Kwik-Key to Soil-Dwelling Invertebrates

by

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Introduction

Beneath our feet lives a world of organisms most people have never seen. The soil surface of a typical forest or grassland is covered by 2.5-5.0 cm of humus, a complex mixture of organic matter in various stages of decay. This layer of humus teems with living organisms that play important roles in soil fertility and nutrient cycling. These soil dwellers represent all trophic levels: herbivores, carnivores, omnivores, and decomposers. Their foods include roots, seeds, fungi, dead wood, and decaying leaves. They may be predators, parasites, or saprophytes. This soil community is a microcosm of the complex ecological interactions among all living organisms. Its diversity is astonishing: 15 to 20 major taxonomic groups can often be collected in a single square-foot sample of humus, with the population density of some species exceeding one million individuals per acre.

This booklet is designed to help anyone with a rudimentary knowledge of biology identify many of the small organisms likely to be found in soil and leaf litter. The Kwik-Key is purposely short so the process of identification does not become a burdensome chore. Because of its brevity, the key is neither comprehensive nor infallible. It does, however, provide reasonably high accuracy for most of the organisms commonly found in North American grassland communities, deciduous forests, compost heaps, and family gardens. Some primitive arthropods add segments (and legs) each time they molt. The Kwik-Key is written for adults of these taxa, so it may help to "add" a few pairs of legs if the illustrations in the synoptic overview do not seem to match the specimen in hand. Other characters should be reasonably similar.

Most soil-dwelling organisms are too small to be identified or studied without the aid of a good stereoscopic microscope. Magnification of at least 20-30X is essential for properly examining many of the structures used as identification characters in the Kwik-Key. Most specimens should be stored in 70% ethanol (ethyl alcohol) and examined in a shallow pan (Stender dish or watchglass) containing enough alcohol to keep the specimen submerged..

A System of Classification for Soil-Dwelling Invertebrates

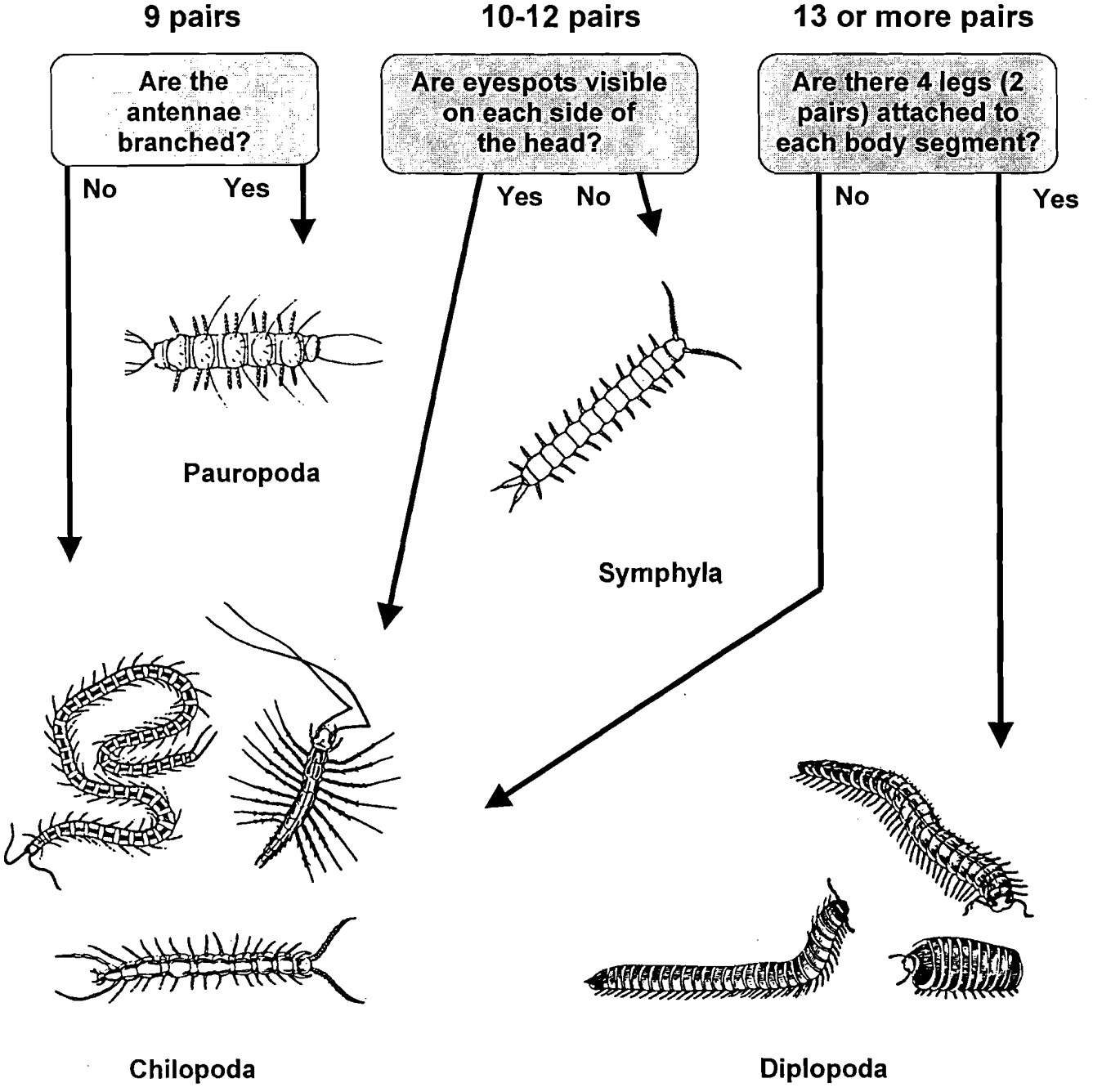
Kingdom: Animalia

- Phylum: Aschelminthes (roundworms, nematodes)
- Phylum: Annelida (segmented worms, earthworms)
- Phylum: Arthropoda
  - Division: Chelicerata
    - Class: Arachnida
      - Order: Araneae (spiders)
      - Order: Opiliones (harvestmen, daddy longlegs)
      - Order: Acarina (mites, ticks)
      - Order: Pseudoscorpiones (pseudoscorpions)
  - Division: Mandibulata
    - Class: Crustacea
      - Order: Isopoda (pillbugs, sowbugs, rollypollies)
    - Class: Chilopoda (centipedes)
    - Class: Diplopoda (millipedes)
    - Class: Symphyla
    - Class: Pauropoda
    - Class: Insecta
      - Order: Protura (coneheads)
      - Order: Diplura
      - Order: Collembola (springtails)
      - Order: Thysanura (silverfish, bristletails)
      - Order: Orthoptera (grasshoppers, crickets)
      - Order: Dermaptera (earwigs)
      - Order: Isoptera (termites)
      - Order: Blattodea (cockroaches)
      - Order: Psocoptera (booklice, barklice)
      - Order: Thysanoptera (thrips)
      - Order: Hemiptera (true bugs)
      - Order: Homoptera (aphids, leafhoppers, planthoppers)
      - Order: Coleoptera (beetles, weevils)
      - Order: Neuroptera (antlions, lacewings)
      - Order: Diptera (true flies)
      - Order: Siphonaptera (fleas)
      - Order: Lepidoptera (moths)
      - Order: Mecoptera (scorpionflies)
      - Order: Hymenoptera (bees, ants, wasps)

Kwik-Key to Soil-Dwelling Invertebrates

Step 1. How many walking legs are present?

a. Zero . . . . . Go to Step 8.
b. 4-6 (2-3 pairs) . . . . . Go to Step 3.
c. 8-16 (4-8 pairs) . . . . . Go to Step 2.
d. 18 or more (9 or more pairs) . . .



Step 2. Organisms with 4-8 pairs of legs.

Is the body shaped like a caterpillar (eruciform) with abdominal legs that are different in shape or structure from the thoracic legs?

Yes → Go to Step 3.

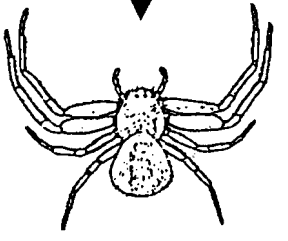
No

Does the body have exactly 4 pairs of walking legs?

Yes

Is the body sharply constricted behind the last pair of legs?

Yes



Araneae

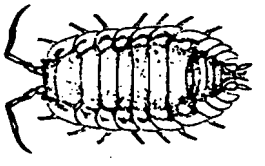
No

Are there exactly 7 pairs of legs and gill openings on undersides of the last 5 body segments?

No

Chilopoda
See illustrations on previous page

Yes

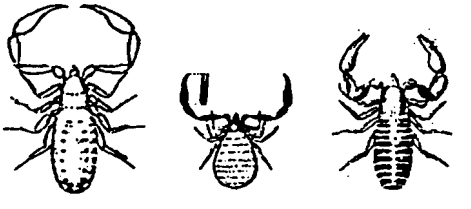


Isopoda

No

First pair of appendages (pedipalps) enlarged as pincers?

Yes

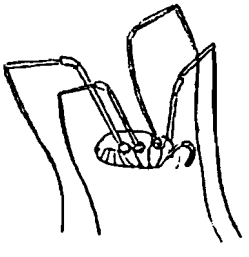


Pseudoscorpiones

No

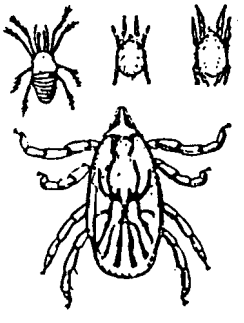
Are walking legs more than twice as long as the body?

Yes



Opiliones

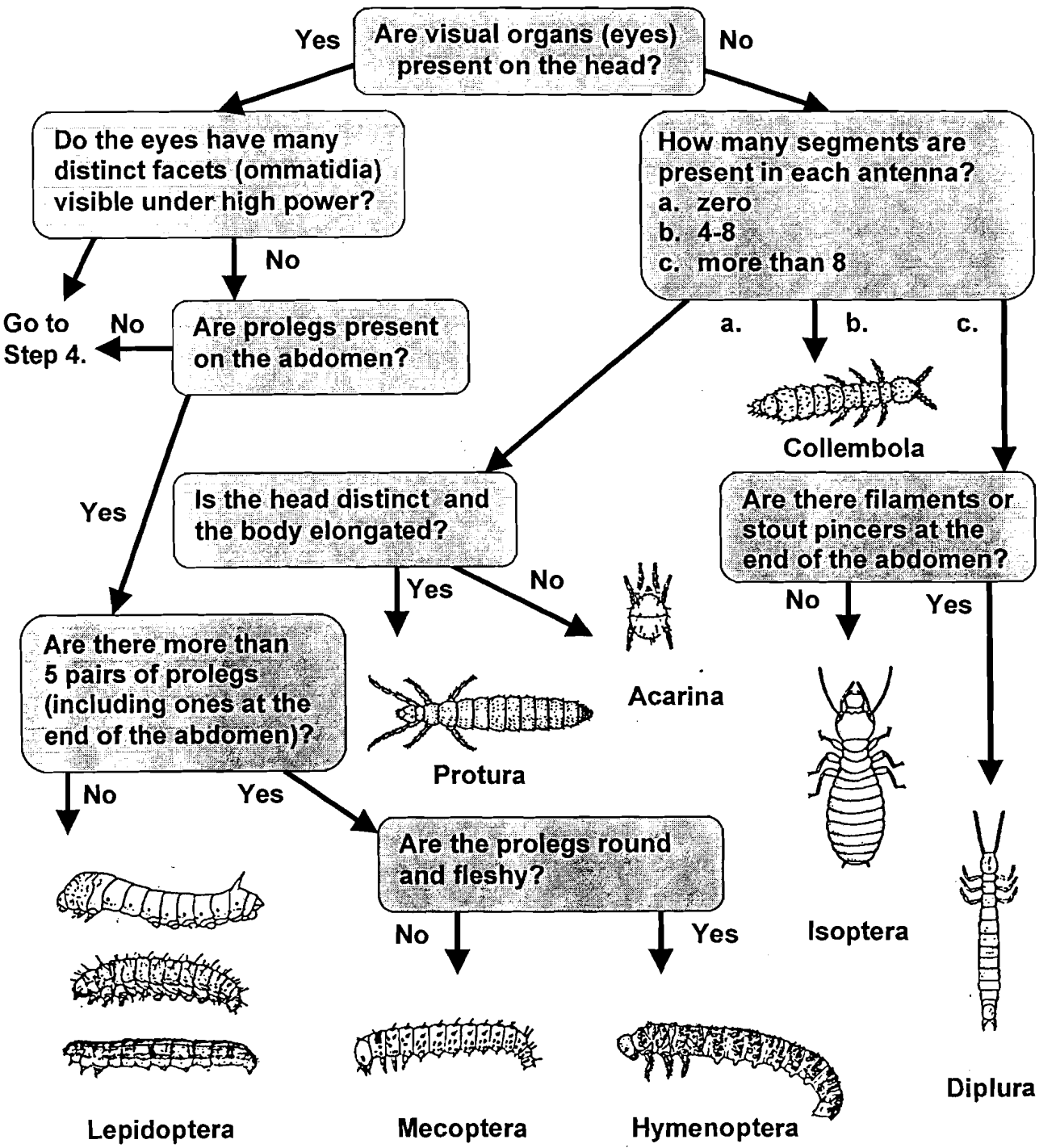
No



Acarina

Step 3. Look for evidence of wings on the thorax:

a. One pair of wings present . . . . . Go to Step 6.
b. Two pairs of wings present. . . . . Go to Step 7.
c. Hardened wing covers (elytra). . . . . Go to Step 6.
d. Short wing pads present . . . . . Go to Step 4.
e. No visible evidence of wings . . .



Step 4. Insects - - wingless adults, nymphs, and young

Do the antennae have more than 8 segments?

Yes → Go to Step 5.

No

The mouthparts are best described as:
a. Mandibulate (with 2-4 palps)
b. Hidden within the head
c. Piercing/sucking (slender proboscis)

a. b. c.

Body slender and spindle-shaped with no abdominal appendages

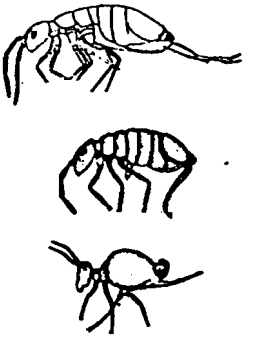
Yes No

Antennae elbowed. Usually 1 or 2 tiny segments between the thorax and abdomen

Yes No

Hymenoptera

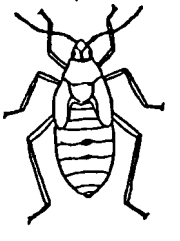
Thysanoptera



Collembola

Where does the proboscis originate on the head?
a. near the front
b. toward the back

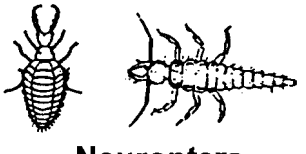
a. b.



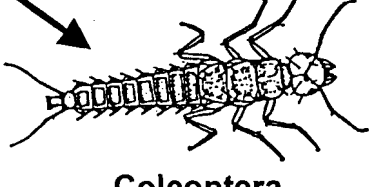
Hemiptera

Mandibles and maxillae long and sickle-shaped. Two stout hooks at end of abdomen.

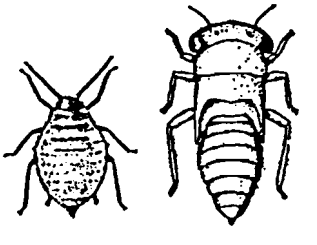
Yes No



Neuroptera

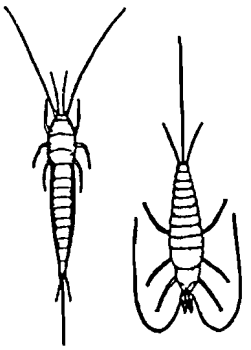


Coleoptera



Homoptera

Step 5. Wingless insects with long antennae:



Thysanura

What structures are present on the end of the abdomen?
a. 2-3 long, slender filaments
b. spines, short cerci, or bare
c. stout pincers

a. b. c.

Dermaptera

Does the body have a narrow "neck" just behind the head?

No Yes

Are there knobs or clubs (halteres) on the thorax?

Yes No

Diptera

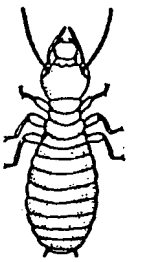
Antennae elbowed. Usually 1 or 2 tiny segments between the thorax and abdomen

Yes No

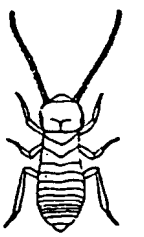
Hymenoptera

How are the mouthparts oriented?
a. forward
b. downward

a. b.



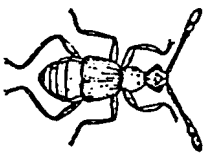
Isoptera



Psocoptera

Are the hind legs adapted for jumping?

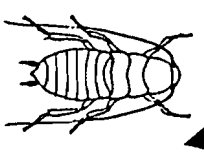
No Yes



Coleoptera

Are the antennae nearly as long as the body?

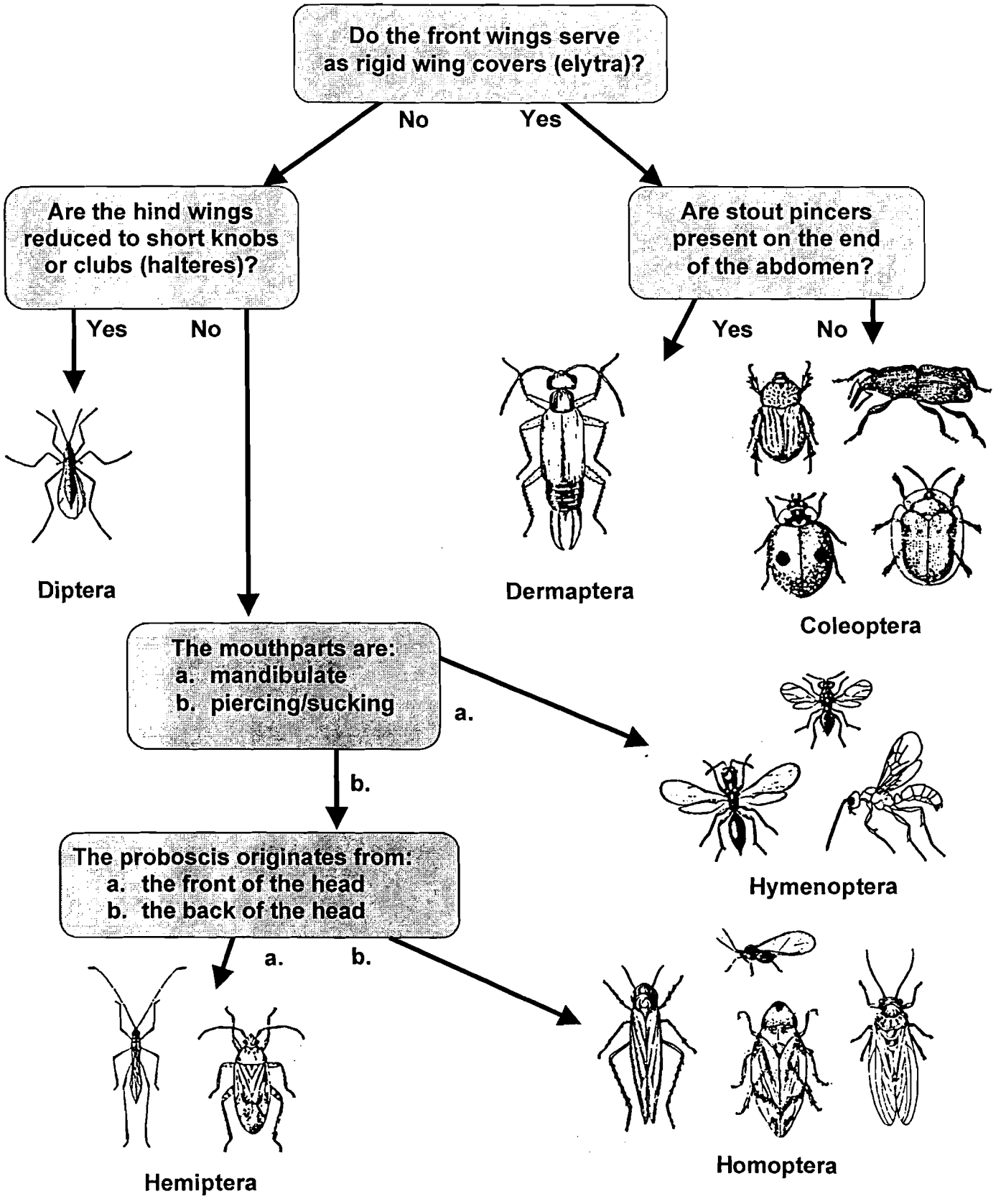
No Yes



Blattodea

Orthoptera

Step 6. Winged Insects



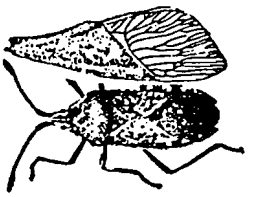
Step 7. Insects with two pairs of wings:

The front wings are best described as:

a. Covered with a fine dusting of scales → Lepidoptera

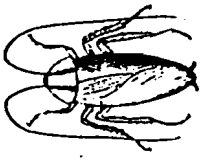
b. Rigid, inflexible (elyta) . . .Go back to Step 6.

c. Half membranous and half leathery → Hemiptera

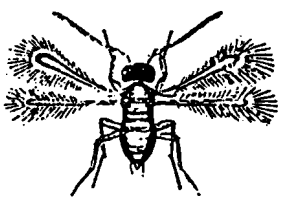


d. Rod-like with a long fringe of hairs → Thysanoptera

e. Opaque or leathery in appearance → Blattodea

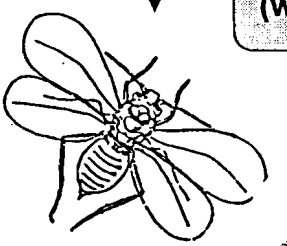


f. Entirely membranous → Hymenoptera



What type of mouthparts are present?
a. piercing/sucking
b. mandibles with palps

a. → Homoptera

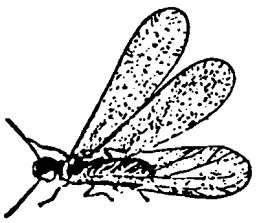


b. → Are the hind legs adapted for jumping?

Yes → Orthoptera

No → Are both pairs of wings similar in shape and veination?

Yes → Isoptera



No → Hymenoptera

Is the first part of the thorax much narrower than the head and abdomen?

Yes → Psocoptera

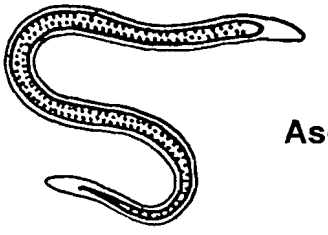
No → Are both pairs of wings similar in shape and veination?

Body spindle-shaped, (widest near middle)

Yes → Thysanoptera

No → Hymenoptera

Step 8. Body completely lacking legs:



Aschelminthes

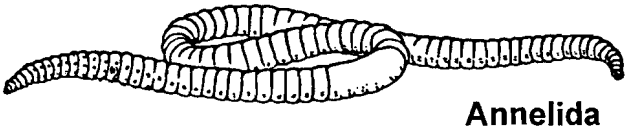
Is the body divided into segments?

No

Yes

Does the body have more than 15 segments?

Yes



Annelida

No

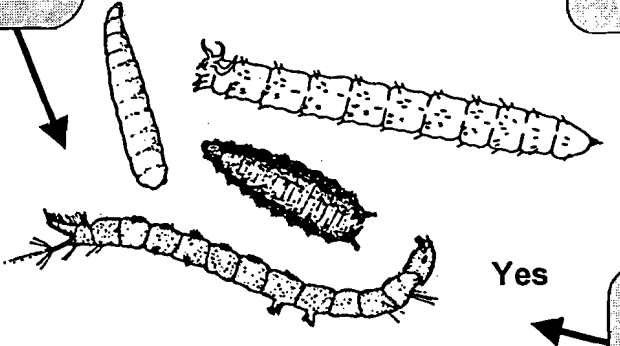
Is the body fleshy with no distinct head or mouthparts?

No

Are the last pair of spiracles larger than any others (often at the ends of short pegs or branched stalks)?

No

Yes



Diptera

Yes

Is the body tapered (vermiform) with two distinct circles on the broader end?

Yes

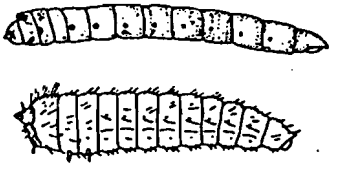
No

Hymenoptera

Are the mouthparts hard and dark in color?

Yes

No

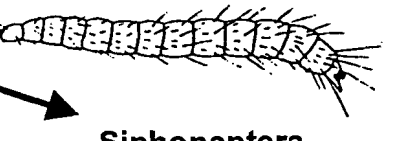


Coleoptera

Is the body somewhat hairy?

No

Yes



Siphonaptera

Order: ACARINA

Ticks and Mites

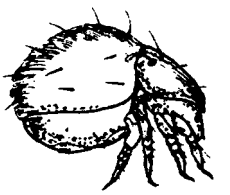
Ticks and mites are members of the largest and most diverse order within the class Arachnida. They differ from all other arachnids because they have no external body segmentation – head, legs, and abdomen are all part of a single body region that is covered by a shield-like carapace. In most species, the legs are short in comparison to the body. Some mites may be born with only six legs, but add another pair after the first molt.

All ticks are blood-sucking ectoparasites of land vertebrates. Some species transmit disease pathogens to humans and domestic animals (e.g., lyme disease and rocky mountain spotted fever).

Tick:

Mites are among the most abundant organisms found in soil and leaf litter. Some mites are ectoparasites, but most are predators or herbivores. Most of the plant-feeding species are regarded as pests, but the predatory mites are usually considered beneficial because they feed on nematodes, insect eggs, and other types of mites. The free-living mites most commonly found in soil and humus include:

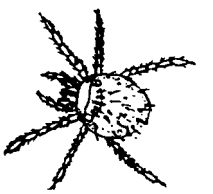
Beetle mites – family Oribatidae Hard-bodied, dark-colored, round or oval in shape with four pairs of short legs. Most species are predators.



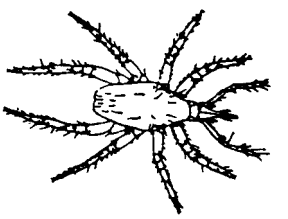
Beetle mite

Chiggers – family Trombiculidae Adults are predators of insects or insect eggs. Immatures are parasites; a few carry disease.

Chigger



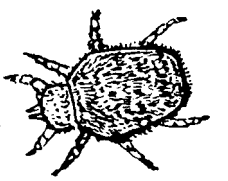
Spider mites – family Tetranychidae Adults and immatures are herbivores, often pests of agricultural plants



Spider mite

Velvet mites – family Trombidiidae Large and often velvety red in color. Parasites and predators of insect eggs.

Velvet mite



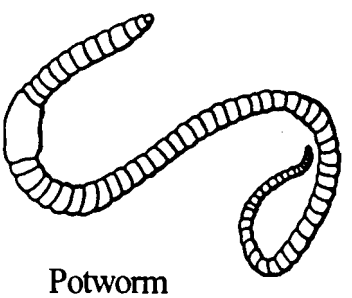
Phylum: ANNELIDA

Segmented worms, Earthworms

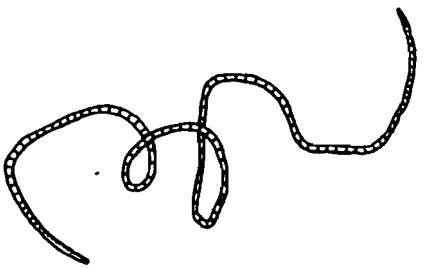
All members of the Phylum Annelida have multi-segmented bodies with a moist, rubbery outer cuticle. They have no distinct head capsule or other appendages such as legs, antennae, gills, etc. Depending on age and species, they range in length from 1-20 cm., and may have up to several hundred body segments. In most soil-dwelling species, there is a swollen band of 2-50 segments (usually 7) around the body near its anterior end. During reproduction, this band, known as the clitellum, secretes a mucus sleeve that slides off the body and forms a cocoon in which the embryos develop.

Earthworms and related species burrow in rich, loamy soil or live in the surface layer of humus where they consume large amounts of soil and digest the organic matter contained within it. Under ideal conditions, they can be extremely abundant – up to 400 earthworms per cubic meter of soil.

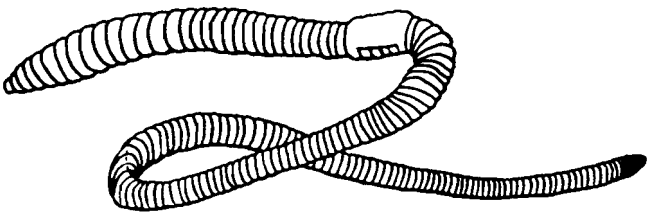
Segmented worms play an important role in developing and maintaining soil fertility. They break the components of soil down into smaller particles, mixing organic matter and aerating the soil as they burrow through it. This process prevents soil compaction, increases the penetration of rainwater, and facilitates plant growth.



Potworm



Mudworm



Earthworm

Order: ARANEAE

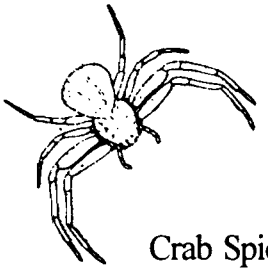
Spiders

Spiders have a body that is divided into two parts, a cephalothorax and an abdomen. The cephalothorax contains the mouthparts (both chelicerae and pedipalps), 2 to 8 eyes, and eight legs (there are no antennae). The abdomen contains the book lungs (for breathing), most of the internal organs, and spinnerets for producing silk. The silk is used to catch prey, to construct nests, and to protect the eggs and immatures.

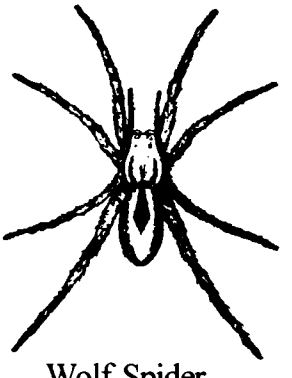
All spiders are predators, but they ingest their food only in liquid form. Spiders bite their prey with fang-like chelicerae, injecting a poison that quickly kills or immobilizes the victim. Digestive enzymes are then injected to liquify body tissues which are later sucked out as the spider feeds.

Spiders are common in most terrestrial habitats. Most of them live on the ground or in vegetation, but a few are aquatic. They are often regarded as pests, but very few species are harmful to humans. As predators of other arthropods, they can be highly beneficial as agents of biological control.

There are over 36,000 species of spiders. The largest families of soil-dwelling spiders include wolf spiders (family Lycosidae), crab spiders (family Thomisidae), jumping spiders (family Salticidae), grass spiders (Agelenidae), and dwarf spiders (family Linyphiidae).

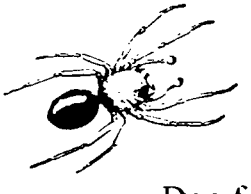


Crab Spider

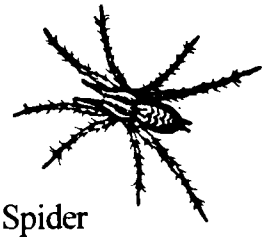


Wolf Spider

Jumping Spider



Dwarf Spider

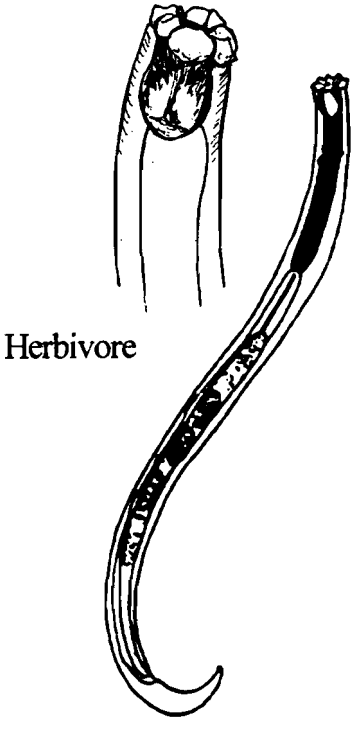


Grass Spider

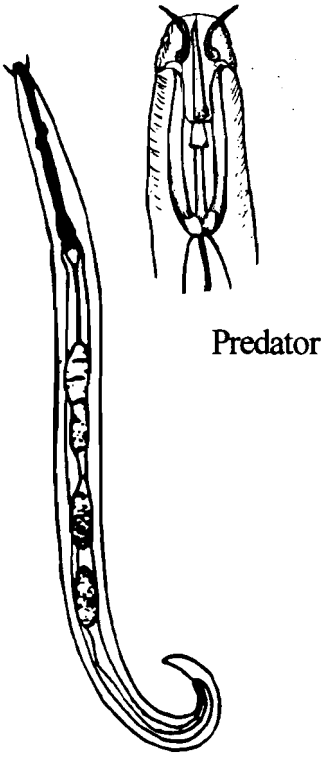
Phylum: ASCHELMINTHES

Roundworms, nematodes

Although many roundworms are internal parasites of plants and animals, there are a large number of free-living species that live in the soil. Most of these animals are very small in size; they live in the film of water that coats soil particles and generally cannot be seen without magnification. Special techniques are usually needed to extract nematodes from the soil, because they become encysted (form shell-like covers) whenever they dry out. One way to extract nematodes is to put a soil sample into a bag made from cheese-cloth and suspend the bag for several days in a container of water. After removing the bag, centrifuge the water for several minutes at a low speed, collect material from the bottom of the centifuge tube in a pipet, and examine it under a good quality compound microscope.



Herbivore



Predator

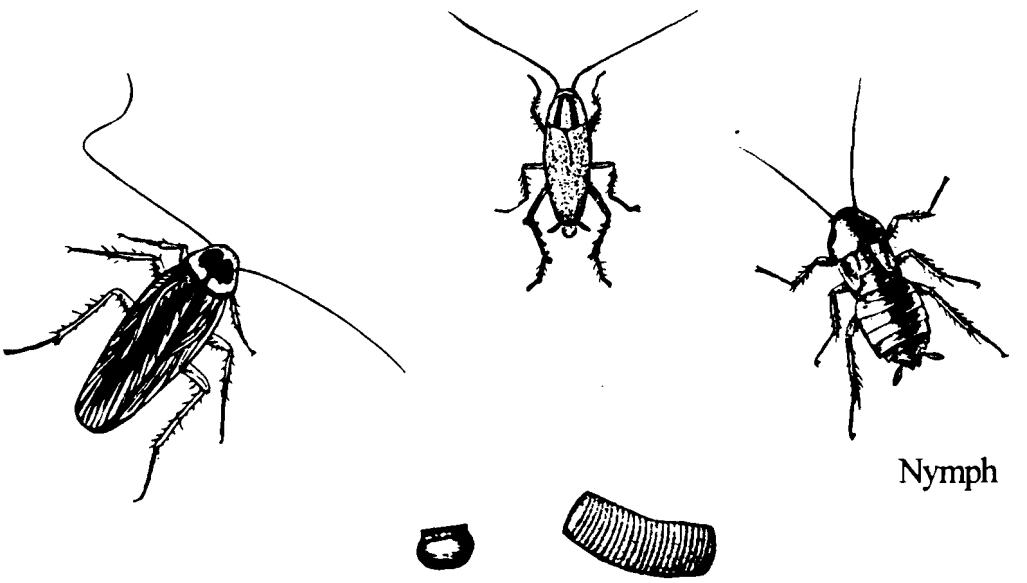
Order: BLATTODEA

Cockroaches, Waterbugs

Cockroaches are among the most cosmopolitan of all insects. We generally associate them with human dwellings, but most roaches are cryptozoic insects that live in forest leaf litter or under stones and dead logs. They have an oval, somewhat flattened body that is well-adapted for running and squeezing into narrow openings. Much of the head and thorax is covered and protected dorsally by a large plate of exoskeleton (the pronotum). Antennae are long and slender. Most adults are winged (two pairs), but a few species remain wingless throughout their entire lives. Rather than flying to escape danger, roaches usually scurry into cracks or crevices.

Cockroaches are scavengers or omnivores. They are most active at night and will feed on almost any organic material they can find, including dead plants or animals, seeds and grains, wood and paper products, or honeydew from aphids and scale insects.

When cockroaches reproduce, the female forms a purse-like capsule around her eggs. This structure, known as an öotheca, may be dropped on the ground, glued to a substrate, or retained within the female's body. In woodland species, the öotheca is often found under stones, bark, or dead logs.



Nymph

Egg Cases (öothecae)

Class: CHILOPODA

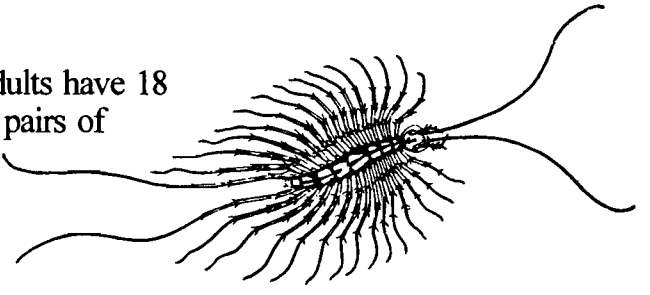
Centipedes

Centipedes are arthropods whose bodies are divided into two regions: a head and a long, many-segmented trunk. The head includes a pair of antennae, simple eyes (usually a cluster of several ocelli), and mouthparts (mandibles and two pairs of maxillae). The first segment of the trunk bears a large pair of poison jaws (maxillipeds) used in catching and killing prey. Each of the remaining trunk segments (usually 15 or more) contains a pair of walking legs. Most species add body segments (and legs) each time they molt.

All centipedes are predacious. They feed on a variety of small arthropods, worms, snails, nematodes, and other small animals. Centipedes are very common in leaf litter and compost. There are about 3,000 described species. Major orders include:

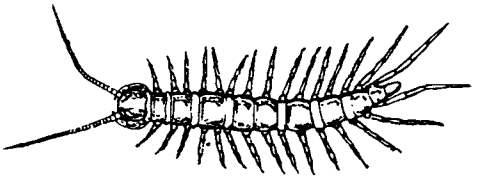
Scutigeromorpha:

House centipedes. Adults have 18 body segments and 15 pairs of unusually long legs.



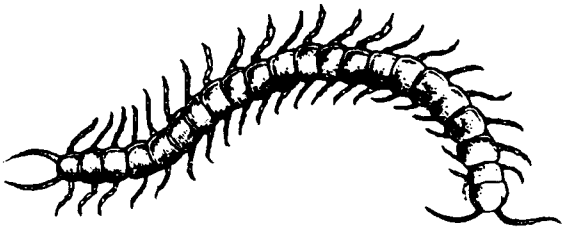
Lithobiomorpha:

Stone centipedes. Adults have 18 body segments and 15 pairs of short legs.



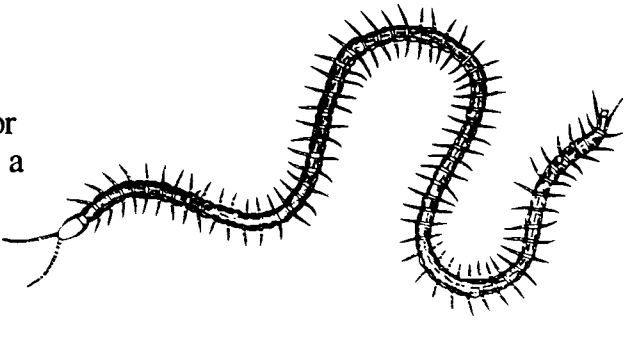
Scolopendromorpha:

Scolopendrids. Adults have 21 or 23 trunk segments, each bearing a pair of legs.



Geophilomorpha:

Soil centipedes. Adults have 29 or more trunk segments, each bearing a pair of legs.



Order: COLEOPTERA

Beetles, Weevils

Coleoptera is the largest order in the class Insecta. As adults, most beetles have a hard, dense exoskeleton that covers and protects most of their body surface. The front wings, known as **elytra**, are just as hard as the rest of the exoskeleton. They fold down over the abdomen and serve as protective covers for the large, membranous hind wings. At rest, both elytra meet along the middle of the back, forming a straight line that is probably the most distinctive characteristic of this order. During flight, the elytra are held out to the sides of the body where they provide a certain amount of aerodynamic stability.

Both larvae and adults have strong mandibulate mouthparts. As a group, they feed on a wide variety of diets, inhabit all terrestrial and fresh-water environments, and exhibit a number of different life-styles. Many species are herbivores – variously adapted to feed on the roots, stems, leaves, or reproductive structures of their host plants. Some species live on fungi, others burrow into plant tissues, still others excavate tunnels in wood or under bark. Many beetles are predators. They live in the soil or on vegetation and attack a wide variety of invertebrate hosts. Some beetles are scavengers, feeding primarily on carrion, fecal material, decaying wood, or other dead organic matter. There are even a few beetles that live as external parasites on birds, mammals, or other insects.

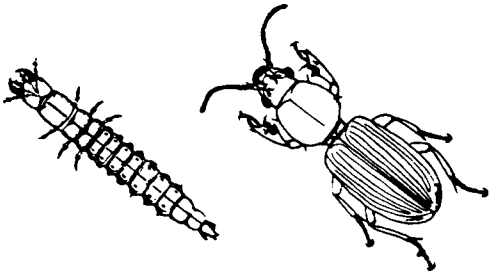
Common soil-dwelling beetles include:

<u>Larvae:</u> <u>Adults:</u>

Weevils – family Curculionidae. Front of head is elongated into a proboscis. Elbowed antennae attach to the proboscis. Mostly herbivores.

Rove beetles – family Staphylinidae. Elytra are very short, exposing much of the abdomen. Mostly predators or scavengers.

Ground beetles – family Carabidae. Mandibles are pointed, adapted for catching prey. Second segment of hind leg (trochanter) is unusually large and distinctive. Most species are predators.

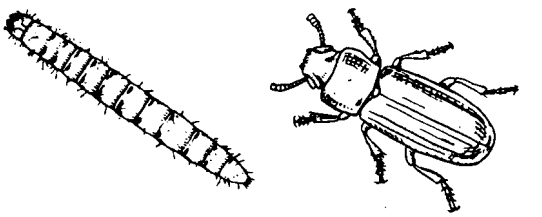


Coleoptera, cont.

Larvae: Adults:

Hister beetles – family Histeridae. Oval, convex, and shiny black. Antennae are usually clubbed. Mostly predators or scavengers.

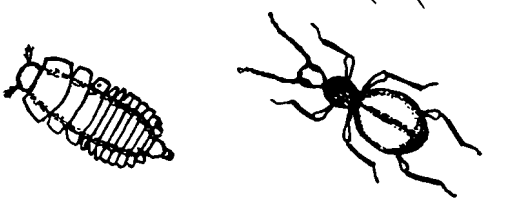
Darkling beetles – family Tenebrionidae. Resemble ground beetles, but have only four segments in the hind tarsi (instead of five). Larvae are called "mealworms". Mostly herbivores or scavengers.



Carpet beetles – family Dermestidae. Small, round beetles with clubbed antennae. Larvae are oval and extremely hairy. Most species are scavengers.

Scarab beetles – family Scarabaeidae. Rotund beetles with heavy spines on the legs. Antennae are lamellate. Larvae are called "white grubs". Mostly herbivores and scavengers.

Ant-like stone beetles – family Scydmaenidae. Brown, hairy beetles that resemble ants. Femur of legs often club-shaped. Most species are predators of mites.



Click beetles – family Elateridae. Larvae, known as "wireworms", are common in wood and soil. Shape of thorax is distinctive in adults. Most species are herbivores.

Fireflies – family Lampyridae. Larvae often occur in the soil. Many are luminescent. Most larvae are predators.

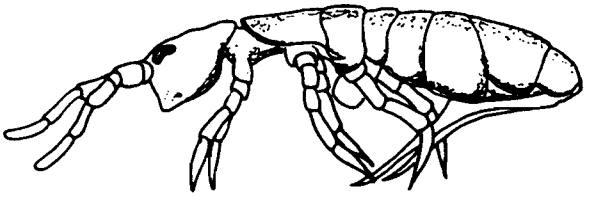
Order: COLLEMBOLA

Springtails

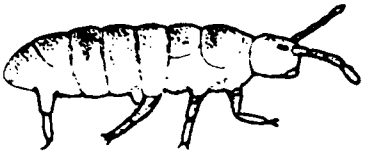
The springtails are among the most abundant of all soil-dwelling arthropods. They live in a variety of habitats where they feed as scavengers on decaying vegetation and soil fungi. Most species are small (less than 6 mm in length) and quite susceptible to desiccation unless they remain in a moist environment. A unique, tube-like structure, the collophore, is located ventrally on the first abdominal segment of most species. The exact function of this organ is unknown, but it probably helps maintain water balance by absorbing moisture from the environment.

Springtails are named for the forked jumping organ (the furcula) found on their fourth abdominal segment. The furcula is retracted against the ventral wall of the abdomen and held there, in cocked position, by a special catch (the tenaculum) on the third abdominal segment. Releasing the tenaculum causes the furcula to snap down against the substrate and flip the organism some distance through the air. This device, present in all but a few genera, seems to be an effective adaptation for avoiding predation.

Immature collembola are similar in appearance to adults. They usually molt 4-5 times before reaching sexual maturity, and continue to molt periodically throughout the rest of their life. Unlike most other arthropods, springtails appear to have evolved in a cool climate. Development is most rapid under cool, humid conditions, and their relative abundance in the soil tends to increase as the mean annual temperature decreases.



Isotomidae



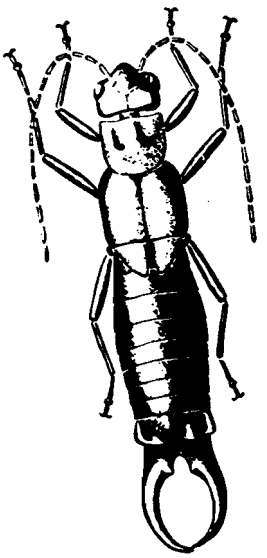
Hypogastruridae

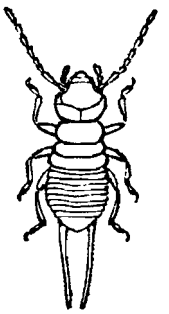
Sminthuridae

Order: DERMAPTERA

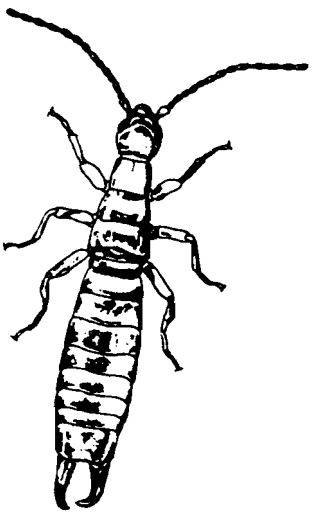
Earwigs

Earwigs are mostly scavengers or herbivores that hide in dark recesses during the day and become active at night. They feed on a wide variety of plant or animal matter. A few species may be predatory. Females lay their eggs in the soil, and may guard them until they hatch. Nymphs are similar in appearance to adults, but lack wings. The front wings are short, thick, and serve as protective covers for the hind wings. Hind wings are large, fan-shaped and pleated. They fold (both length-wise and cross-wise) to fit beneath the front wings when not in use. Some species are secondarily wingless. In all earwigs, the cerci at the end of the abdomen are enlarged and thickened to form pincers (forceps). These pincers are used in grooming, defense, courtship, and even to help fold the hind wings.





Nymph



Class: DIPLOPODA

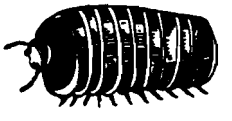
Millipedes

Millipedes are long, slender arthropods with many pairs of legs. The body is divided into a short, round head and a long trunk. Although they are nicknamed "thousand-leggers", millipedes usually have only 30-100 pairs of legs – two pairs per trunk segment.. The head has a pair of antennae, simple or compound eyes, and mouthparts (mandibles and maxillae).

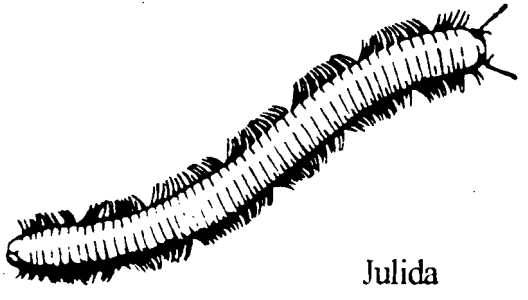
All millipedes are scavengers or herbivores. They feed on decaying organic matter and soft plant tissues. They may become so abundant that they are regarded as pests, but they usually do not cause severe injury to growing plants. Most millipedes are rather slow-moving animals, yet they are surprisingly strong. Because of a hard exoskeleton and the force exerted by many legs, they can force their way into small cracks and crevices.

Millipedes defend themselves in one of two ways: they may curl up into a ball or a tight coil, exposing only the hard dorsal plates of their exoskeleton, or they may release a foul-smelling repellent from glands along the sides of the body.

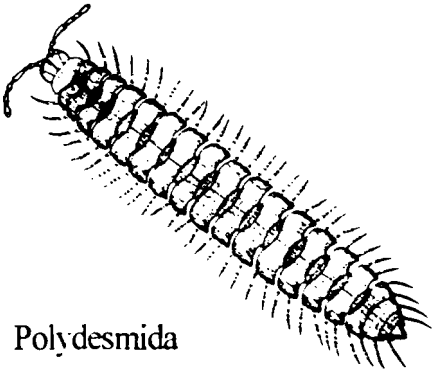
Polyxenida



Glomerida



Julida



Polydesmida

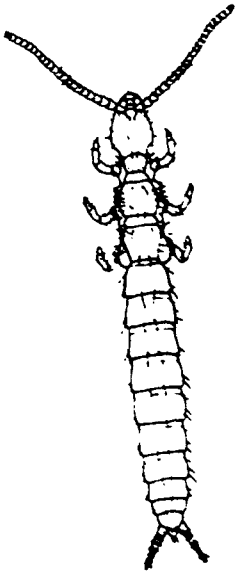
Order: DIPLURA

Diplurans

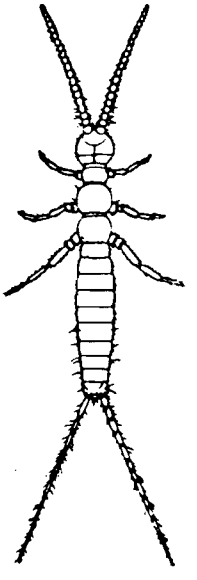
These small, eyeless arthropods are considered to be among the most primitive of all hexapods. They have a pair of long, beaded antennae on the head and a pair of segmented sensory structures (cerci) at the rear. In one common family (Japygidae), these cerci are developed into strong pincers.

Diplura are tiny, cryptozoic animals that live in moist soil, leaf litter, or humus. They have small, eversible vesicles on the ventral side of most abdominal segments that seem to help regulate the body's water balance, perhaps by absorbing moisture from the environment.

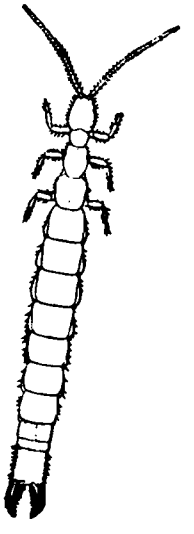
Most diplura are predators; their diet probably includes a wide variety of other soil-dwellers, including collembola, mites, symphyla, insect larvae, and even other diplurans. They may also survive on vegetable debris and fungal mycelia, but most species seem to prefer animal prey.



Projapygidae



Campodeidae



Japygidae

Order: DIPTERA

True flies, Gnats, Midges

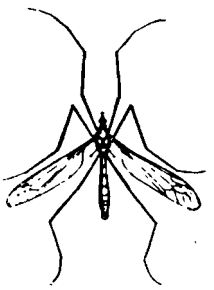
The Diptera are a distinctive group of insects because they have only one pair of membranous wings in the adult stage. The second pair of wings (the hind ones) are always reduced to form small, club-shaped structures (called **halteres**) that vibrate during flight to help the insect maintain balance.

All dipteran larvae are legless. They are commonly found in leaf litter, in plant or animal tissues, and in carrion or dung – always where the environment is moist or humid. Some species are herbivores, but most feed on dead organic matter or parasitize other animals, especially vertebrates, molluscs, and other arthropods. In the more primitive families (suborder Nematocera), fly larvae have well-developed head capsules with mandibulate mouthparts. These structures are reduced or absent in the more advance suborders (Brachycera and Cyclorrhapha) where the larvae, known as **maggots**, have worm-like bodies and only a simple pair of mouth hooks for feeding.

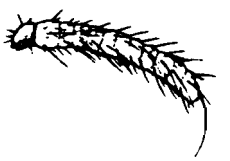
Although most adult flies rarely spend much time in the soil, there are some species that are especially adapted for this environment. In a few cases, these soil-dwelling species have no wings at all (or very short, non-functional ones). Most of these flies feed on fungi and dead organic matter.

Common soil-dwelling flies belong to four major groups – each containing several families:

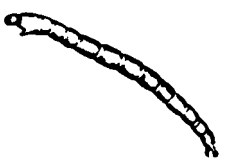
Crane flies:



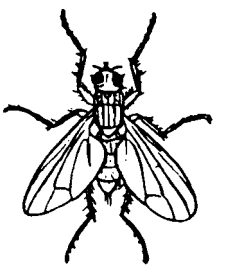
Gnats:



Midges:



Muscoid flies:



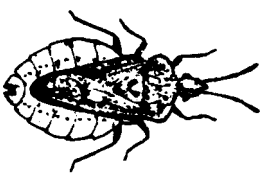
Order: HEMIPTERA

True bugs

All members of the order Hemiptera have piercing/sucking mouthparts contained within a distinctive beak (**proboscis**) that arises near the front of the head. The proboscis surrounds four slender, interlocking stylets (two mandibles and two maxillae) that form a flexible feeding tube no more than 0.1 mm in diameter. As adults, most of the Hemiptera have very distinctive front wings, called **hemelytra**, in which the basal half is leathery and the apical half is membranous. At rest, these wings cross over one another and lie flat along the insect's back.

The Hemiptera are an unusually diverse group of insects. Members of this order have become adapted to a broad range of habitats – terrestrial, aquatic, and semi-aquatic. Terrestrial species are often associated with plants. They feed in vascular tissues or on the nutrients stored within seeds. Other species live as scavengers in the soil or underground in caves or ant nests. Still others are predators on a variety of small arthropods. A few species even feed on the blood of vertebrates.

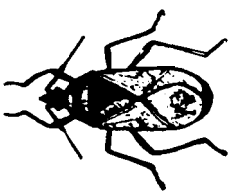
Common families of soil-dwelling hemiptera include:



Flat bugs – family Aradidae

Seed bugs – family Lygaeidae

Burrower bugs – family Cydnidae



Minute pirate bugs – family Anthocoridae

Order: HOMOPTERA

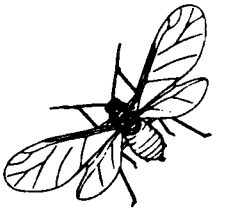
Cicadas, Aphids, Leafhoppers, and others

All members of the order Homoptera have piercing/sucking mouthparts; they feed by withdrawing sap from the phloem of vascular plants. The beak (rostrum) is relatively short (1-3 segments) and emerges from near the ventral posterior margin of the head (near the front legs). Some adult homoptera are wingless, but the majority have two pairs of wings that fold tent-like over the body at rest.

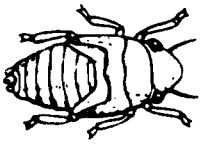
Cicadas are the largest members of the order. As nymphs, they live underground and feed on the roots of trees and shrubs. Some species complete development in as little as four years, but others have a 13- or 17-year life cycle. In contrast, the aphids are tiny, soft-bodied insects with multiple generations per year. Many species have complex life cycles involving more than one host plant. Winged and wingless forms of the same species may develop at different times of the year. Asexual reproduction (parthenogenesis) is common and males are unknown in some species.

Cicadas:

Aphids:



Leafhoppers, Treehoppers, and Planthoppers



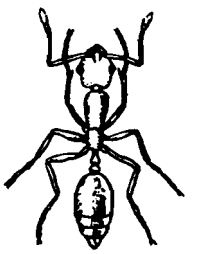
Order: HYMENOPTERA

Ants, Bees, Wasps

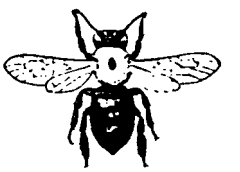
As a rule, members of the order Hymenoptera can be regarded as ecological specialists. Most species are rather narrowly adapted to specific habitats and/or hosts. Their remarkable success as a taxon probably has more to do with their immense range of behavioral adaptation rather than any physical or biochemical charcteristic. Hymenoptera is the only order besides Isoptera (termites) to have evolved complex social systems with division of labor. In social hymenoptera, all members of the worker caste are adult females.

Except for worker ants, most adult Hymenoptera have two pairs of wings. Front and hind wings are linked together by hooks (**hammuli**) along the leading edge of the hind wings that catch in a fold near the back of the front wings. In flight, both wings operate in unison to form a single aerodynamic surface. A narrow junction between the thorax and abdomen is a distinguishing characteristic of all ants, bees, and wasps.

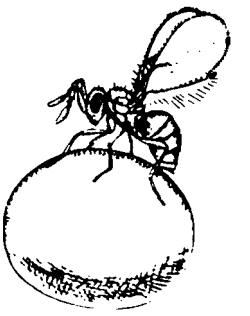
There are three major groups of soil-dwelling Hymenoptera:



Ants – family Formicidae. Ants are among the most abundant and diverse of all soil-dwelling insects. All ants live in communal nests. Some species are herbivores, some are predators, others are scavengers. Ants can usually be distinguished from all other insects by the size and shape of the first abdominal segment and the presence of elbowed antennae.



Solitary bees – superfamily Apidoidea. Many species of solitary bees burrow and nest in the soil. These soil-nesting bees gather nectar or pollen as a food resource for their larvae. A few species are parasitic on other bees. The mouthparts are modified into a proboscis that works like a tongue to collect nectar from flowers.



Predatory and parasitic wasps – many families. The large hunting wasps are agile predators that catch and paralyze insects (or spiders) as food for their offspring. Larvae of the parasitic wasps feed internally on the living tissues of other arthropods (or their eggs). These insects eventually kill their host, but not before completing their own larval development within its body. Despite their small size and narrow host range, these wasps are quite abundant and can have a big impact on the population dynamics of other insects.

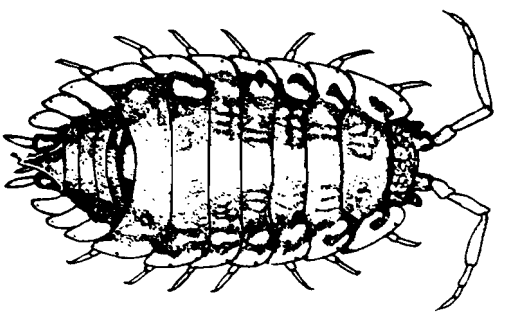
Order: ISOPODA

Woodlice, sowbugs (family Oniscidae)
Pillbugs, rolypolies (family Armadillidae)

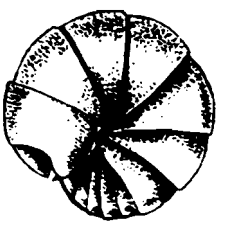
Isopods are crustaceans – in fact, pillbugs and sowbugs are the only crustaceans that can live on land. Like all other members of their class, they breathe by means of gills on the underside of the body. The gills must remain wet in order to function, so these animals can only survive in cool, moist environments. They are usually found under stones or logs and are most active at night. Pillbugs are named for their ability to curl up into a tight ball as a defensive reaction.

All isopods have long, oval bodies covered by rounded plates of smooth, gray exoskeleton. Most species are 5-20 mm in length. The head and eyes are small and indistinct, but they have one large pair of antennae and seven pairs of walking legs. Five pairs of gills are located ventrally on body segments near the back of the body. The gills are usually hidden under a protective cover known as the operculum.

Pillbugs and sowbugs are primarily scavengers. They feed on most any organic matter, plant or animal, that is available to them. They are usually not abundant enough to be considered pests. Some birds and spiders are their natural enemies.



Sowbug



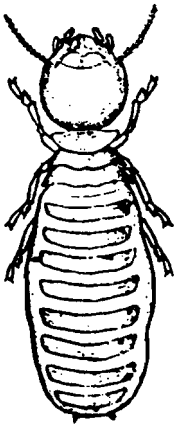
Defensive Posture
of a pillbug

Order: ISOPTERA

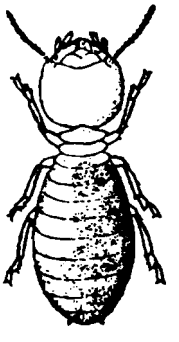
Termites

All members of the order Isoptera are social insects. In the United States, most species nest in the ground and feed on wood that is in close proximity to the soil. A termite cannot digest the wood fibers it eats, but enzymes from symbiotic microorganisms in its digestive system convert the wood into useful nutrients. Isoptera are most abundant in tropical and subtropical soils where they play an important role in the natural decomposition of dead wood.

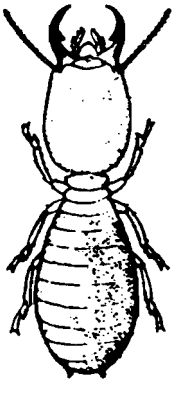
Termites are often known as "white ants". They are similar to ants in size, but are generally lighter in color and do not have a constricted "waist" between the thorax and the abdomen. A termite nest contains adult reproductives (one king and one queen) plus hundreds or thousands of immatures (nymphs) that serve as workers and soldiers. A soldier is similar to a worker but has an enlarged head and stronger mandibles.



Queen



Worker



Soldier

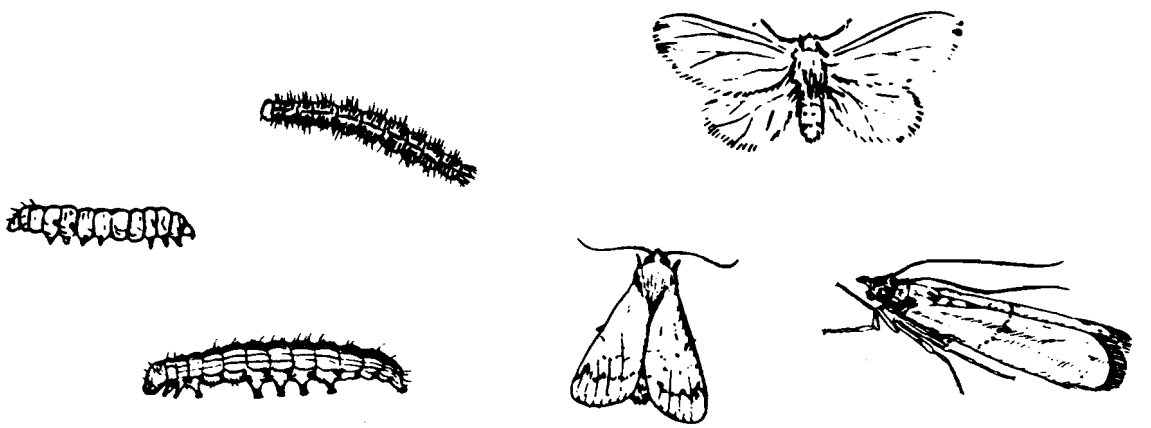
Order: LEPIDOPTERA

Moths, Butterflies

Moths are members of the second largest order in the class Insecta. Adults are distinctive because their body and wings are covered with tiny, overlapping scales. In butterflies (and some moths), these scales produce distinctive color patterns that play an important role in courtship and intraspecific recognition. But most of the soil-dwelling Lepidoptera are small brown or gray moths that blend in with their environment. Wings are held horizontally against the substrate, folded flat over the back, or curled around the body. They are most active near dusk or after sunset.

Moth larvae are known as caterpillars. They have a well-developed head with chewing mouthparts. In addition to three pairs of legs on the thorax, they have two to five pairs of fleshy abdominal prolegs that are structurally and embryologically different from the thoracic legs. A ring of small hooks (crochets) near the tip of each proleg is the most distinctive characteristic of lepidopteran larvae.

Nearly all of the Lepidoptera are herbivores. Larvae have chewing mouthparts; they consume foliage, burrow into stems or roots, or tunnel in leaf tissue. Most adults have a tubular proboscis which lies coiled like a watch spring beneath the head. It uncoils by hydostatic pressure and acts as a siphon tube for sipping liquid nutrients, such as nectar, from flowers and other substrates.



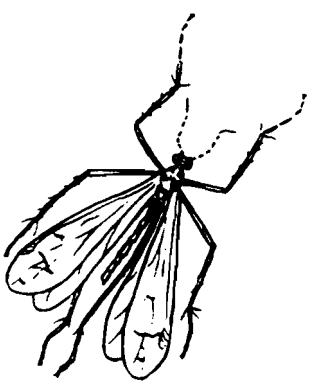
Larvae Adults

Order: MECOPTERA

Scorpionflies

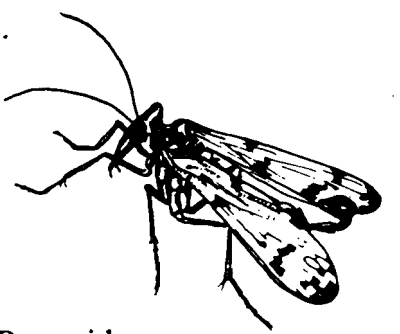
The Mecoptera are an interesting, but rather uncommon group of terrestrial insects that live in moist sylvan habitats. They are most abundant in temperate and sub-tropical climates. Both larvae and adults are omnivorous; they feed upon decaying vegetation and dead (or dying) insects. Larvae generally remain in the soil. They have chewing mouthparts and resemble caterpillars (Lepidoptera) or white grubs (Coleoptera). The abdominal prolegs are more slender than those of Lepidoptera and do not have the small hooks (crochets).

Most adults have an elongated head with slender, chewing mouthparts near the tip of a stout beak. Front and hind wings are similar in shape (occasionally reduced in size or absent), and often mottled with patches of color. The common name of this order (scorpionfly) refers to the distinctive appearance of male genitalia in members of the family Panorpidae: the terminal segments are enlarged and held recurved over the abdomen like the tail of a scorpion.



Bittacidae

Larva



Panorpidae

Order: NEUROPTERA

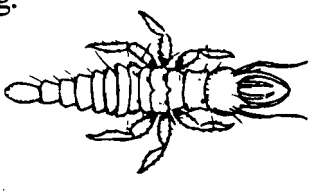
Lacewings, Antlions, Snakeflies

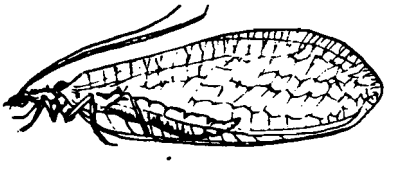
All immature Neuroptera are predators, and most species are regarded as beneficial. Antlion larvae live in the soil and construct pitfall traps to snare prey. Lacewing larvae are usually found in vegetation where they typically feed on aphids, mites, and scale insects. Snakefly larvae live in leaf litter or under bark and catch aphids or other soft-bodied prey. In most cases, the adults of these insects are also predators -- the non-predatory species usually feed on nectar, pollen, or honeydew.

The larvae of antlions and lacewings have specialized mouthparts with large, sickle-shaped mandibles and maxillae that interlock to form pincers. Once impaled on these pincers, a prey's body contents are sucked out through hollow food channels running between the adjacent surfaces of the mandibles and maxillae.

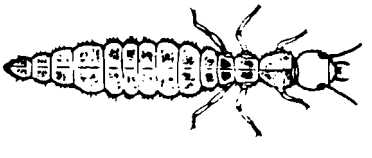
As adults, all neuropterans have two pairs of membranous wings with an extensive pattern of veins and crossveins. At rest, the wings are folded flat over the abdomen or held tent-like over the body. Most species are rather weak fliers.

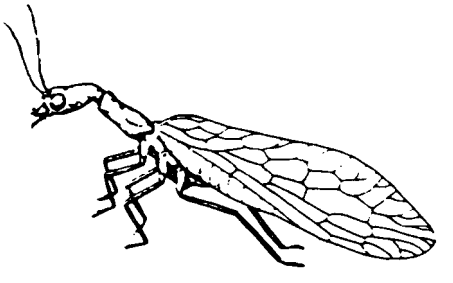
Lacewing:



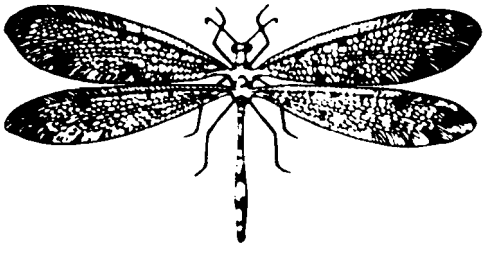


Snakefly:





Antlion:



Order: OPILIONES

Harvestmen, Daddy-longlegs

These long-legged arthropods belong to a different order than true spiders. They have a compact, oval body (generally 5-10 mm in length) with four pairs of unusually long, thin legs. Most species are brown or gray in color. The head is small and closely joined to the rest of the body. Mouthparts consist of a pair of chelicerae and a pair of pedipalps (each pedipalp has a small claw at its tip).

In addition to providing locomotion, a harvestman's legs help detect food, excrete wastes, and ward off predators. The tips of the legs contain sensory organs that "taste" whatever they touch. The legs also contain the animal's only excretory organs as well as scent glands that produce an offensive odor.

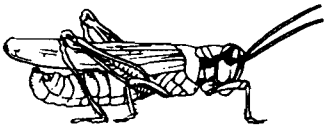
Although daddy-longlegs are found throughout the world, they are most abundant in tropical climates. They usually live in habitats where vegetation is abundant. Most of the harvestmen appear to feed as scavengers on plant juices and dead insects. A few species are known to be predators of small, soft-bodied arthropods (such as aphids).

Order: Orthoptera

Grasshoppers, Crickets, Katydids

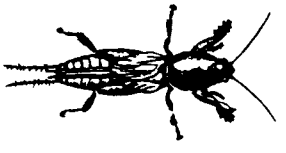
The Orthoptera is one of the largest and most important groups of plant-feeding insects. Most members of the order can be easily recognized by the large hind legs that are adapted for jumping. Some species (camel crickets, for example) do not have wings even as adults, but in most other Orthoptera, wing buds develop during the late nymphal stages and become functional only in adults. The front wings are usually slender and somewhat thickened. They fold back over the abdomen to protect membranous, fan-shaped hind wings. Most Orthoptera have the ability to produce and detect sounds, although in some cases, these sounds are above the range of human hearing.

Soil-dwelling Orthoptera are most like to be members of one of the following families:



Grasshoppers (family Acrididae) have relatively short antennae, a tympanum (ear membrane) on the first abdominal segment, and three-segmented tarsi. They feed on the leaves of many plants.

Crickets (family Gryllidae) are herbivores or scavengers. They have relatively long, slender antennae, three-segmented tarsi, and a tympanal slit on the tibia of the front legs.



Mole crickets (family Gryllotalpidae) lack the characteristic hind jumping legs of other orthopterans, but they have distinctive mole-like front legs used for burrowing through the soil. They feed on the roots of grasses and other plants.

Camel crickets (family Gryllotalpidae) are humpbacked, wingless insects with long, thread-like antennae. They are mostly scavengers, living in wood piles and other sheltered sites where they feed on dead insects or other organic matter.

Katydids (family Tettigoniidae) feed on the leaves of plants. They have very long, slender antennae, four-segmented tarsi, and tympanal slits on the tibia of the front legs.

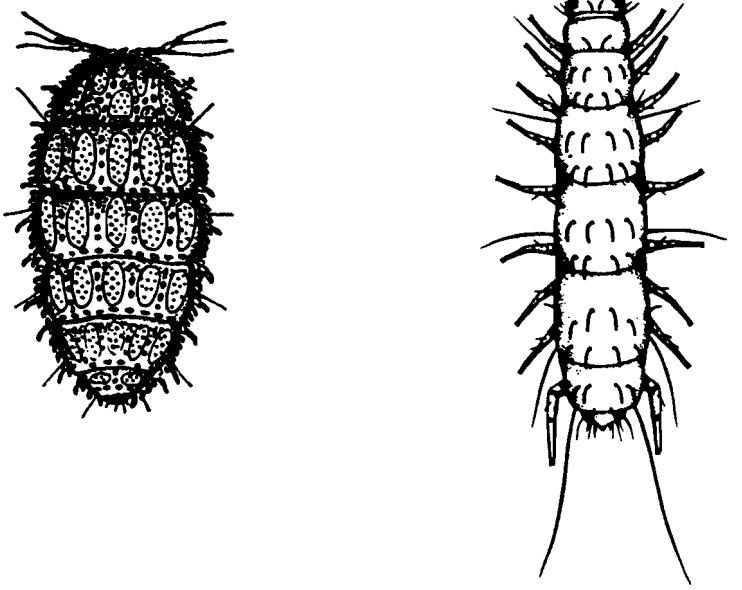
Class: PAUROPODA

Pauropods

These arthropods are rather closely related to centipedes and millipeds, but they are much smaller in size (usually 0.5 to 2.0 mm in length). As adults, they have nine pairs of legs and one pair of distinctive, three-branched antennae. Their bodies are soft, plump, and unpigmented (usually white or ivory in color). The head is small and sometimes covered by the first segment of the trunk. They do not have eyes.

Pauropods live in moist soil and leaf litter or under stones and logs where they feed as scavengers on fungi, dead organisms, and organic debris. They are most common in temperate and tropical climates.

Immature pauropods are born with only six legs. They add additional legs and body segments each time they molt (anamorphosis).

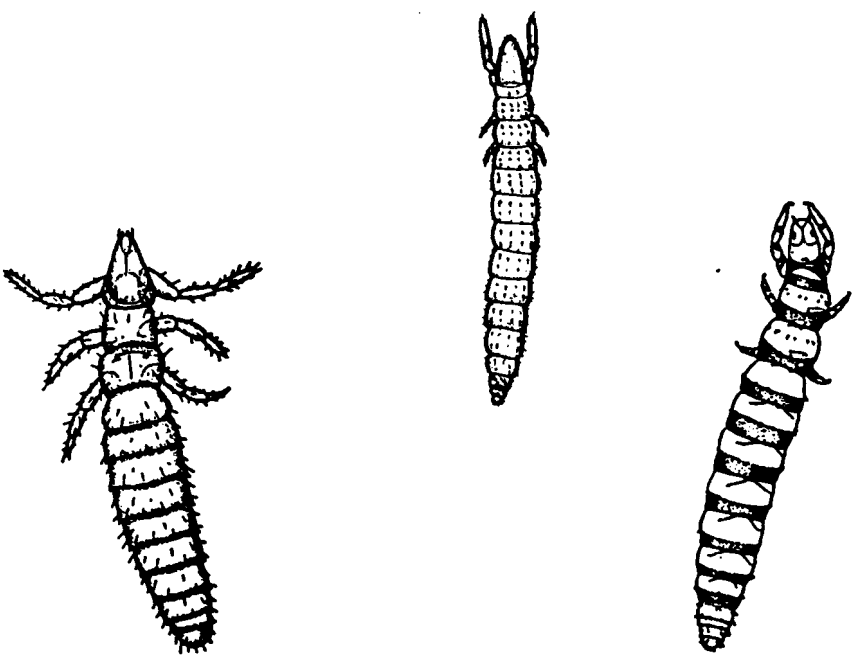


Class: PROTURA

Proturans, Coneheads

Proturans are usually regarded as the most primitive of all hexapods. They have six legs and three body regions (head, thorax, and abdomen), but they lack most of the other physical features that are common to soil-dwelling arthropods. Most species are very small (0.5 - 2.0 mm) and unpigmented. They are always found in moist habitats – usually in the humus and leaf mold of temperate deciduous forests. Both adults and immatures feed on organic matter released by decay.

Proturans do not have eyes or antennae. The front pair of legs are usually held in front of the body and apparently serve as sensory organs. Newly hatched proturans have nine abdominal segments. Each time they molt, another segment is added near the end of the abdomen until they are fully grown (and sexually mature) with 12 abdominal segments. Additional molts may occur during adulthood, but the body does not grow any longer.



Order: PSEUDOSCORPIONES

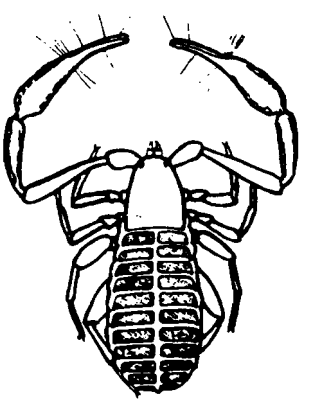
Pseudoscorpions

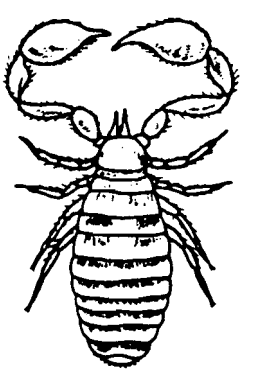
The pseudoscorpions are small chelicerate arthropods that live under bark and stones, in leaf litter and moss, and occasionally in the nests of birds, mammals, or insects. Most species are quite small (under 1 cm). They are relatively common, but not well known because of their small size and secretive habits. There are over 200 species found in North America.

As their name ("false scorpion") implies, these arthropods bear a resemblance to true scorpions. They have a pair of large pincer-like claws (pedipalps), but they lack the stinging tail of a true scorpion. Pseudoscorpions have an oval or pear-shaped body with a small head and four pairs of walking legs immediately behind the pedipalps.

Pseudoscorpions are predators. They are generally considered beneficial because they feed on a wide variety of small, soil-dwelling invertebrates. Like other arachnids, they have poison fangs (chelicerae) which they use to kill their prey. Pseudoscorpions do not bite humans or domestic animals, but they occasionally catch a ride from place to place on the body of another animal.

In some species, the males and females engage in a mating dance while holding each other's pedipalps. Males deposit a spermatophore that the females must pick up in order to become fertilized. Eggs are usually carried on the underside of the female's body. When they hatch, the young offspring are kept in a silk nest where they feed from their mother's body until the first molt.



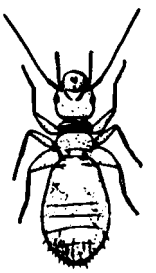


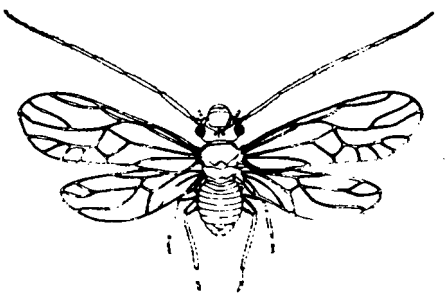
Order: PSOCOPTERA

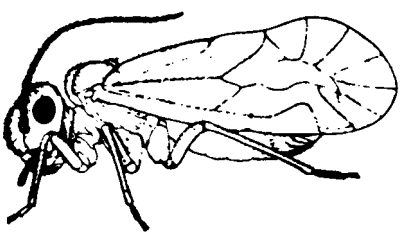
Booklice, Barklice

Most members of the order Psocoptera are relatively small insects (under 5 mm). They generally live in moist terrestrial environments (in leaf litter, beneath stones, on vegetation, or under the bark of trees) and forage on algae, lichens, fungi, or various plant products. A few species may invade homes or warehouses where they feed on stored grains, book bindings, wallpaper paste, fabric sizing, and other starchy products. Some species are gregarious, but they seldom become pests.

A psocopteran is fairly distinctive in appearance. It has a prominent head with bulging eyes, long slender antennae, and a relatively narrow neck-like prothorax. Tarsi are 2- or 3-segmented. Adults may be winged or wingless. When present, the wings are membranous (two pairs) and usually held tent-like over the abdomen.





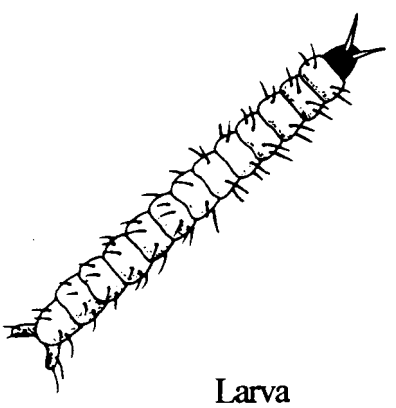


Order: SIPHONAPTERA

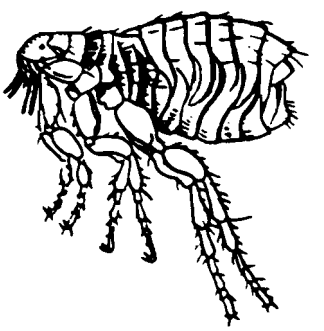
Fleas

Adult fleas are blood-sucking external parasites. Most species feed on mammals, although a few (less than 10%) live on birds. Only adult fleas inhabit the host's body and feed on its blood. They are active insects with a hard exoskeleton, strong hind legs adapted for jumping, and a laterally flattened body adapted for ease of movement within the host's fur or feathers. Since most fleas spend a considerable amount of time away from their host, they are occasionally collected in litter samples. Adult fleas can live for a year or more, and may survive for weeks without food.

Flea larvae are worm-like (vermiform) in shape with a sparse covering of bristles. They rarely live on the body of their host. Instead, they are usually found in its nest or bedding where they feed as scavengers on organic debris (including adult feces). Larval fleas can be fairly abundant in soil samples taken near the nest of an infested animal. Under favorable conditions, a flea can complete its life cycle in less than a month.



Larva



Adult

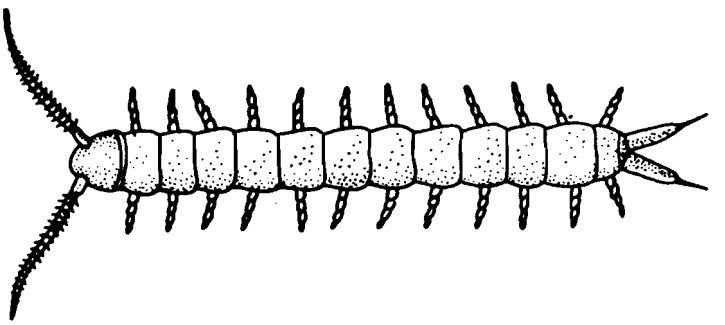
Class: SYMPHYLA

Symphylans

The class symphyla contains only about 125 species. These are small, soft, unpigmented arthropods (1-8 mm in length). The body is divided into two functional regions: a well-developed head capsule and a slender trunk. Symphylans are eyeless, but they have long, beaded antennae on the head and a pair of sensory structures (trichobothria) on the rear end. The trunk consists of 15-22 segments with 10-12 pairs of walking legs. Most symphylans are very active and resemble centipedes.

Most of a symphylan's diet consists of plant material, although they have been known to feed occasionally on small invertebrates. A few species become abundant enough to cause damage – *Scutigerella immaculata* is occasionally a pest in greenhouses.

Like many other small arthropods, the symphylans can survive only in environments where the humidity is always high. For this reason, they avoid light and are most common in humus and leaf litter or under stones and dead logs.



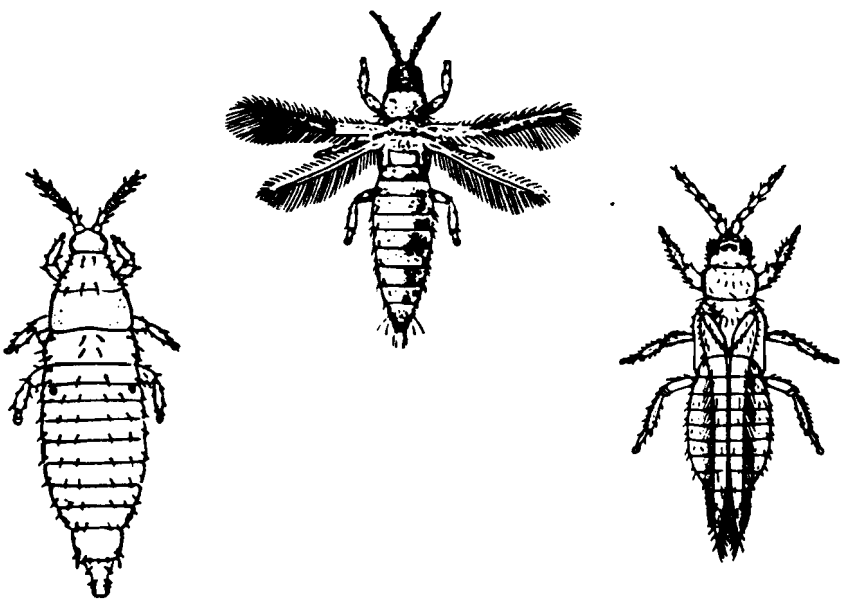
Order: THYSANOPTERA

Thrips

Thrips are very small insects (generally under 3 mm). Most species feed on plant tissues (often in flower heads), but some are predators of mites and various small insects (including other thrips). They are often common in soil and leaf litter.

All thrips have a distinctive spindle-shaped body with short antennae (6-10 segments) and short legs. There is a small eversible bladder on the tip of each foot that helps the insect adhere to glassy smooth surfaces. Adults may be winged or wingless. When present, the wings are slender and rod-like with a dense fringe of long hairs. The name "Thysanoptera" means "fringed wings".

The mouthparts of thrips are asymmetrical – there are three needle-like feeding stylets housed within a conical mouth opening. The stylets (two maxillae and one mandible) pierce and lacerate host tissue. Macerated food is then drawn into the mouth by suction. These mouthparts are often hard to see, even with good magnification.



Order: THYSANURA

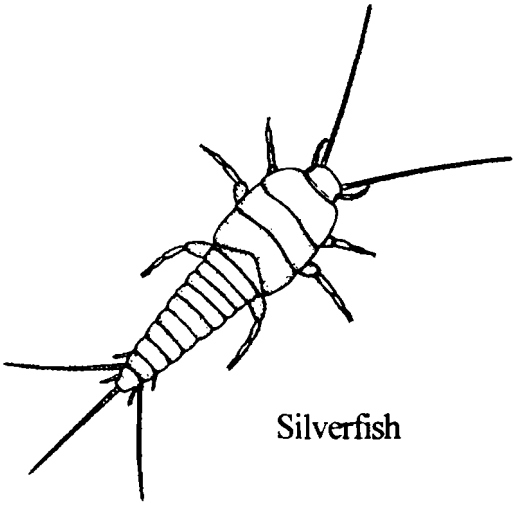
Silverfish, Bristletails

Thysanurans are fast-running insects that hide under stones or leaves during the day and emerge after dark to search for food. A few species are resistant to desiccation and well-adapted to survive in domestic environments such as basements and attics. Silverfish are scavengers or browsers; they survive on a wide range of food, but seem to prefer a diet of algae, lichens, or starchy vegetable matter. Bristletails are mostly woodland species that feed on mosses, lichens, or decaying organic matter.

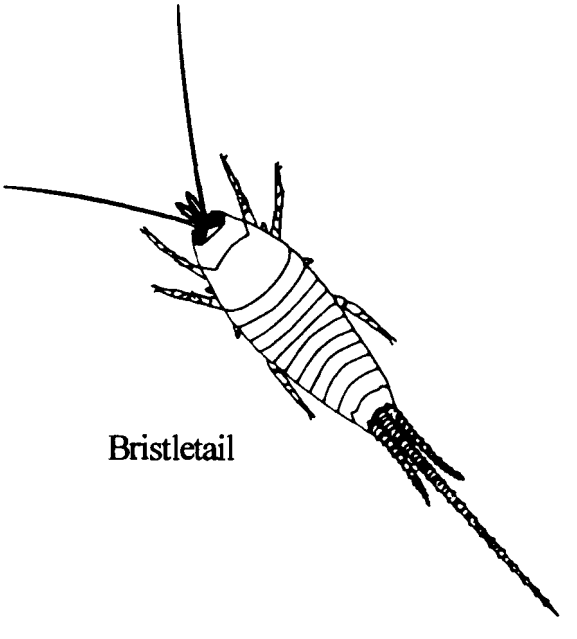
The name Thysanura means "fringed tail". It refers to the three long filaments at the tip of the abdomen. All thysanurans are wingless, even as adults. They have a pair of long, slender antennae, two compound eyes, and six legs. Their body is usually gray or brown in color and often covered with powdery scales that brush off easily.

Thysanurans may be rather long-lived – three years is probably typical and up to seven or eight years may be possible. They continue to molt frequently, even after reaching adulthood. The frequent molts may be an adaptation that helps reduce the risk of infection by parasitic fungi.

Silverfish have an elaborate courtship ritual to insure exchange of sperm. The male spins a silken thread between the substrate and a vertical object. He deposits a sperm packet (spermatophore) beneath this thread and then coaxes a female to walk under the thread. When her cerci contact the silk thread, she picks up the spermatophore with her genital opening. Sperm are released into her reproductive system, and then she ejects the empty spermatophore and eats it.



Silverfish



Bristletail

Additional References

General Background:

Nardi, J. B. 1988. Beneath Our Feet. (Chapt. 5 in: Close Encounters with Insects and Spiders). Iowa State Univ. Press., Ames, Iowa. pp. 143-64.

Rhine, R. 1972. Life in a Bucket of Soil. Lothrop, Lee & Shepard Co., New York. 96 pp.

Russell, H. R. 1971. Small Worlds. Little, Brown and Co., Boston. 32 pp.

Teale, E. W. 1937. Grassroot Jungles. Dodd, Mead and Co., New York. 233 pp.

Illustrated Nature Guides:

Eisenbeis, G. and W. Wichard. 1987. Atlas on the Biology of Soil Arthropods. Springer-Verlag. Berlin. 437 pp.

Levi, H. W. and L. R. Levi. 1968. Spiders and Their Kin. Golden Press. New York. 160 pp.

Zim, H. S. and C. Cottam. 1956. Insects: A Guide to Familiar American Insects. Golden Press. New York. 160 pp.

Identification Aides:

Bland, R. G. and H. E. Jaques. 1978. How to Know the Insects, 3rd Edition. Wm C. Brown Co. Dubuque, Iowa, 409 pp

Chu, H. F. 1949. How to Know the Immature Insects. Wm C. Brown Co. Dubuque, Iowa. 234 pp.

Dindal, D. L. 1990. Soil Biology Guide. John Wiley & Sons, New York. 1349 pp.

Resource and Reference:

Borror, D. J., C. A. Triplehorn, and N. F. Johnson. 1989. An Introduction to the Study of Insects, 6th Edition. Saunders College Publishing. Philadelphia. 875 pp.

Burges, N. A. and F. Raw (eds.). 1967. Soil Biology. Academic Press. New York. 532 pp.

Dickinson, C. H. and G. J. F. Pugh (eds.). 1974. Biology of Plant Litter Decomposition, 2 Vols. Academic Press. New York. 775 pp.

Edwards, C. A., B. R. Stinner, D. A. Stinner, and S. Rabatin (eds.). 1988. Biological Interactions in Soil. Elsevier Publ. Amsterdam. 380 pp.

Kevan, D. K. McE. 1962. Soil Animals. Philosophical Library. New York. 237 pp.

Schaller, F. 1968. Soil Animals. Univ. of Michigan Press. Ann Arbor. 144 pp.

Wallwork, J. A. 1970. Ecology of Soil Animals. McGraw-Hill. New York. 283 pp.

Wallwork, J. A. 1976. The Distribution and Diversity of Soil Fauna. Academic Press. London. 355 pp.