Introduction to Entomology

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Insects and mites are among the most numerous animals on earth. In a typical midsummer landscape and garden, there are approximately a thousand insects in addition to mites and spiders! The goals of this publication is to introduce the science of entomology and insect identification to those who are active in outdoor landscapes or natural settings.

Insects play a valuable role in our natural world. For example:

- Bees and some species of flies pollinate most fruits and vegetables.
- Many insects are sources of food for birds, fishes, reptiles, amphibians and spiders.
- Some insects produce useful products such as honey, wax, shellac, and silk.
- Another group are decomposers that help maintain nutrient cycles in the environment.
- Other insects are considered beneficial as predators and parasites, by feeding upon insects or mites considered to be pests.

Even though relatively few types of insects are pests, they are the ones most often talked about. Some insects such as aphids, leafhoppers, and thrips spread plant diseases. Insects such as mosquitoes and midges may spread deadly or debilitating diseases to humans, livestock, and wildlife.

Basics of Classification

Arthropods represent more than three-fourths of the animal species known to exist. They have three characteristics in common — a segmented body, jointed legs, and an exoskeleton. The Arthropoda phylum is divided into classes, and some common names of each class includes the crustaceans, centipedes, millipedes, spiders, ticks and mites, and the insects. Within the class Insecta, various characteristics are used to group insects into orders (*Table 1*). These characteristics are easily visible and do not require a microscope; for example, mouthparts, wings, and type of metamorphosis are all identifying characteristics.

Table 1. The following table describes the common names associated with each insect order.

Blattodea	Cockroaches
Coleoptera	Beetles and Weevils
Collembola	Springtails
Dermaptera	Earwigs
Diplura	Diplurans
Diptera	Flies, Mosquitoes, Gnats, Midges
Embioptera	Webspinners
Ephemeroptera	Mayflies
Hemiptera	True Bugs, Scale Insects, Aphids, Leafhoppers
Hymenoptera	Ants, Bees, Wasps
Isoptera	Termites
Lepidoptera	Butterflies, Moths
Mantodea	Mantids
Mecoptera	Scorpionflies
Megaloptera	Alderflies, Dobsonflies, Fishflies
Neuroptera	Lacewings, Antlions, Mantispids, Dustywings
Odonata	Dragonflies, Damselflies
Orthoptera	Grasshoppers, Crickets, Katydids
Phthiraptera	Sucking and chewing lice
Plecoptera	Stoneflies
Psocoptera	Booklice, Barklice
Raphidioptera	Snakeflies
Siphonaptera	Fleas
Thysanoptera	Thrips
Thysanura	Silverfish, Bristletails
Trichoptera	Caddisflies
Zoraptera	Zorapterans

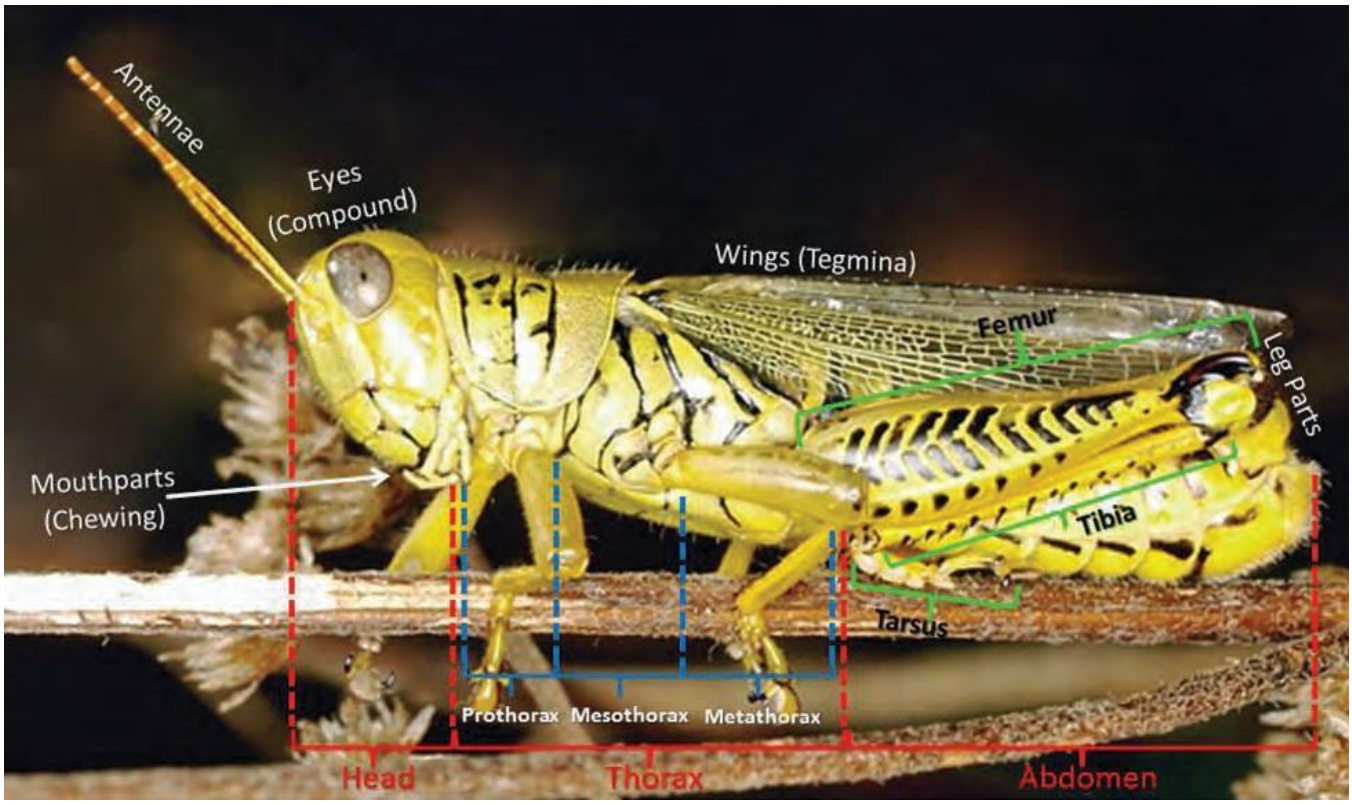


Figure 1. Grasshopper body parts and regions.

Since there are numerous insect species, and because many of them are small and seldom encountered, relatively few species have common names. Those that do are either particularly showy insects, such as the luna moth and the tiger swallowtail, or they are economically important species, like the honey bee and the dreaded Colorado potato beetle.

Insect Morphology

Insects possess the following characteristics: three body regions; three pairs of legs; one pair of antennae; and none, one, or two pairs of wings. Legs and other appendages are often greatly modified to suit the insect's habit and environment.

Insect Body

eaH, thorax, and abdomen . The adult insect's body is made up of three parts (head, thorax, and abdomen) and is supported by a hard body wall, the exoskeleton (*Figure 1*). The exoskeleton has a flexible, top layer known as the cuticle, which contains a layer of wax and helps to prevent desiccation. The exoskeleton of an immature insect is not usually as hard as that of the adults, because the cuticle is not fully formed.

heTthorax, located between the head and abdomen, is made up of three segments: prothorax, mesothorax, and metathorax. Each segment has one pair of legs. In addition, the mesothorax and metathorax each may bear one pair of wings. Some insects, such as beetles and grasshoppers, have a thickened, protective pair of wings. The abdomen contains several segments, each joined by a flexible membrane so it can expand and contract to aid with respiration. Some insects have tail-like appendages at the end of the abdomen, referred to as **cerci**.

- **Legs.** An important classification characteristic of insects is the presence of three pairs of jointed legs. Almost all adult insects have legs, and some immatures do not have legs, but will as adults. An insect's legs are adapted according to how the insect lives and behaves (*Figure 2*). For example, if an insect hops a lot to avoid predators, then the femur is enlarged, as is the case with grasshoppers. Thus, legs vary in size and shape because they can be used for walking, jumping, digging, grasping, feeling, swimming, holding objects, building structures, and cleaning parts of the body. One important leg adaptation in larvae is prolegs. Prolegs, or false legs, are fleshy body projections with rows of tiny hooks, helping the insect cling to surfaces and plants. They also provide additional support in locomotion.
- **Wings.** Venation, or arrangement of veins in the wings, is different for each species of insect; thus, it

Cursorial (running)

Fossorial (digging)

Saltatorial (jumping)

Raptorial (catching and holding)

Natatorial (swimming)

iguFre 2. The five types of insect legs.

y — fSctaned scales with hair

Elytra — hard protective cover wings

Hemelytra — half leathery and half membraneous

Membranous — transparent

Tegmina — leathery

Halteres — club-like

Figure 3. The six types of insect wings.

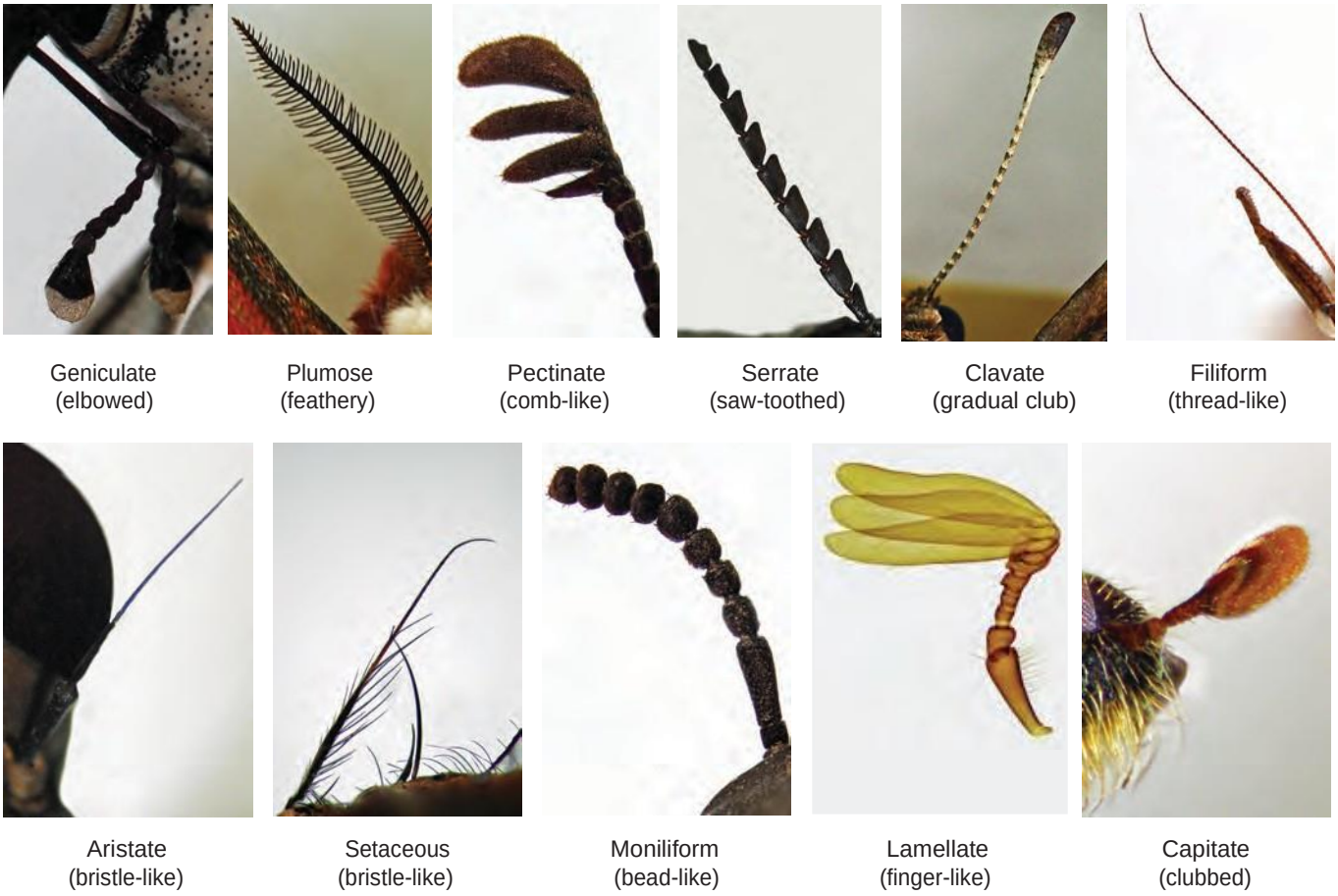


Figure 4. The various types of insect antennae.

serves as a means of identification (*Figure 3)*. Many insect orders end in "**ptera**," which comes from the Greek word meaning "wing." For instance, Hemi**ptera** means "half-winged," Hymeno**ptera** means "membrane-winged," and Di**ptera** means "two-winged." Most immature insects do not have wings, but some have wing pads that enlarge as the insect grows toward adulthood. One wing modification of flies is the presence of **halteres**, which are small, knobbed structures that replace the hind pair of wings and aid in balance.

Antennae. The antennae are a prominent and distinctive feature of most insects, and a pair is always present on the adult's head. Antennae are located between or in front of the eyes and are segmented structures that vary greatly in form and complexity (*Figure 4*). They are primarily organs of smell, but can serve other functions such as sensing humidity levels, sound, flight air speed, taste, direction, and touch.

- **Mouthparts.** The most remarkable and complicated structural feature of insects is the mouth. Just like insect legs, mouthparts vary in form and function, based on where and how an insect lives and what it feeds upon (*Figure 5*). Each type of mouth is made up of several basic, common structures, but some may be greatly reduced while others are enlarged. **Chewing mouthparts**, which consist of mandibles and other parts, work together to hold/pinch, maneuver, chew, and deliver chewed food to the mouth. An example of a **chewing-lapping** mouthpart is the honeybee's mouth, which is composed of mandibles and its extendable tongue. These components work together to help the bee chew, mold wax, suck up nectar, and regurgitate fluids to feed the young (brood), etc. **Siphoning mouthparts** are common with butterflies and moths. No mandibles are present, only a long, flexible tube used to insert into flowers to extract nectar. **Piercing-sucking mouthparts** occur with true bugs, aphids, and mosquitoes. This type of mouthpart is sharp at the tip and is inserted into plants or animals to withdraw nutrients.

In some cases, insects of the same order will always have the same mouthparts for each life stage, as with grasshoppers. Others will have different mouthparts in different life stages. For example, the monarch

Siphoning Sponging Chewing-Lapping Piercing-Sucking Chewing

Figure 5. The five types of insect mouthparts.

caterpillar has chewing mouthparts, but the adult monarch butterfly has siphoning mouthparts. Some adult insects have vestigial mouthparts and do not feed at all.

Insect Development

One of the distinctive features of insects is **metamorphosis**. The term is a combination of two Greek words: *meta*, meaning "change," and *morphe*, meaning "form." It is commonly defined as an abrupt change in form or structure and refers to all stages of development.

Most insects do not grow gradually over their lifespan, as many other animals do; instead, they grow through stages of development called **instars**. The young insect (larva, nymph, or naiad) sheds its skin (molts) by splitting open and emerging from its old skin, now having a new and larger body covering. This process occurs at various stages of growth, and is controlled by a change in hormone levels. The number of instars varies according to species, and to some extent it varies due to food supply, temperature, and moisture during development. The intervals between **molts** are called stages or **stadia**.

There are three types of metamorphosis: complete, gradual, and incomplete; a fourth is termed as no metamorphosis.

Complete Metamorphosis includes the egg, larva, pupa, and adult stages. The larval stage is the primary growth and feeding stage, in which energy is converted from food and stored for the pupal and adult stages. Common names for the larval stage include caterpillars, maggots, and grubs. Complete metamorphosis exhibits the most drastic body changes in an insect's life by breaking down entire body structures, such as prolegs, and forming new structures such as wings and antennae. Insects

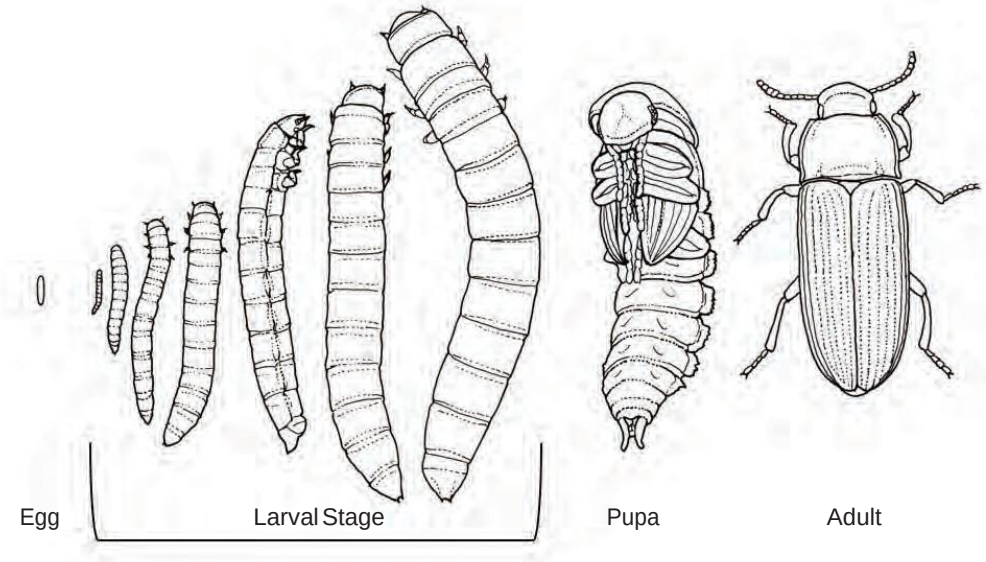


Figure 6. Complete metamorphosis life stages.

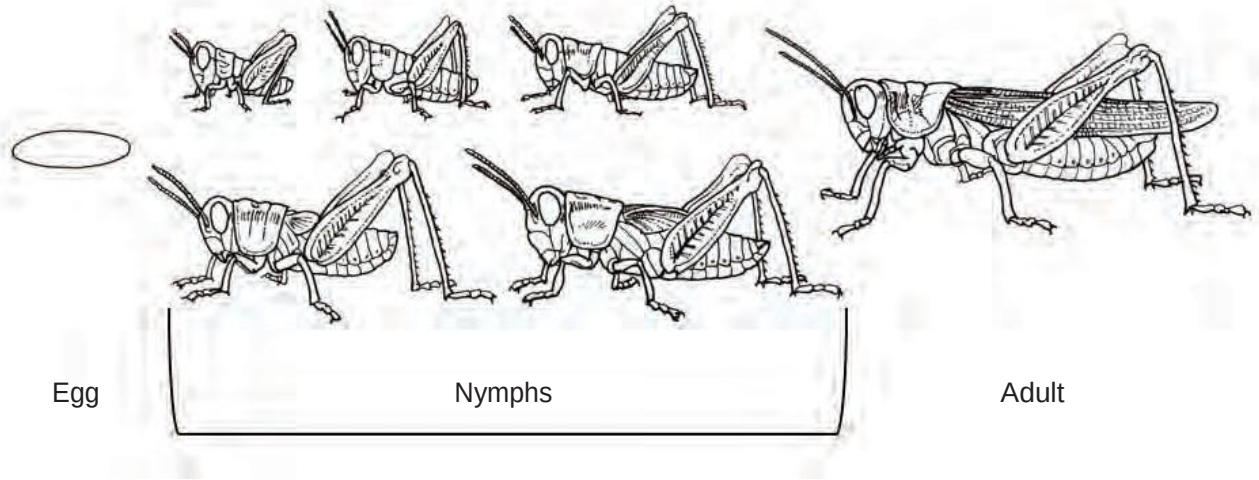


Figure 7. Gradual metamorphosis life stages.

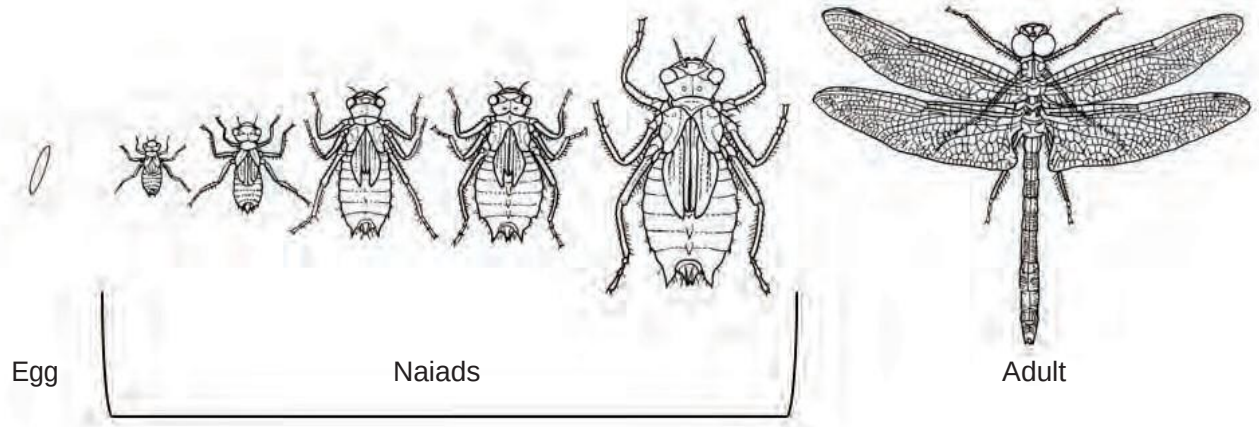


Figure 8. Incomplete metamorphosis life stages.

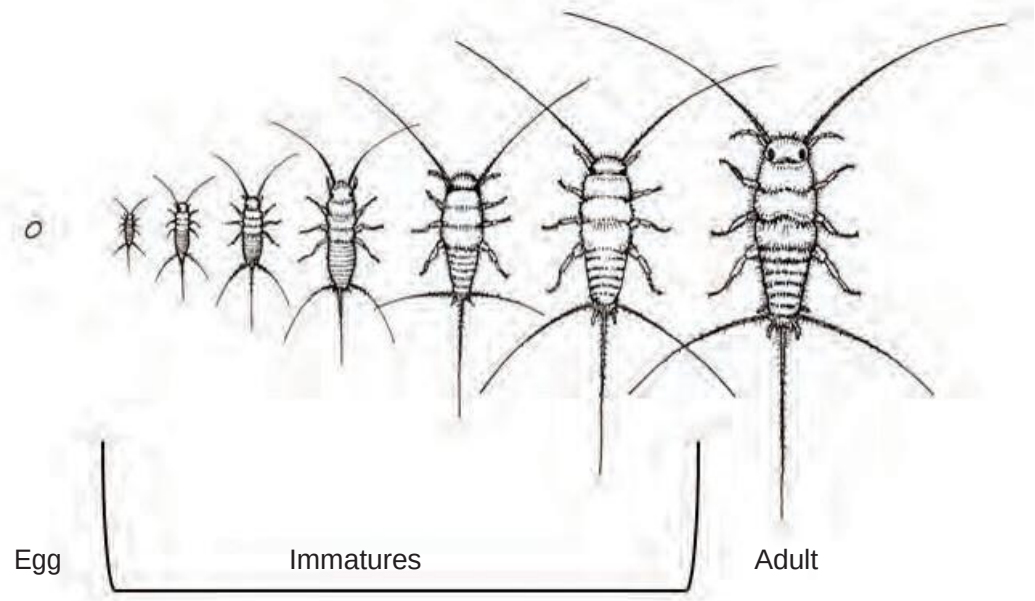


Figure 9. No metamorphosis life stages.

in the orders Neuroptera, Coleoptera, Lepidoptera, Diptera, Siphonaptera, Mecoptera, Raphidioptera, Megaloptera, Trichoptera, and Hymenoptera undergo this type of metamorphosis (*Figure 6*).

- **Gradual metamorphosis** includes the egg, nymph, and adult life stages. Gradual metamorphosis does not include a resting stage as complete metamorphosis does (pupal stage); instead, it includes nymphal stages. Nymphs resemble adults but are smaller, and they consume the same food source and live in the same habitats as adults. Insects in the orders Blattodea, Hemiptera, Dermaptera, Isoptera, Psocoptera, Zoraptera, Phthiraptera, Mantodea, Phasmida, and Orthoptera all undergo this type of metamorphosis (*Figure 7*).

- **Incomplete metamorphosis** includes the egg, naiad, and adult life stages. This differs from gradual metamorphosis in that the naiads are aquatic, and live in a different habitat than the adults. Insects in the orders Ephemeroptera, Odonata, Thysanoptera, Embioptera, and Plecoptera all undergo this type of metamorphosis (*Figure 8*).

- **No metamorphosis** includes egg, immatures, and adults. It is a primitive form of metamorphosis. Immatures look *exactly* like adults but are only smaller. As they grow larger, they shed their skins. Less apparent is the fact that the nymph's reproductive organs are not fully developed. Insects in the orders Collembola, Diplura, and Thysanura undergo no metamorphosis (*Figure 9*).

Other parts of an insect life cycle include **diapause** and **mating**. **Diapause** is similar to hibernation and is induced by hormones and changes in the environment. Depending on the species, diapause will occur at a specific life stage, such as the egg, larval, nymphal, pupal, or adult stage. Some species will have a diapause in the adult stage, where reproductive maturity takes a very long time to reach. For the insect, diapause is a time of rest where respiration, physical activity, feeding, and metabolic processes are reduced or completely stopped. For many species, especially those living in temperate regions, diapause occurs as a protection from extreme winter temperatures.

In temperate regions like Nebraska, some species can have multiple generations throughout the year. Within this time, diapause may occur, prompted by heat and drought, but it will not last as long as winter diapause. As winter approaches, environmental conditions change, no longer favoring insect success. Some insects pupate underground, or adults hide in plant debris, or eggs remain in protective cases throughout the winter. As soon as weather conditions are favorable, overwintered immature insect stages will become active and mature into adulthood to mate and start the cycle all over again.

Adult insects usually are quite mobile and their purpose is to feed and store energy, find mates, and deposit eggs for the next generation. However, in some insects, mating and reproduction is unnecessary. This type of reproduction is known as **parthenogenesis**. Bees, ants, wasps, walkingsticks, and aphids are notable examples of insects that can reproduce by parthenogenesis, where adult males are unnecessary.

Identifying Insects

Most gardeners and landscape managers can classify an insect by the common name of its order: beetles, wasps, butterflies, flies, etc. However, knowing the insect orders enables access to more valuable information. This information includes the type of mouthparts the insect has, its life cycle, and type of habit. For example, knowing the type of mouthpart can help when a gardener or landscape manager finds feeding damage to a plant, but does not find the insect. By putting the clues together, such as the shape of the feeding wounds and where on the plant feeding has occurred, pest identification and possibly even a method of control can be determined.

Some insect families are well known and should be learned, based on their reputation as being a common pest family or common beneficial family. Identifying insects beyond the family level becomes very difficult, often requiring a dissecting microscope and a reliable insect **key**, which progressively compares traits to facilitate identification.

Insect Orders

In this section, insect orders are divided into two groups: those containing insects important to the gardener; and orders containing insects of lesser importance.

Insect Orders Important To the Gardener

BLATTODEA — Cockroaches

Brownbanded cockroach life stages (egg, nymph, adult)

Brownbanded cockroach — bristly legs

Death's head cockroach — chewing mouthparts

igFure 10. Insects in the Blattodea order have the following characteristics:

1. Flat bodies covered by two pairs of highly-veined wings; front wings thickened (**tegmina**).
2. Pronotum is oval/shield-like and covers much of the head and thorax.
3. Long, slender filiform antennae which carry sense organs and act as feelers.
4. Chewing mouthparts, omnivorous feeding habit.
5. Legs bristly and adapted for swift running.
6. Gradual metamorphosis.

COLEOPTERA — Beetles, Weevils

Soldier beetle

Bluegrass billbug larvae

Dogwood weevil

Tumbling flower beetle

Asiatic garden beetle grub (larva)

Japanese beetle

Figure 11. Insects in the Coleoptera order have the following characteristics:

1. Adults have hardened, tough outer skeletons.
2. Adults have two pairs of wings, the outer pair is hardened (wing covers) and the inner pair is membranous. (A few beetles are practically wingless, and some have only an outer hard pair of wings.)
3. Chewing mouthparts. Weevils have chewing mouthparts at the tip of a "snout."
4. Adults usually have noticeable antennae.
5. Larvae have a head capsule, three pairs of legs on the thorax, and no legs on the abdomen. (Weevil larvae lack legs.)
6. Complete metamorphosis.

Many turfgrass pests are referred to as white grubs, and they are actually the larval form of a scarab beetle. **Larvae** are the active, feeding, and growing stages of one of the higher insects, preceding the pupal or resting stage.

DERMAPTERA — Earwigs

European earwig — male in marigold

European earwig — female

Figure 12. Insects in the Dermaptera order have the following characteristics:

1. Chewing mouthparts.
2. Elongated, flattened body with strong, movable forceps on the rear end.
3. Shortened outer wings and folded, membranous inner wings.
4. Nymphs resemble adults.
5. Gradual metamorphosis.

Horse fly — stabbing mouthparts

Blue bottle fly (blow fly)

House fly life stages (egg, larva, pupa, adult)

Bee fly

Midge

Mosquito

Figure 13. Insects in the Diptera order have the following characteristics:

1. Adults have one pair of wings, and are soft-bodied, often hairy.
2. Adults have sponging (fly), piercing-sucking (mosquito), or stabbing (horse fly) mouthparts.
3. Larvae may have mouth hooks (house fly maggots) or chewing mouthparts (midge larvae).
4. Larvae are generally legless and wormlike; some are called maggots.
5. Complete metamorphosis.

Flies are known to have spectacular **compound eyes**, which are composed of many individual elements (**ommatidia**). Each is represented externally by an individual facet within the compound eye. The dark brown, capsule-like object in the house fly life stage image above is known as a **puparium**. Within it is the pupal, or resting stage between larva and adult.

HEMIPTERA — Stink Bugs, Plant Bugs, Boxelder Bugs, Scale Insects, Mealybugs, Whiteflies, Aphids, Cicadas

Lace bug

Chinch bug

Ash plant bug

Latania scale

Red-banded leafhopper

Alder spittlebug

Greenbug — aphid

Dog day cicada

Greenhouse whitefly

Figure 14. Insects in the Hemiptera order have the following characteristics:

1. Winged and non-winged forms. Two pairs of wings.
2. Nymphs resemble adults.
3. Piercing-sucking mouthparts.
4. Both adults and nymphs can cause damage and can **vector** plant pathogens from one plant to another.
5. Gradual metamorphosis.

Many aphids secret a sticky-sugary substance called **honeydew**, which is attractive to ants, and in some cases, promotes sooty mold development. In addition, many aphids develop eggs without fertilization, which is called **parthenogenesis**, and is the cause of rapid explosions of aphid populations. This is a form of asexual reproduction.

Molting is an important process in the development and growth of some insects. An example is the final nymphal molts of cicadas, resulting in the occurrence of cast skins (**exuvia**) on tree trunks. The intervals between **molts** are called stages or **stadia**; the form assumed during a particular stage is known as an **instar**.

Carpenter ant

Honey bee — foraging

Acrobat ant — nuptial queens

Wheat stem sawfly

Cuckoo wasp — ovipositor

Paper wasp larvae/brood

Figure 15. Insects in the Hymenoptera order have the following characteristics:

1. Adults have two pairs of membranous wings.
2. Larvae have no legs (wasps, bees, ants), or have legs on the thorax and abdomen (some sawflies).
3. Generally have chewing mouthparts.
4. Other soft-bodied or slightly hard-bodied adults.
5. Complete metamorphosis.

The carpenter ant is showing its very large **mandibles**, which are strong, chewing mouthparts.

LEPIDOPTERA — Butterflies, Moths, and Skippers

Viceroy chrysalis (pupa)

Zebra caterpillar (larva) — chewing mouthparts

Morpho butterfly — scaly wings

Celery looper moth

Caterpillar — legs, prolegs

Silverpotted skipper-siphoning mouthparts

Figure 16. Insects in the Lepidoptera order have the following characteristics:

1. Adults: Soft-bodied with four membranous wings covered with small, often colorful scales.
2. Larvae: Have chewing mouthparts.
3. Adults: Mouthparts are a coiled, sucking tube (siphoning). Adults feed on nectar.
4. Larvae: Are caterpillars, worm-like, variable in color, and voracious feeders.
5. Larvae: Generally have legs on the abdomen (prolegs), as well as the usual pairs on the thorax.
6. Complete metamorphosis.

Female moths and many other kinds of insect emit chemicals called **pheromones** to attract males in order to mate.

MANTODEA — Mantids

Chinese mantid — chewing mouthparts

Chinese mantid egg case

Mantid nymph with prey

Figure 17. Insects in the Mantodea order have the following characteristics:

1. Immatures resemble adults.
2. Triangular head and chewing mouthparts.
3. Two pairs of wings, front wings thickened (tegmina).
4. Males are usually smaller and thinner than females.
5. Spined front legs (raptorial) adapted for catching prey.
6. Gradual metamorphosis.

MEGALOPTERA — Dobsonflies, Fishflies, Alderflies

Alderfly

Dobsonfly

Dobsonfly — egg mass

Figure 18. Insects in the Megaloptera order have the following characteristics:

1. Adults are moderate to large, often rather soft-bodied.
2. Males have large mandibles in some species.
3. Long, flapping wings.
4. Larvae are predaceous and aquatic.
5. Adults are active at night and attracted to lights.
6. Chewing mouthparts.
7. Complete metamorphosis.

Some taxonomists include this order as a suborder under Neuroptera, because these insects are closely similar to lacewings.

Antlion larva

Antlion adult

Green lacewing larva — with prey

Mantidfly

Green lacewing adult

Owlfly

Figure 19. Insects in the Neuroptera order have the following characteristics:

1. Adults and larvae are generally predaceous.
2. Two pairs of similar wings, which have fine, net-like veins.
3. Chewing mouthparts.
4. Complete metamorphosis.

The green lacewing larva is feeding on its prey and is classified as a **predator**, which lives at the expense of other insects. An insect predator differs from a parasite in that it feeds externally on its host and must constantly search for hosts.

Jerusalem cricket

Northern mole cricket

Broadwinged katydid

Striped ground cricket

Grasshopper

Grasshopper egg masses from sandy soil

Figure 20. Insects in the Orthoptera order have the following characteristics:

1. Adults are moderate to large, usually hard-bodied.
2. Adults usually have two pairs of wings. Forewings are elongate, narrow and leathery (tegmina); hindwings are membranous with extensive folds.
3. Chewing mouthparts.
4. Hind legs often enlarged for jumping.
5. Nymphs resemble adults, and develop larger wing pads with each older instar.
6. Gradual metamorphosis.

The striped ground cricket above is a female. This can be determined by the obvious presence of an **ovipositor**, which is a tube at the tip of the abdomen with which the female deposits eggs into soil.

PHASMIDA/PHASMATODEA — Walkingsticks

Walkingstick — lateral view

Walkingstick — dorsal view

Figure 21. Insects in the Phasmida order have the following characteristics:

1. Immatures resemble adults.
2. Long, cylindrical body and long, thin legs.
3. Chewing mouthparts.
4. Wings generally absent.
5. Walkingsticks camouflage themselves among host plants while feeding. They also move slowly.
6. Parts of legs or an entire leg can be regenerated.
7. Gradual metamorphosis.

THYSANOPTERA — Thrips

Flower thrips — dorsal view

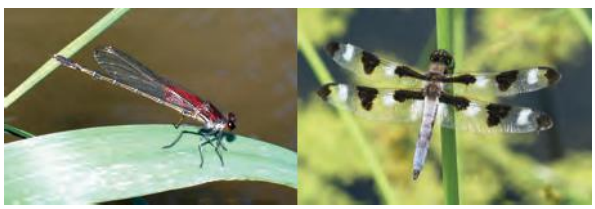
Gladiolus thrips on leaf

Figure 22. Insects in the Thysanoptera order have the following characteristics:

1. Adults are quite tiny, soft-bodied insects, and slender in form.
2. Mouthparts are rasping-sucking.
3. Found on flowers or leaves of plants, often feeding within buds or sheaths.
4. Two pairs of wings, slender and fringed with hairs, so as to appear feathery.
5. Varied metamorphosis (a mixture of complete and gradual). Early immature stages are called larvae.

Thrips, whether singular or plural, are always called “thrips.”

Insect orders of lesser importance to the home gardener

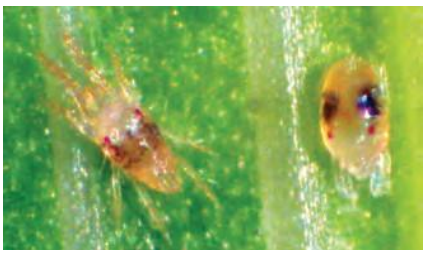
Order	Common Name	
1. **Collembola**	Springtails	
Springtails are tiny and prevalent in organic matter that is moist and decaying. They seem to disappear when disturbed.		
2. **Diplura**	Diplurans	
Diplurans are present in damp areas (soil, rotting organic matter, beneath stones).		
3. **Embioptera**	Webspinners	
Webspinner bodies are cylindrical and soft, adapted for the silken, tubular-shaped galleries that they spin and live in. Female adults and nymphs are herbivorous, and males never eat.		
4. **Ephemeroptera**	Mayflies	
Immature stages (naiads) live in lakes, ponds, and streams, feeding on algae and decaying plant matter.		
5. **Isoptera**	Termites	
Termites play an important role in decomposing fallen timber in wooded areas, thus restoring key nutrients for the use of plants. Termites can damage wooden structures. Part of their success is due to their ability to emit **pheromones** within the colony to induce specific behaviors and maintain unity.		
6. **Mecoptera**	Scorpionflies	
Adults and larvae are predators of other insects; some species feed on plants.		
7. **Odonata**	Dragonflies and Damselflies	
Dragonflies and damselflies are attractive, beneficial insects that consume mosquitoes, midges, and other small flying insects. Nymphs live in lakes, ponds, and streams.		

Order	Common Name	
8. **Phthiraptera**	Sucking and Chewing Lice	 
Sucking lice are external parasites of mammals and feed on blood. Chewing or biting lice feed on birds and some mammals. They feed on feathers, hair, skin, and blood. Lice spend their entire life on the host. Lice live on other organisms (**hosts**) and obtain all of their nutrients from the host, contributing nothing of benefit to the host. For these reasons, they are classified as **parasites**.		
9. **Plecoptera**	Stoneflies	
Stoneflies are aquatic. Naiads are grazers on plants and algae in rivers and streams. They possess external gills. Adults fly about on rocks, plants, and on banks.		
10. **Psocoptera**	Booklice and Barklice	 
Booklice thrive in damp locations where mildews may develop. They can be common in libraries and stored grain/cereal products. Barklice thrive in forests, feeding on algae and lichens. They often produce fine webbing on tree trunks.		
11. **Raphidioptera**	Snakeflies	
These slender-necked insects are prevalent in the western United States on woodland plants. They feed on other insects and pollen.		
12. **Siphonaptera**	Fleas	 
Adults withdraw blood from mammals and birds. The worm-like larvae hide in nests and pet bedding, where they feed on dried blood specks and organic debris.		
13. **Thysanura**	Silverfish and Bristletails	 
These delicate insects are scaly and have long thread-like tails. They feed on lichens, bark, paper, dead insects, fabric and natural fibers. They can be found in moist locations such as under bark and stones, but also thrive in homes.		
14. **Trichoptera**	Caddisflies	 
Caddisflies resemble moths but have hairs rather than scales. Larvae live in rivers and streams and feed on algae, submerged plants and other organic matter. Adults are strongly attracted to lights at night.		

Other Insect-Like Creatures

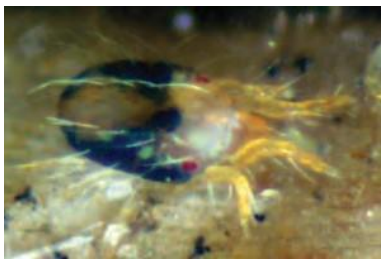
A number of arthropods not related to insects may be found in the field and in the home. These include:

Spiders, Spider Mites, Ticks, and Scorpions – (Class Chelicerata). This class includes the orders Araneae, Acari, and Scorpiones. Arthropods in this class have no antennae, have four pairs of legs, and have two body regions — **cephalothorax** (head and thorax) and abdomen, although in mites and ticks, the body may be compact (*Figure 23-25*).



Twospotted spider mites

Clover mites



Spruce spider mite

Figure 23. Spider Mites

Spider mites are tiny, soft-bodied animals with two body regions, an abdomen that is broad at the base, four pairs of legs, and no antennae. They often produce fine webbing.

Western black widow spider

Brown recluse spider

Bold jumper spider

Figure 24. Spiders

Spiders resemble mites except that most are larger and the two body regions are more clearly separated from one another by being constricted. Most spiders are beneficial predators and are not poisonous, with the exception of the black widow and brown recluse.

American dog tick questing

Lonestar tick (lower left), black-legged tick (top), American dog tick (lower right)

Engorged brown dog tick

Figure 25. Ticks

Ticks resemble large mites and are important pests in agriculture and medicine in that they are parasites of man and animals and transmit debilitating diseases.

Millipedes — (Class Diplopoda). Arthropods in this class have two body regions, a head and a trunk that is round in cross section. With the exception of the first four or five segments within the trunk, all of the body segments possess two pairs of legs. Some species have no eyes; they never have more than two simple eyes. Millipedes possess one pair of antennae and have chewing mouthparts but do not bite humans (*Figure 26*).

Giant millipede

Garden millipede

Millipedes

Figure 26. Millipedes

Millipedes are relatively slow moving. They generally feed on leaf litter, plants, and decaying organic matter, but some can be destructive to vegetables or other plants in greenhouses.

Centipedes — (Class Chilopoda). Arthropods in this class resemble millipedes by having two body regions—head and trunk, and by having one pair of antennae. They are different in that they have longer antennae, are flattened, move rapidly, and have venomous glands. In addition, they have one pair of legs per body segment and have a pair of poison fangs below the head (*Figure 27*).

House centipede

Garden centipede

House centipede's venomous fangs

Figure 27. Centipedes

Centipedes are beneficial by being predators of other arthropods. They are active particularly at night. Centipedes live beneath leaf litter, rotted logs or stones, and in neglected compost piles.

Sowbugs, Crayfish, Crabs, Shrimps and Pillbugs — (Class Malacostraca). Arthropods in this class are oval or elongated in shape and have a hard outer shell composed of plates. They feature two pairs of antennae, five to seven pairs of legs, and two to three body regions (*Figure 28*).

Pillbug

Hermit crab

Rusty crayfish
insectimages.org
U.S. Geological Survey Archive

Figure 28. Pillbugs and Crabs

Crayfish and pillbugs must maintain some connection with water or moisture in order to prosper.

Insects as Vectors of Plant Diseases

Since 1892, when it was first proved that a plant disease (fire blight of fruit trees) could be spread by an insect (the honeybee), the knowledge of this subject has grown rapidly. Insects are responsible for spreading plant diseases in a number of different ways: by feeding, laying eggs, or boring into plants. Through these actions, entrance points are created that allow a plant disease organism to invade the plant (*Figure 29*).

The pathogen itself can either be *on* or *in* the insect's body. If it is *on* the body, when the insect moves from plant to plant, it can spread the disease. Typically, if the pathogen is inside the insect's body, it will be transmitted when the insect feeds on and wounds the plant. The insect's body can protect the disease from natural enemies and adverse conditions, such as cold winter weather, a period of drought, or host plant scarcity. In addition, insects can act as the disease's host for an incubation period, which increases pathogen numbers in a stage of the life cycle. Additionally, some plant pathogens can only affect stressed plants, and if vectored by an insect, the insect also may show preference for the plant and contribute its own damage.

Examples of Insect Vectored Plant Diseases

Disease	Vector
Dutch Elm Disease (fungus)	Bark Beetle
Fireblight (bacterial)	Pollinating Insects
Tomato Curly Top (virus)	Beet Leafhopper
Cucumber Mosaic (virus)	Aphids
Aster Yellows	Aster Leafhopper
Rose Rosette	Eriophyid Mite
Tomato Spotted Wilt (virus)	Flower Thrips

Figure 29. Bacterial wilt of cucumbers vectored by striped cucumber beetle.

Benefits and Value of Insects

Nearly 75 percent of all known animals are insects, and there are estimated to be up to 30 million species worldwide. Insects have been very successful in living in nearly every natural habitat in the world. In the course of spreading across the world and adapting to various habitats, they have developed an amazing diversity in size, form, color, and function.

Insects are beneficial to the gardener in several ways:

- Insects, chiefly honeybees and wild bees, aid in the production of fruits, seeds, vegetables, and flowers by pollinating blossoms. Most common fruits and vegetables are pollinated by insects. Many ornamental plants, both in the greenhouse and outdoors, are pollinated by insects.

- Parasitic insects destroy other injurious insects by living on or in their bodies and their eggs.

- Predaceous insects consume other injurious insects, thus decreasing populations of harmful insects.

- Some insects feed on or destroy weedy plants, such as musk thistle weevil and spurge hawk moth.

- Insects improve the physical condition of the soil and promote its fertility by burrowing throughout the surface layer. Dead insect bodies and insect frass act as a natural fertilizer and promote the creation of organic matter.

- Insects perform a valuable service in decomposition of organic matter. They feed on dead animals, dead plants, and other dead insects. Some insects feed on and break down animal fecal matter, and others such as termites feed on fallen trees.

As organic and sustainable gardening has increasingly become popular, so has the interest in beneficial insects (*Figure 30*). Such insects are viewed as an alternative method to chemical control when incorporated into an integrated pest management (IPM) program. Such tactics are usually quite successful if implemented correctly, consistently, and updated. However, numerous factors affect the success of beneficial insects such as weather, pest populations, and temperature — which can cause IPM programs that include beneficial insects to occasionally become ineffective.

Figure 30. The following is a list of some common beneficial anthropods.

Wolf spider

Crab spider

Orb weaver spider

Predatory mite

Soldier beetle

Ground beetle larva

Lady beetle larva

Cecidomyiid fly larvae

Syrphid fly larva

Tachinid fly

Figure 30. Continued

Minute pirate bug

Assassin bug

Damsel bug

Yellowjacket wasp

Egg parasitoid wasps

Braconid wasp larvae

Giant ichneumonid wasp

Lacewing larva

Praying mantid

This publication has been peer reviewed.