Core Manual
Master Gardener
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Insects

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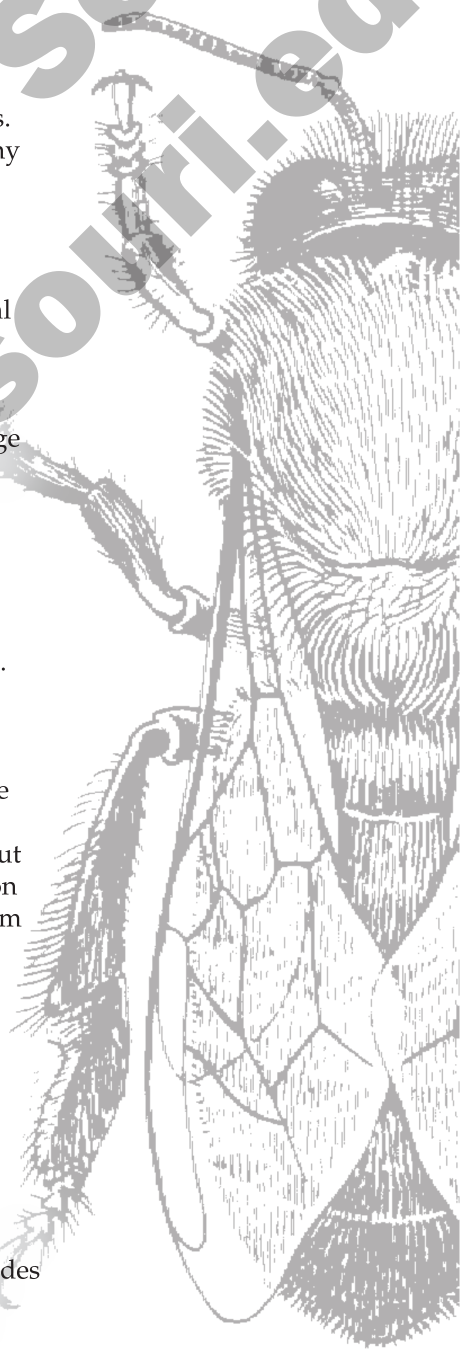
Insects are the most abundant animals on earth. They exert important effects, both positive and negative, on our lives in ways we may not even think about. While the vast majority of insects are either beneficial or harmless, we often are most familiar with those insects that cause problems. For example, the mosquito is responsible for more deaths each year than any other insect.

On the whole, insects are enormously beneficial. Insects pollinate plants and provide food for birds, fish and animals. Many beneficial insects prey on other insects that are pests. By studying insects, we gain a better understanding of their role in the web of life, as indicators of environmental quality, as predators of harmful species, and as potential threats to crops, homes and health. Also through the study of insects, we help to preserve beneficial species by understanding their behavior patterns and modifying their habitat. Our ultimate goal as Master Gardeners is to reduce the damage caused by insects.



Insect basics

Insect classification

Insects are divided into categories using a standard classification system. Each insect is identified by a unique genus and species, just as plants are. This system is known as binomial nomenclature, which means "naming with two names." Common names differ from state to state and country to country. The binomial nomenclature system ensures that the scientific name of an organism is the same throughout the world in whatever language is prevalent. Binomial classification is just a filing system for information about organisms, organizing them within related groups based on shared common attributes such as structure, function and life history. To illustrate this system of classification, the honey bee can be described as follows:

Phylum: Arthropoda
Class: Insecta
Order: Hymenoptera
Family: Apidae
Genus: *Apis*
Species: *mellifera*
Common name: honey bee

The phylum Arthropoda — the highest level in this classification — includes all organisms with an external skeleton, jointed legs and ventral nerve cord.

The arthropods are then subdivided into smaller groups, each with its own unique features. This additional grouping based upon like features is known as a class, the largest of which is Insecta, which includes all insects.

The class Insecta refers to organisms with three pairs of legs, external mouthparts, three body regions of head, thorax and abdomen, and one pair of antennae (Figure 1). Several other types of arthropods commonly confused with insects are spiders, ticks and mites. These organisms are in the class Arachnida, primary characterized by four pair of legs and only two body regions.

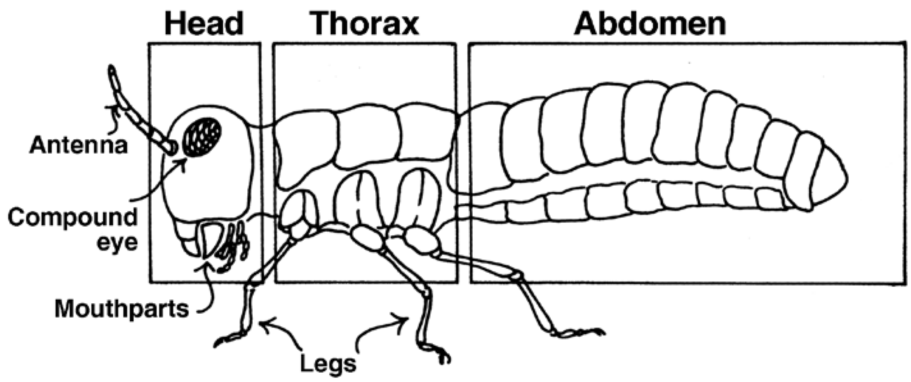


Figure 1. All insects have three main body segments – head, thorax and abdomen. The head contains the mouth and associated parts for food manipulation, the main sensory organs, including antennae and the compound eye, and the brain. The thorax contains the body parts used for locomotion – legs and wings. The abdomen contains the internal organs. Many females have an ovipositor for placement of eggs.

Insects, like all other living organisms, are grouped into orders, often by characteristics such as physical appearance and behavior. Each insect order consists of any number of families, within which are genera (the plural of genus) and species.

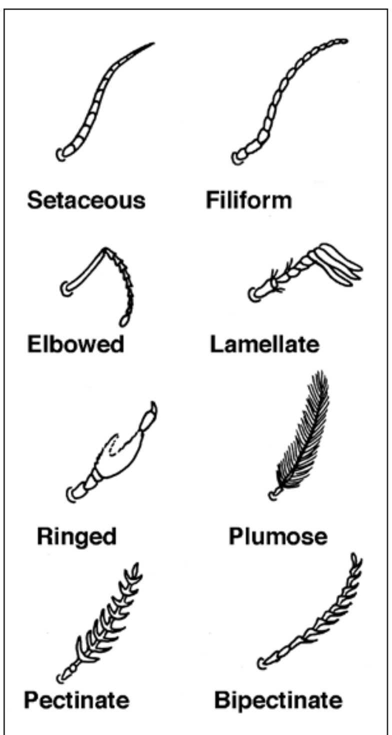


Figure 2. Insects sense their enviroment with antennae. Insects mainly sense smell but also sound and vibration, finding food as well as mates by perception of chemicals. Antennae are important in insect identification.

Three main sections of an insect

Head

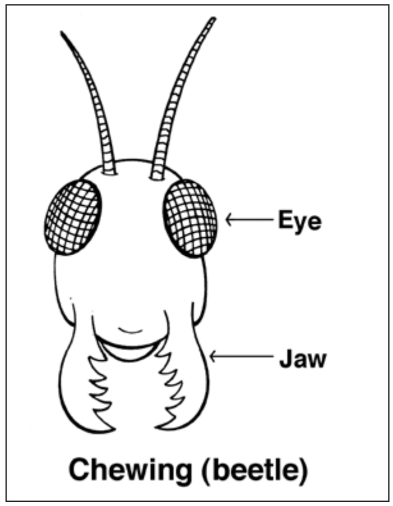
The head is the hardened region at the front of the body, which includes the eyes, antennae and mouthparts. There are two types of eyes. Simple eyes are small eyes located on top of the head in adults. Compound eyes are the large eyes found on most adult insects. These eyes contain a few to several thousands of individual eye units.

Insects have one pair of antennae, which are two long, jointed feelers that grow from the insect's head. Antennae come in many forms and can be used to aid in insect identification. Antennae function as sensors to detect the odor, sound, taste and feel of the surrounding environment (Figure 2).

Insect mouthparts and implications for control. Insect mouthparts are of two main types: chewing and piercing-sucking (Figure 3). Some insects have modifications of these two basic types. Mouthparts determine how an insect feeds and therefore play a role in the type of insect control that is most effective. Insects feed on leaves, buds, stems, roots, fruits and seeds, as well as on plant tissue at various stages of decay. They feed internally or externally. Insects that restrict their feeding to one type of plant only are referred to as monophagous. Others may be general feeders and include a diversity of plants in their diet and are said to be polyphagous. Insects that are moderately discriminating in their tastes are referred to as oligophagous. An example is the Colorado potato beetle, which feeds only on plants in the genus *Solanum.*

Insects exhibit great variation in their mouthparts, which have evolved to fit the various diets on which insects feed. The most basic mouthparts, from which all other types have evolved, are for chewing. Predators such as the lady beetle have chewing mouthparts, but the mandibles have evolved into long, pointed appendages they can also use to grasp prey.

Chewing mouthparts allow the insect to bite or rasp off and swallow solid food. Symptoms of the damage caused by chewing insects include holes in plant tissue, missing leaves, "windowpane" leaves showing bared veins, and scraped areas. Insects with chewing mouthparts feed externally on the plant parts and have strong mandibles. Caterpillars use their chewing mouthparts to consume many times their own weight in plant tissue in the course of their development. Much fibrous tissue passes through the caterpillar gut undigested and forms a major part of the large fecal pellets caterpillars leave behind. These pellets are a characteristic sign of caterpillar damage and serve to distinguish these pests from those with other kinds of mouthparts.



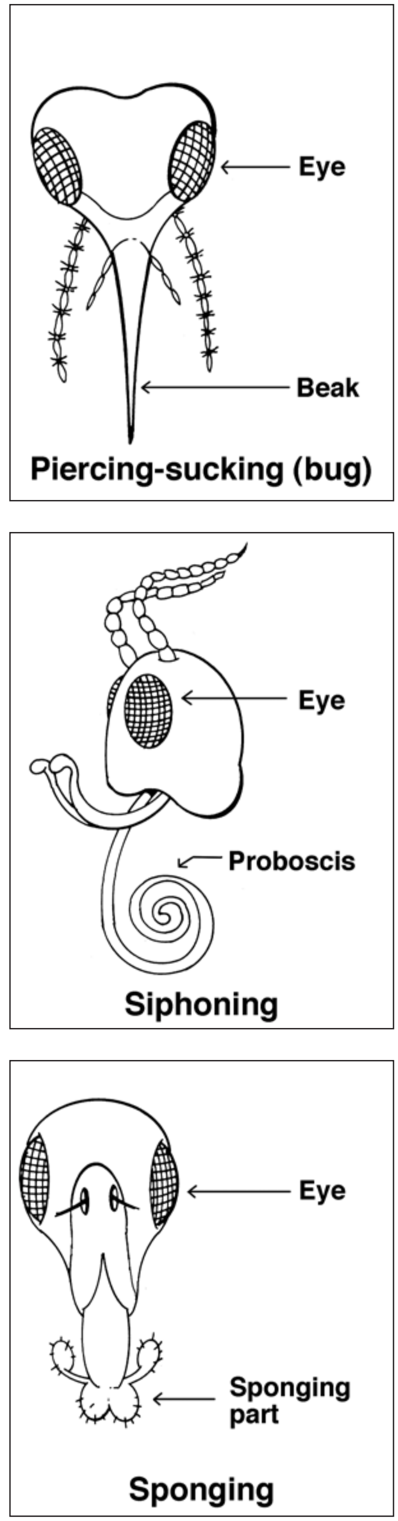


Figure 3. Insect mouthparts are highly variable, depending on how an insect feeds. Chewing mouthparts are the most general type. Piercing-sucking mouthparts have become modified for piercing the skin of animals or plants and sucking liquid food. Other common modifications enable particular insects to collect liquid food with long, coiled tubes or spongelike structures.

Many insects feed on liquid food for which chewing mouthparts are not effective. Many of these insects have a beak, referred to as a proboscis, that is modified to suck up liquids. The "piercing-sucking" mouthparts of such insects have evolved into fine stylets that can pierce plant and animal tissue to extract fluid nutrients.

Insects with piercing-sucking mouthparts feed on plant sap by piercing plant tissue and extracting plant fluids. Their delicate stylets can penetrate leaves, stems and even tree bark, and are flexible enough to pass between fibrous plant elements and probe to find phloem or vascular bundles. Because they are removing plant fluids, symptoms of their feeding damage include spotting, curling, wilting and ultimately tissue death. Insects with piercing-sucking mouthparts feed internally on plant tissue. Damage results from the removal of plant fluids, the toxicity of insect saliva to the plant, or diseases transmitted by the insect mouthparts. Insects with these mouthparts ingest primarily plant fluids, and their feces are watery and sticky (referred to as honeydew in some insects such as aphids and scales).

Butterflies and moths have a long, slightly coiled proboscis that serves to siphon plant nectar. House flies have a proboscis that has modified into a kind of sponge. House flies regurgitate salivary enzymes onto their food and then lap up the predigested, liquid food with their sponging mouthpart. Thrips have a short, stout proboscis and three stylets modified for rasping-sucking. It is thought that thrips scrape the surface of a plant to make the epidermal layer easier to penetrate. The stylets of mosquitoes are slender and needle-like to penetrate the skin of animals and suck blood. The itching sensation associated with mosquito bites is due to an anticoagulant that is injected into the skin to keep the blood flowing while mosquitoes feed.

Identification of mouthparts is a key to correct diagnosis of insect damage, which in turn is critical to selecting correct control tactics. If an insect has chewing mouthparts, it will ingest a pesticide that is present on the surface of the plant. However, if an insect has piercing-sucking mouthparts, any pesticide on the surface of the plant will not be ingested because the insect feeds internally within plant tissue. To kill insects with piercing-sucking mouthparts, an insecticide must have contact toxicity — meaning it kills by just contacting the insect. (See section on ***Insect control*** for more information.)

Thorax

The thorax is the second section of the insect's body and contains the muscles that control the insect's movement. Wings and legs are attached to the thorax. Insects have three pairs of legs, and each leg has five parts even

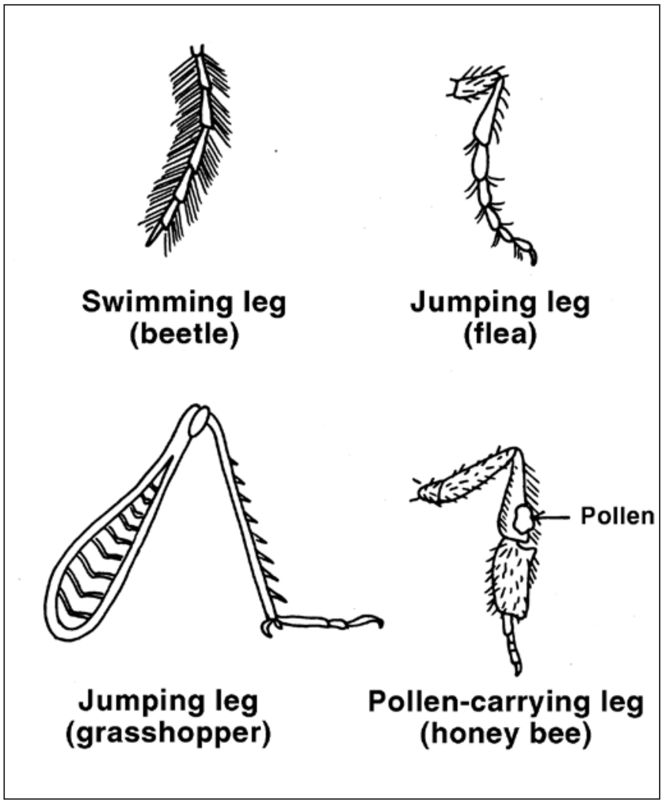


Figure 4. The thorax of an insect is specialized for locomotion and has three pairs of jointed legs. Each leg is composed of six segments. Many insects have a pair of claws (tarsi) at the end of their legs. These claws enable insects to climb and hang on surfaces upside down.

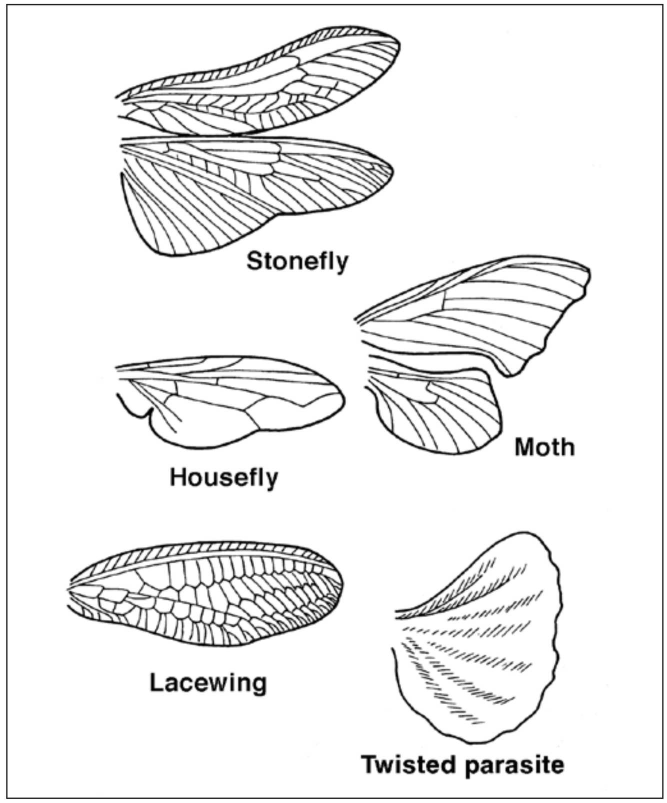


Figure 5. Insect wings are almost always found only on mature insects. Most insects have two pairs of wings. In several groups of insects, such as beetles, the front wings are more hardened and serve as protection for the hind wings. Some insects (e.g., fleas and lice) have no wings.

though these can be hard to distinguish in many species. Legs come in many forms depending on their function, such as running, jumping, grasping or swimming (Figure 4). Insect wings also vary greatly in shape, size, color, thickness and vein pattern. The shape of the insect wings and the pattern of veins are used widely in identification (Figure 5). Not all adult insects have wings.

Abdomen

The abdomen is the third and final section of an insect's body. It may be visible or hidden under the wings. This section contains the internal organs of an insect, including the stomach and intestines, where food is digested and absorbed. The sexual organs are in the abdomen as well. The abdomen has glands that secrete various fluids to mark the insect's trail, for example, or to drive enemies away, attract mates or signal to others the location of food supplies. The abdomen may also have a needle-like projection for piercing or stinging.

Most female insects have an added appendage called an ovipositor at the end of the abdomen. The primary function of the ovipositor is for placing eggs in a protected location during egg laying. Most insects with an ovipositor make a hole with this appendage and then place the egg in that hole. In some insects such as many bees and wasps, the ovipositor has been modified into a stinger for protection. Male bees and wasps cannot sting as they do not have an ovipositor. Parasitic wasps that lay their eggs on or in their hosts use the ovipositor to sting the prey before placing the egg in or on the prey.

How insects grow and develop

Insect development occurs through changes not only in size but also in form. The series of changes that insects undergo as they grow and develop to the adult stage is known as metamorphosis (Figure 6). Almost all insects begin as eggs, although in a few cases the eggs hatch within the mother so they are born alive. The young insect develops through a series of distinct stages. As an insect develops, its outer skeleton (cuticle) does not grow and must be shed and replaced. Insects are especially vulnerable during the period when they shed an old cuticle and until the new one hardens.

Most insects undergo "complete" metamorphosis (Figure 7). Adults lay eggs, which hatch into larvae (caterpillars). The larva is the primary feeding stage with complete metamorphosis — usually the primary function of the adult stage is reproduction. The larva becomes a pupa, which is the sedentary stage as the larva transforms into an adult. Insects that exhibit complete metamorphosis include beetles, butterflies and moths, flies, bees and wasps. It is important to consider the life stage of an insect when deciding which control methods to use. If insect damage is observed on the leaves of a tree, but the insect has already pupated, it is of no use to apply a pesticide because the damage is done and the insect has moved on.

Incomplete metamorphosis has three stages — egg, nymph and adult (Figure 8). The immature stages are similar to the adult in appearance, food habits and habitat. Development is a gradual increase in size of the wing pads until the final molt, after which the wings and reproductive organs are fully formed. Insects with incomplete metamorphosis include aphids and scales, true bugs, grasshoppers and katydids, crickets, cockroaches, mayflies, dragonflies and stoneflies. As stated above, the immature stages are similar to adults in food habits and therefore all stages have the potential for feeding damage to the plant. Therefore control should be considered at all stages if damage is severe enough to warrant control.

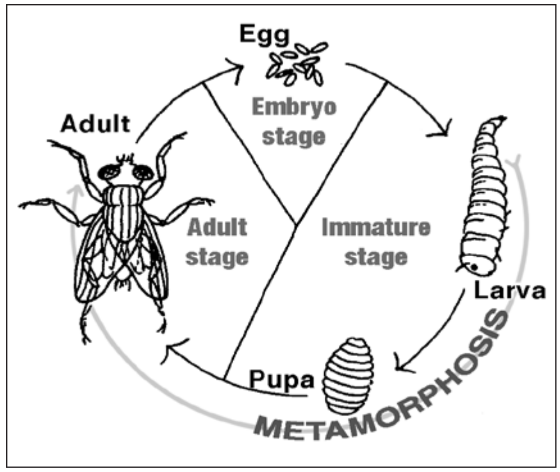


Figure 6. Insects pass through a series of stages as they develop, and these changes from one life stage to the next are called metamorphosis.

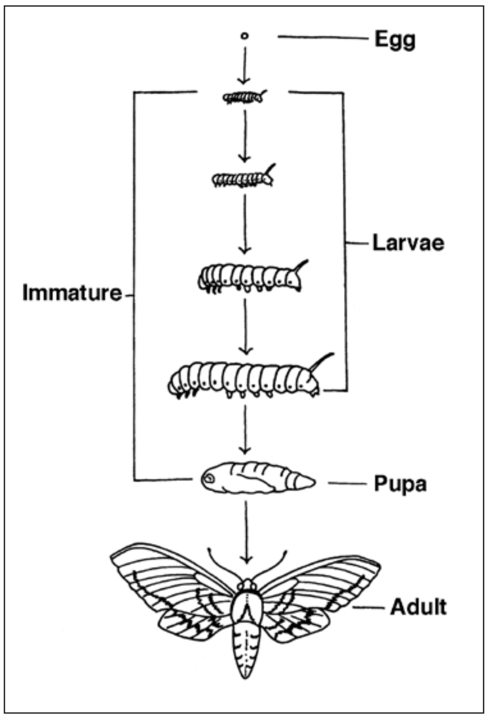


Figure 7. Most insects undergo "complete" metamorphosis with four primary stages: egg, larva, pupa and adult. Caterpillars pass through several stages, shedding their skin between them, as they feed and develop. Caterpillars of some insects, such as moths, spin silken cocoons to protect the pupa as it develops into an adult.

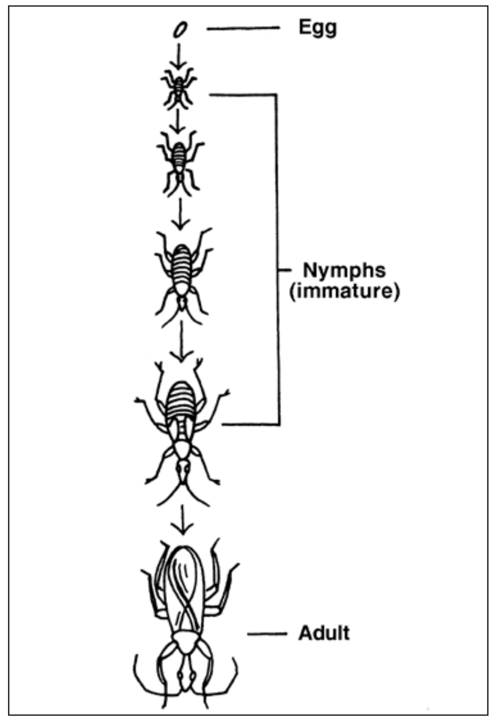


Figure 8. Immature insects that undergo "incomplete metamorphosis" are called nymphs, which resemble the adults. Growth from one nymph stage to the next occurs by molting. A nymph's wings get larger with each successive shedding of skin, and by maturity as an adult, the wings are fully developed.

Beneficial insects

The vast majority of insects are either neutral or beneficial in the garden. Many people spend a great deal of time and effort to destroy insects only to find out later that the insects they destroyed were beneficial.

Insects as pollinators

Insects provide a huge benefit in the pollination of plants. Many plants require an insect to transfer the pollen needed to fertilize the flower and set fruit. Apple crops are not self-pollinated and rely almost exclusively upon insects for pollination. It has become common for orchards to have honey bee hives among the trees to promote pollination. It is suggested that the pollination activity of bees annually provides benefits worth tens of millions of dollars to regional agriculture. Many native plants are dependent upon insect pollination for their survival. Insects that pollinate plants include honey bees, flies, butterflies, moths, bumblebees and wasps.

> *If all mankind were to disappear tomorrow, the world would regenerate to the rich state of equilibrium that existed 10,000 years ago. If insects were to vanish, the terrestrial ecosystems would collapse into chaos.*
>
> – E.O. Wilson

Insects and the natural recycling of nutrients

Insects play a key role as scavengers in recycling nutrients by feeding on decaying plant or animal material, thus hastening decomposition. Insects help break down organic matter they scavenge on and also add organic matter to the soil as they live and breed. Dung beetles, for example, are usually found beneath cow dung, horse manure or carrion. Without insects such as dung beetles, the manure of cattle and other animals would not break down. Fly maggots (larvae of flies) play a vital role in the decomposition of animal material, especially carcasses. Termites are considered pests when they destroy wooden structures but are extremely valuable scavengers that enhance the decomposition of wood materials in the environment.

Insects in the food webs of wildlife

Insects play a valuable role in the food chain of life as food for other species such as fish, birds and small mammals. Many game fish such as trout depend on insects as a major component of their diet, as do many songbirds. Mayflies, which are primarily aquatic insects, are reliable environmental indicators of water quality. If the mayfly populations are good in a water source, then it can be assumed that the water quality is good. However, declining populations of mayflies may indicate the water quality is declining as well.

Insects as biological control of pests

Biological control is any activity of one species that reduces the adverse effects of another species. Virtually every pest (weed or insect) has natural enemies that reduce its population under certain circumstances. For many pest insects, the most important factor keeping their populations in check is the activity of other insects. There are two categories of insects used for biological control, phytophagous insects that feed on plants and act as biocontrol agents by destroying or limiting plant growth, and entomophagous insects that feed on other insects and keep pest populations in check.

The Klamathweed beetle was one of at least 268 species of insects (mostly flies, beetles and moths) that have been introduced in attempts to control various noxious weeds. Klamathweed beetles have virtually eliminated Klamathweed (also called common St. Johnswort) from millions of acres of rangeland in the western United States, Australia, Canada, Chile, New Zealand and South Africa. Introduced insects have significantly reduced puncturevine, musk thistle, tansy ragwort and waterlettuce. There is reason to hope that insects can also help control leafy spurge and purple loosestrife.

The single most important factor in keeping plant-feeding insects in check is that other insects feed upon them. Insects that feed upon other insects are considered either predators or parasites. Predators actively hunt and feed on other insects as prey. The prey is typically smaller than the predator, but not always. Parasites live on or in the bodies of their hosts and get their food from them. Parasitic wasps or flies lay eggs on certain kinds of insects, and their young feed inside the host, killing it and emerging in the adult form. Hosts are typically larger than the parasites and are not killed immediately but continue to live in close association with the parasite. Lady beetles can consume up to several hundred aphids during the two or three weeks that they are growing and many more after the beetles become adults.

Insects as pests

Less than 1 percent of insects are pests, but that small fraction can do expensive damage. Insects cause damage in a variety of ways.

Chewing insects

One way an insect feeds is to bite off and chew the external parts of a plant. This type of injury may weaken the plant and cause it to be less productive or to die. Many pests such as grasshoppers feed on many different plants, while other insects such as cabbageworm and Colorado potato beetle feed on only a few types of plants.

Piercing-sucking insects

Insects such as aphids and scales feed on the sap from plants by piercing the epidermal layer of the plant and sucking the plant sap from the cells. In this process, they damage the plant cells and remove valuable nutrients. Plant damage may include distorted leaves, curled leaves, chlorotic-looking (yellow) tissue, deformed fruit and even death of the entire plant. Some insects inject a salivary toxin into the plant that does additional damage. Well-known insects with piercing-sucking mouthparts include aphids, scales, leafhoppers, squash bugs and plant bugs.

Internal feeders

Many insects feed internally within the plant tissue, which makes control difficult or impossible. These insects enter the host plant either through the egg stage when the female adult lays the egg within the plant tissue, or they hatch and immediately eat their way into the plant tissue. Internal feeders include wood borers, codling moth in apples, leaf miners, seed weevils and gall insects. Perhaps the most widely noticed internal feeders are those that cause galls. These unusual growths on plants can be caused by many different insects, including wasps and flies. Most internal feeding insects emerge as adults. Control must be aimed at the immature stage before it enters the plant or at the emerging adult to reduce the population in subsequent generations by reducing the number of females that will lay eggs.

Insects that transmit plant diseases

Many insects pick up plant viruses and bacteria as they feed and then later transmit diseases to healthy plants. They may actually carry the disease from plant to plant on their body, or transmit the disease through plant injection as they feed. This can result in severe damage or death to the plant. Insects that transmit plant diseases include the bark beetles that move fungi that cause Dutch elm disease and the aster leafhopper that injects the bacteria that cause aster yellows. Insects can spread plant diseases in many different ways. Their feeding or boring into plants can create openings through which diseases can enter the plant.

For further information

MU publications

(http://extension.missouri.edu/explore/agguides/hort/)

G7200 - G7424 entomology series, including:

G7190 *Insect Borers of Fruit Trees*

G7200 *White Grubs in the Lawn*

G7250 *The Bagworm in Missouri*

G7270 *Insect Defoliators of Missouri Trees: Colony Feeders*

G7271 *Insect Defoliators of Missouri Trees: Web Producers*

G7272 *Insect and Mite Galls on Missouri Trees*

G7273 *Least-Toxic Control Methods to Manage Indoor Plant Pests*

G7274 *Aphids, Scales and Mites on Home Garden and Landscape Plants*

Related reading

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Cranshaw, Whitney. 1998. *Pests of the West*. Golden, Colo.: Fulcrum Publishing.

Dreistadt, Steve H. 2004. *Pests of Landscape Trees and Shrubs*. Davis: Statewide Integrated Pest Management Project, University of California, Division of Agriculture and Natural Resources.

Salsbury, Glenn A., and Stephan C. White. 2000. *Insects of Kansas*. Manhattan: Kansas Department of Agriculture.

Insect control

It is crucial that an insect pest be properly identified to know what treatments are appropriate. Insect behavior can determine which insecticides work best. If a particular insect species must come into contact with the chemical to die, and if that insect characteristically feeds on the underside of leaves, then it cannot be controlled by a general spraying of the garden. Squash bugs are an example of an insect that feeds on the underside of leaves. Sevin spray is effective against squash bugs, but when applicators do not get the chemical under the leaves, failures result.

Insect mouthparts also play a role in the effectiveness of the control options available. For example, Sevin dust is an example of a stomach poison that must be ingested to be effective and therefore provides good control against insects with chewing mouthparts. Insects with piercing-sucking mouthparts do not chew external plant material and therefore would not ingest the Sevin dust. *Bacillus thuringiensis,* or Bt, dust is another product that must be ingested to provide control. Contact chemicals kill most insects on contact and do not need to be ingested to be effective. Contact chemicals include Sevin spray, malathion, orthene, soaps and oils.

Methods of insect control

Several types of control are available for managing insect pests. Many times a combination of controls is more effective than one type by itself.

Cultural controls are the first line of defense when controlling insects in the garden. Selecting resistant varieties if available saves time, energy and money by not having to worry about pests whatsoever. Keeping plants healthy gives them the extra edge they need to overcome insect feeding. Healthy trees, for example, are not as easily attacked by wood-boring insects. Sanitation is crucial to remove insect-infested plant material. Beneath an infested tree, twigs may fall to the ground with insects inside them; these insects can be controlled by simply removing the infected material. Pruning tent caterpillar egg cases from tree limbs removes the insect from the area. Squash left on the ground will attract squash bugs and will provide a reservoir for them to overwinter unless they are removed. Finally, proper planting ensures plant vigor, which helps the plant to tolerate and even overcome insect damage. Rotating the crop helps manage insects by not providing a host in subsequent seasons, and altering the planting times to avoid pests can provide effective control.

Mechanical or physical controls involve using all available means to control the insects. Handpicking the insects and use of water sprays are two effective mechanical controls. Other methods include trapping insects and subjecting insects to freezing temperatures such as placing food items infested with grain insects in a freezer.

Biological control involves using natural controls that already exist in the environment such as beneficial insects or naturally occurring soil bacteria such as *Bacillus thuriengensis* (Bt). Beneficial insects such as ladybird beetles can be encouraged by having diverse plants in the garden and by providing profuse nectar-producing plants. Perhaps the most important single step toward improving the survival of beneficial insects in the garden is to reduce the use of insecticides.

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