to the mite. After the induced change has altered the behavior of the affected cell or cells, the mite does not have to remain on the site to insure continuation of gall growth. Eriophyid galls occur on soft plant parts, usually on green tissue that was infested when the plant was young. Galls occur in many different shapes. These include pouch or purse galls, bladder galls, nail galls, finger galls and head galls.

Sampling. For detection of spider and false spider mites, a 10? to 15? magnifying glass is a necessity. Examine the undersides of the leaves closely for mites, cast skins and webbing. A more proficient technique is to place a sheet of white typing paper or white paper plate beneath the leaves and strike the foliage sharply. The mites will fall onto the white surface and can be more easily observed and identified than on the green foliage.

Eriophyid mites are so small they are virtually impossible to see without a microscope and a trained eye. If damage symptoms indicate a possible infestation, take the affected plant parts to your county extension office.

Chewing Insects

General Description. The two major groups of insects that cause damage to plants via their chewing mouthparts are the caterpillars and beetles. Other chewing insects that are sometimes damaging to plants include grasshoppers, katydids and their relatives. Caterpillars are the immature or larval stage of moths and butterflies. Their bodies are usually cylindrical and either slender or robust. However, some are oval and others are flattened. They may be striped, marked with various color patterns, or solid. They also may be naked or extremely hairy. Most mature larvae are :" to 1**2**" long, but some are much smaller and some may be more than 4" long. Caterpillars have three pairs of jointed, true legs on the thorax and usually four pairs of soft, fleshy projections (prolegs) on the abdomen, with a fifth pair at the extreme rear of the abdomen. The prolegs have tiny hooked spines (crochets) to aid in holding on to leaves and other plant parts.

Many species of beetles frequently cause injury to ornamentals. Both the adult stage and the larval stages are injurious, and both have chewing mouthparts. Some beetles, such as lady beetles, are extremely beneficial in both the larval and adult form. Adult beetles vary in size tremendously; some are less than 1/8" long and some are more than 2". They may be any color or combination of colors. However, the most common colors are black or brown. The larvae of beetles vary greatly in feeding habits, body shape, size and color. Some species feed on leaves while other species feed on roots (grubs). Some are elongate with relatively long legs and may be brightly colored, while others, usually grubs, are robust, C-shaped, and white with a brown head. Mature beetle larvae vary from 1/8" to more than 2" in length.

Grasshoppers are :" to almost 3" in length, gray or brownish, and some have brightly colored hind wings. The lubber grasshopper is the largest grasshopper in Florida. Adults often exceed 2**2**". They have very short wings, are clumsy and incapable of flight. There are two color forms in the adults. Some are yellow with red, brown and black markings, and others are almost black. The nymphs are black with red markings.

Important Species. There are more than 11,000 species of moths and butterflies in the United States and Canada. More than 95 percent of the economically important species are the larvae of moths. Very few butterfly larvae damage plants. Adult moths and butterflies feed on nectar, pollen, etc., and are not harmful to plants. There are more than 30,000 species of beetles in the United States and Canada, and most feed on plants. The short-horned grasshopper complex and the eastern lubber grasshopper are the most damaging grasshoppers in Florida.

Biology. The life cycle of moths and butterflies is divided into four distinct stages: (1) the egg; (2) the caterpillar, or larva; (3) the pupa, or resting stage; and (4) the adult. Although there is considerable variation in the group, the life cycle is quite similar for the different species. In

general, adult females lay several hundred eggs, singly or in clusters. The eggs hatch in two days to two weeks. The larvae begin feeding immediately after hatching. After feeding for several days, the caterpillar molts and, in the process, increases greatly in size. The period between each molt is a larval instar. Caterpillars pass through five to seven larval instars before they enter the pupal stage. Many moth larvae construct small earthen cells below the surface of the soil in which they change to the pupal stage, while others construct silken cocoons. Two to three weeks are spent in the pupal stage, where they transform to adult moths.

After the adult emerges from the soil or cocoon, mating takes place and the female is ready to lay eggs. Under optimum conditions, three to six weeks are required for most moths to develop from egg to adult.

Like moths, beetles go through a complete body change or metamorphosis (egg, larva or grub, pupa and adult).

Host Plants and Damage. Virtually all plants are subject to attack from one or more species of beetles, beetle larvae, or grasshoppers and their relatives.

Caterpillars begin feeding immediately after hatching. Initial infestations of newly hatched caterpillars are difficult to detect because they feed on the tissues of the lower leaf surface. After feeding for several days, leaf skeletization begins to appear. Mature larvae chew holes or irregular areas in the leaves or flowers.

Adult beetles usually feed on foliage or flowers while the larvae or grubs feed on foliage or roots, or bore through stems. Like caterpillars, some species restrict their feeding to a single plant while others are general feeders. Usually they chew holes in the leaves along the leaf margins. Sometimes they cause scars on the leaf by chewing only through the upper epidermis. Many species of beetles feed during the night hours. The damage is noticed the following day; however, there are no insects present because they tend to hide under mulch or other debris on the soil surface during the daylight hours.

Sampling. Observe for caterpillars, beetles or other chewing pests or for leaf skeletonizing or holes in the leaves during the regular scouting of the nursery.

Leafminers

General Description and Important Species. Leafminers are so named because of their habit of mining between the upper and lower surface of leaves. They are one of the most serious pests of commercial flower crops, especially chrysanthemums, as well as bedding plants. With very few exceptions, azalea and hollies for example, they are not a serious problem on woody ornamentals.

Leafminers may be the larvae (maggots) of flies, caterpillars of moths or grubs of beetles. The most damaging leafminers in Florida are the serpentine group, which leave winding trails in the leaves. Foremost among these is the vegetable leafminer (*Liriomyza sativae*). The adult is a small, black fly about 1/20" long and marked with yellow or gold patches. The larva is laterally compressed, legless and headless. It is yellowish and may have dark intestinal contents. The blotch leafminers (*Amauromyza* spp. and *Phytomyza* spp.) are another important group of leafminers that produce a blotch or blister instead of a serpentine mine. The adults are black or gray flies about the size of the common housefly.

Three lepidopterous leafminers of importance in Florida are the azalea leafminer (*Caloptilia azalealla*), the palm leafminer (*Homaledra sabalella*) and the oak leafminer.

Comparatively few beetles have developed leaf-mining habits. However, the magnolia leafminer (*Prionombrus calcealus*) is an economic pest in some areas of Florida.

Biology. All leafminers have complete metamorphosis (egg, larva, pupa and adult). The entire life cycle of the vegetable leafminer can be completed in 21 to 28 days and even more rapidly if conditions are favorable. Adult females insert their eggs into the leaf tissue. Eggs hatch in one to three days into laterally compressed maggots. Larval development requires three to four days during which the characteristic mine is made. The mature larva usually cuts a hole at the end of its mine, emerges and drops to the soil to pupate. The tiny yellow puparia, which is approximately 1/16" long, can be found on the soil around the host plant. Adults emerge in seven to 14 days. There are many generations per year.

Amauromyza flies also insert their eggs into the leaf, and larvae develop inside the leaf. Pupation is outside the leaf tissue, and the puparium is reddish. Little detailed information is available on the life cycle of *Amauromyza*.

Larvae of *Phytomyza* form a linear mine in the first instar. This mine later develops into an irregular blotch. Pupation occurs in the mine. The larvae feeds slowly throughout the summer and overwintering takes place in the third instar or pupal stage.

The azalea leafminer deposits eggs on the underside of the leaf along the midrib. Early larval instars mine between the leaf surfaces. Later they roll the leaf over their body and continue to feed on the leaf surface. When mature, the larva often selects an undamaged leaf, rolls up in it and pupates. The adult moth emerges in about a week, mates and begins the cycle again.

The palm leafminer, or skeletonizer moth, deposits eggs on the unfolding fronds. The larvae are gregarious and create large longitudinal mines. Pupation occurs on the leaf, and there are several generations each year.

Host Plants. Serpentine leafminers attack a number of plants inside greenhouses, under Saran cover and outdoors. Host plants include ageratum, aster, calendula, chrysanthemum, dahlia, gerbera, gypsophila, marigold, petunia, snapdragon and zinnia.

Blotch leafminers (*Amauromyza*) attack chrysanthemum and other flowering plants. Phytomyza attacks many species of holly. Seven species of *Phytomyza* are recorded in Florida, of which four feed as leafminers on *Ilex* spp. The azalea, palm and magnolia leafminers are host-specific.

Seasonal Abundance. The Dipterous leafminers (*Liriomyza* and *Amauromyza*) occur throughout the year but peak numbers coincide with warm, dry weather. *Phytomyza vomitoriae*, the primary leafminer pest of the *Phytomyza* spp., attacks Yaupon holly and is a cool-season pest. The azalea leafminer is also a cool-season pest. The palm and oak leafminers occur primarily in the summer and fall months.

Damage. Leafminer larvae tunnel through the leaves, feeding on the parenchymal cells between the upper and lower epidermal leaf surfaces. *Liriomyza* spp. produce a serpentine mine. These mines appear in the upper leaf surface three to five days after oviposition.

In addition to the mines, leaves may appear stippled due to the numerous feeding punctures made by the female fly's ovipositor. Adult flies feed on the sap exuding from these wounds. Feeding punctures occur particularly along the margin or at the leaf apex. Larvae feed singly but mines may be numerous and cross each other.

Amauromyza spp. produce a blotch or blister mine, which appears as a broad brownish spot on the leaf. One to several larvae may inhabit a single blotch mine. *Phytomyza* spp. attack holly, producing large unsightly blotches that can cover much of the foliage in heavy infestations.

Some mines begin as a serpentine trail and end in a blotch mine.

The feeding tunnels and oviposition punctures of dipterous miners are unsightly and objectionable in the market of crops. Depending on the severity of the attack, feeding will reduce assimilation by the plant. This can lead to desiccation and premature leaf loss. If sufficient leaves are attacked, crop production is severely reduced. Seedling plants may be totally destroyed. The wounds in foliage also provide an entry site for fungal and bacterial plant pathogens. Some species have been incriminated as vectors of plant viruses.

The azalea leafminer is a leafminer only for the first half of its larval life. Upon hatching, the young larvae enter the leaf and feed as leafminers, creating a blister on the underside of the leaf. Mid-sized larvae migrate to the upper leaf surface and by means of silk pull the leaf over their bodies and chew holes in the leaf. The larvae may also tie newly expanding leaves together at the tip of a shoot and feed in the same manner. The larvae are then known as leaftiers. After they emerge, the leaf tip or margins fold over. Injured leaves usually turn yellow and drop.

The palm leafminer larvae are gregarious and create longitudinal mines covered with brownish frass pellets webbed together with silk. Oak leafminers attack several species of oaks and usually make a blotch or blister mine. Magnolia leafminers also make blister-like mines, usually at the margin of the leaves. In cases of severe infestation, the leaves turn brown as if scorched by fire.

Sampling. Leafminer populations can be monitored by several methods. Observations of susceptible plants indicate the pest presence. Adults can be caught using sweep nets. Dipterous leafminer adults are attracted to yellow sticky cards or cups placed over the top of the plant canopy. Cards are available commercially or can be constructed by cutting cardboard into 3 ? 5 inch pieces, painted bright yellow and then covered with Tac Trap**7** or STP**7** oil treatment. Also, Solo**7** yellow plastic drinking cups coated with the above adhesives and stapled on stakes above the plant canopy are commonly used. One of these devices every 1,000 square feet throughout susceptible host plants should be sufficient for monitoring adult flies. The number of flies captured on a series of cards or cups in the nursery during a 24-hour period indicates the relative abundance of leafminers. Trapping should be repeated at least weekly. Early detection of adult miners using these monitoring techniques can improve population management.

Boring Insects

General Description and Important Species. Many species of boring insects attack the trunk, stems, bark, buds and roots of woody ornamental plants, and trees in the nursery and landscape. Some bore deeply into the wood (buprestid, cerambycid and ambrosia beetles); many bore just under the bark (dogwood borer, elm borer and bark beetles). Twig beetles are found only in smaller terminal branches (black twig beetles and dogwood twig borer). Others attack the wood near ground level as well as the roots (magnolia borer). The giant palm weevil feeds in the buds of palms.

The two major groups of boring insects attacking woody plants include various beetles and clearwing moths. The primary families of beetles include Cerambycidae (longhorn or round-headed borers), Buprestidae (metallic wood borers or flat-headed borers) and Scolytidae (bark beetles, wood-boring bark beetles and ambrosia beetles). The clearwing moths all belong to the family Sesiidae.

Cerambycid beetles are **2**" to 3" in length, elongate, cylindrical and have long antennae.

Color varies greatly. Virtually all are wood borers in the larval stage. The larvae are whitish, elongate, cylindrical and legless. There are more than 1,400 species in the United States. Buprestid beetles are 3/8" to 1**3**" long, elongate-oval and often metallic-colored. The larvae are whitish with the head greatly expanded and flattened. There are more than 650 species in North America.

Scolytid beetles include the bark and ambrosia beetles. These are small beetles, 1.5 to 8 mm in length, cylindrical, and usually brown to black. The larvae are small, white, C-shaped, legless grubs. The head and mandibles are dark. Most of the economically important scolytids are in three genera: *Dendroctonus*, *Ips* and *Scolytus*.

The clearwing moths, unlike other moths, have no scales on their wings; thus they are transparent or clear. Many species look almost exactly like bees or wasps. They are brightly colored and are active during the day. There are 115 species in North America. The larvae are white and usually without markings. Some of the most common species in Florida include the dogwood borer (*Synanthedon scitula*), elm borer (*S. geliformis*) and maple callus borer (*S. acerni*).

Biology. Buprestid beetles deposit their eggs on the bark, in crevices in bark or under the bark at the edge of wounds. Most spend the winter as adults in pupal cells. The life cycle usually requires one to three years, however some species have several generations per year. Cerambycid beetles deposit eggs in protected places on the bark. The larvae feed on the inner bark, then bore into the sapwood or heartwood.

In some species, the life cycle requires two to three years. Other species have several generations per year. Scolytid beetles usually have two to six generations per year. The Scolytid bark beetles feed on the inner bark of trees. Ambrosia beetles bore into the wood and feed on an ambrosia fungus, which they cultivate. Bark beetles have a large spine at the apex of the front tibia. Ambrosia beetles lack the spine. Clearwing moths typically have one to two generations per year.

Host Plants. Virtually all woody plants and trees are subject to borer attacks. Most always borers attack unhealthy or stressed plants or trees. The preferred and most effective management practice is to keep plants and trees healthy. Prevention is the best cure.

Seasonal Abundance. Borers may attack woody plants anytime during the year, but predominately during the spring, summer and fall months.

Damage. Buprestid larvae tunnel under the bark and some species excavate winding tunnels through the sapwood. These tunnels, often filled with frass, are oval in cross section, more than 3 mm wide, and usually enter the wood at an angle. Foliage discoloration occurs and there is usually noticeable sap-staining of bark around holes. Cerambycid larvae tunnels are circular in cross section, more than 3 mm wide, go straight into the wood for a short distance before turning, and are free of frass. Foliage discoloration occurs, and as in Buprestid damage, there is sap-staining of the bark around holes. There are also usually cone-shaped holes in the bark, made by the female for egg deposition.

Scolytid bark beetles mine between the bark and wood, usually engraving both. They attack twigs, branches, trunks and roots. When the larvae hatch, they feed away from the egg tunnel at right angles. Conifers that are attacked form pitch or resin tubes.

Scolytid wood-boring bark beetles bore directly into the wood and feed on woody material in both adult and larval stages. Scolytid ambrosia beetles bore directly and deeply into the sapwood. They introduce and feed on ambrosia fungi. The fungi, not the beetles or their larvae,

feed on the wood fiber. Their boring activities cause white fluffy boring dust to accumulate at the base of the infested tree or woody plant. Small holes, 2 to 3 mm wide, will be noticed in the bark. The galleries are full of frass and stained a bluish or brownish color from the fungi.

Clearwing moths characteristically deposit eggs near wounds on the trunk. They usually tunnel beneath the bark causing blistering, peeling and spongy areas. Some leave the pupal skin sticking out of their emergence hole.

Sampling. Observe trees and woody plants for sap stains, holes in the bark, blistered, peeling or spongy bark areas, especially on plants that are stressed or have been subjected to trunk injury. Pheromones have been identified for many clearwing moths and can be used to monitor for them.

Insect Galls

General Description. Galls occur on a wide variety of woody plants. These growths may be the result of fungi, bacteria, nematodes or mites, but insects are the prime cause. Gall-forming insects include aphids, phylloxerans, psyllids, midges (gall gnats) and cynipid wasps (gall wasps). The gall wasps (order Hymenoptera, family Cynipidae) are the most important insects that induce plant galls. These wasps are very small and all but a few species are less than 3" in length. Color varies greatly. Some species are black, others are red, yellow or amber. The larvae are legless, and larvae and pupae are white.

These growths are called galls because they contain large amounts of tannin, which has a very bitter taste. Long ago they were known as gallnuts. Galls vary widely in size, shape, texture and color. It is not uncommon to find several different species on the same woody plant or tree. If galls are cut open, larvae, pupae and adults may be observed if they have not emerged. Of more than 2,000 gall-producing insects in the United States, 1,500 are either gall gnats or gall wasps.

Biology. Plant galls are abnormal growths of plant cells formed as a response to the insect's stimulus caused by egg laying or larvae or nymph feeding. In the spring, before leaves are fully developed, eggs are laid in the leaf or stem.

The immature insects can often be found in a cell or cells within the developing gall. After a brief period of cell growth, gall development stops. The insect becomes enclosed by the gall and feeds only on gall tissue during its development. Small holes on the outside of the gall indicate that the adult insects have emerged.

Damage. Gall production is believed to result from the reaction of cambium and other meristematic tissues to stimuli produced by the larvae.

Each gall-forming insect produces a gall that is characteristic of that particular insect. Some galls may be 2" in diameter, while others are so small they are rarely noticed. They occur in almost every conceivable form and color, and their shapes range from spheres to tubes. The surface may be smooth, hairy or covered with spines. Gall susceptibility varies greatly between species in the same location. This is probably due to the general condition of the particular plant and its natural resistance.

Galls are found most commonly on the stems and leaves but also occur on trunks, flowers, leafshoot terminals, petioles and roots.

Sampling. The insects that produce the galls are seldom noticed because the major gall-forming insects such as the wasps and gnats are extremely small. However, the actual gall can readily be observed.