

HANDOUTS FOR THE RIVANNA MASTER NATURALISTS

INSECTS

INSTRUCTOR: LINDA FINK

DATE: SATURDAY, 6 APRIL 2019

1. Resources for studying insects
2. Arthropods
3. A cladogram of insect orders
4. The seven largest insect orders
 1. Odonata
 2. Orthoptera
 3. Hemiptera
 4. Coleoptera
 5. Hymenoptera
 6. Diptera
 7. Lepidoptera
5. Arachnids

These handouts were prepared for use by Sweet Briar students, and provided to the Rivanna Master Naturalists. Please do not distribute them elsewhere.

Linda S. Fink
Dorys McConnell Duberg Professor of Ecology
Sweet Briar College
Sweet Briar VA 24595
lfink@sbc.edu

Insect Resources, March 2019
Linda Fink, Sweet Briar College, lfink@sbc.edu

1. Where to purchase entomology supplies

BioQuip: best source for specialized equipment (<https://www.bioquip.com>)
field collecting equipment (black lights, traps), pinning supplies, museum cases, books

Ward's Science (<https://wardsci.com>)

Insect Lore (<https://www.insectlore.com/>)

Expandable mesh cages good for holding butterflies and other live insects

2. Web resources

A. General Entomology <https://projects.ncsu.edu/cals/course/ent425/index.html>

Professor John Meyer's website for ENT 425 at North Carolina State University. I use its Tutorials as the textbook for Insect Biology at Sweet Briar College.

B. BugGuide <https://bugguide.net>

Online community of insect enthusiasts focusing on identification. A good resource when you find something you can't identify, but not easy for a novice to navigate.

C. Popular insects, beneficial insects, and citizen science programs

Monarch butterflies

Journey North <https://journeynorth.org/>

A web-based "global study of animal migration." The monarch butterfly is one of a dozen migratory species tracked by citizen scientists from all over North America. (Others include robins, humpback whales, whooping cranes, and hummingbirds.) Site includes resources for teachers, links with scientists, and guidance for experiments and data collection.

Monarch Watch <https://www.monarchwatch.org/> **Dedicated to education, conservation, and research on the monarch butterfly. Includes such information as how to rear monarchs, identify milkweeds, establish a butterfly garden. Monarch Watch runs the major ongoing tagging program.**

Honey bees and other pollinators

<https://honeybeenet.gsfc.nasa.gov> NASA is working with volunteers to use honey bees to monitor nectar availability, expected to change as climate changes

<https://www.virginiabeekeepers.org/> Virginia State Beekeepers Association

<https://pollinator.org/> Pollinator Partnership

D. Pest insects

<http://entnemdept.ufl.edu/creatures/> University of Florida/IFAS Featured creatures, in-depth profiles of insects, nematodes, arachnids and more

3. Some of my favorite insect and spider books

a. Friendly for novices

- Castner, J.L. 2001. Photographic Atlas of Entomology and Guide to Insect Identification. Feline Press. *A gentle introduction to insect external anatomy, development and identification. Keys to some of the major families of each order. Very nice for novice entomologists, but not useful for serious identification because it is (deliberately) incomplete.*
- Charney, N. and C. Eiseman. 2010. Tracks and Sign of Insects and Other Invertebrates: A Guide to North American Species. Stackpole.

b. Excellent taxon-specific field guides for the serious amateur

- Bradley, R.A. and S. Buchanan. 2012. Common Spiders of North America. University of California Press.
- Evans, A.V. 2014. Beetles of Eastern North America. Princeton University Press.
- Wagner, D.L. 2005. Caterpillars of Eastern North America: A Guide to Identification and Natural History (Princeton Field Guides). Princeton University Press.
- Wilson, J.S. and O.M. Carril. 2016. The Bees in your Backyard. Princeton University Press.

c. Worthwhile once you've learned a bit, and especially if you already love insects

- Borror and DeLong's Introduction to the Study of Insects. 7th edition, 2004, co-authored by Norman F. Johnson and Charles A. Triplehorn. *For decades the standard introductory text in university entomology departments. If you want to be able to ID the families of beetles, or flies, or any other order, this is how to learn them, after you've picked up enough basic terminology and anatomy not to be overwhelmed.*
- Costa, J.T. 2006. The Other Insect Societies. Harvard. *The eusocial insects (ants, wasps and bees, and termites) have received a lot of attention, but many other insect groups show interesting degrees of sociality. Costa gives these other insects their rightful attention: for example, the substantial social behavior of tent caterpillars; and parental behavior in earwigs, water bugs and burying beetles.*
- Eisner, T., M. Eisner and M. Siegler. 2007. Secret Weapons: defenses of insects, spiders, scorpions, and other many-legged creatures. Belknap Press. *Tom Eisner studied insect defensive behavior and chemistry at Cornell. Short chapters on species he studied, a great introduction to the diversity of arthropod chemical defenses*
- Holldobler, B. and E.O. Wilson. 1990. The Ants. Belknap Press. *Won a Pulitzer Prize.*
- Johnson, W.T. and H.H. Lyon. 1991. Insects that Feed on Trees and Shrubs. Comstock. *If your reaction when you see an insect on a garden plant or tree is "I wonder who that is and what it's doing"*
- Marshall, S. 2006. Insects: Their Natural History and Diversity. Firefly Books.
- Marshall, S. 2012. Flies: The Natural History and Diversity of Diptera. Firefly Books.

d. On the shelves of serious entomologists

- Chapman, R.F., S.J. Simpson and A. E. Douglas. 2012. The Insects: Structure and Function. 5th edition. (4th edition, by Chapman, is 1998). Cambridge. *My "go-to book" to understand what's inside insects and what's going on. Not for novices, but manageable for a curious naturalist with a reasonable understanding of the anatomy or physiology of other organisms.*
- Grimaldi, D. and M.S. Engel. 2005. Evolution of the Insects. Cambridge. *Technical, detailed, full of information that will intrigue naturalists who want to know how the insect groups are related to one another, and what the evidence is.*

Sweet Briar Field Guide

Field Natural History

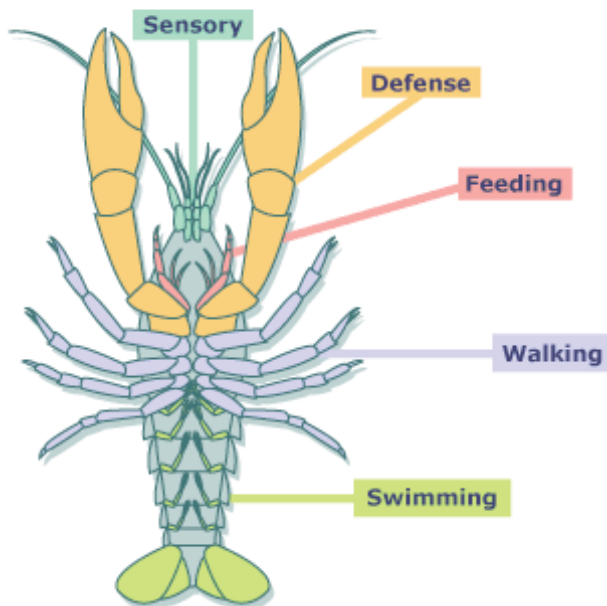
Common name(s) **ARTHROPODS**

Phylum: **Arthropoda**

UNIFYING FEATURES OF ARTHROPODS:

- **Bilateral symmetry**
- **Segmented body and paired, segmented legs**
- Segments are often grouped into larger functional units, called **tagmata** (singular, tagma)
 - Within tagmata, segments tend to have repeated structures (e.g. nerves, limbs, respiratory structures)
- **Hard exoskeleton composed primarily of chitin**
 - chitin (a large polysaccharide) is embedded in a matrix of protein, forming sheets. The molecular structure gives the exoskeleton great tensile strength.
 - Hardness is caused by additional chemical bonds between protein chains, in a process called sclerotization. Varying sclerotization can vary the hardness of different areas of the arthropod's exoskeleton.
 - Because it is nonliving (non-cellular) the exoskeleton does not grow. As the arthropod develops and increases in size, it must periodically **molt**.
 - The external skeleton provides protection both from mechanical injury and water loss
- Having an external skeleton makes movement difficult (think of knights in armor). At joints, the limbs are still covered with chitin, but in these areas it is softer and more flexible.
- **Many pairs of appendages (limbs)**

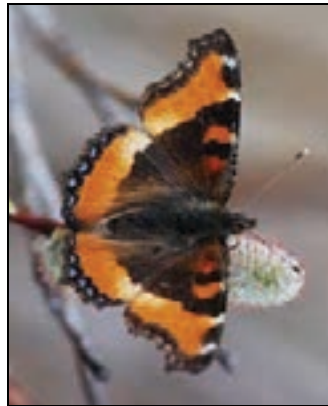
**Many limbs, many functions:
a ventral view of crayfish limbs**



http://evolution.berkeley.edu/evolibrary/article/3_0_0/arthropods_08

ARTHROPOD DIVERSITY:

Five major lineages of arthropods



1. **Myriapods** (myria = 10,000, pod = foot)

body sections (tagmata) are a head and a trunk

one pair of antennae

many limbs

centipedes: somewhat flattened, one pair of legs per segment; long antennae, predators

millipedes: cylindrical, two pair of legs per segment, short antennae, scavengers

2. **Trilobites** (rich fossil record older than 500 million years; extinct 245 mya)

had a head region (cephalon), thorax, and posterior region (pygidium)

body divided longitudinally into three lobes (left, central and right)

one pair of antennae

3. **Chelicerates** (spiders, scorpions, mites, horseshoe crabs)

two tagmata: cephalothorax and abdomen

no antennae

four pairs of walking legs

two pairs of appendages on anterior cephalothorax that function in reproduction and/or feeding (chelicerae and pedipalps)

4. **Crustaceans** (crabs, crayfish, pillbugs, barnacles)

two tagmata (cephalothorax and abdomen)

two pairs of antennae

three pairs of mouth appendages
many of the appendages are biramous (two-branched)

5. Insects

three tagmata (head, thorax, abdomen)
one pair of antennae
three pairs of mouth appendages
three pairs of legs on the thorax
if winged, two pairs of wings, on second and third thoracic segments (one pair may be reduced or lost)

ARTHROPOD SUCCESS

The Arthropoda is the largest phylum, evidence of the group's enormous diversity. Many species are also incredibly abundant. Most multicellular organisms are arthropods.

ARTHROPOD CONSTRAINTS

Marine crustaceans can be very large (spider crabs can weigh 20 kg, lobsters 22 kg.)
Why aren't there huge *terrestrial* arthropods?

Three evolutionary constraints on the body size of terrestrial arthropods (for animations showing each of these constraints, see the Understanding Evolution website):

- **Molting** is more hazardous for large animals.
- **Exoskeleton strength:** The exoskeleton could not support a large animal, unless it became very thick and heavy -- so heavy, in fact, that the animal's muscles could not move it.
- **Respiration:** the method by which insects transport oxygen to their cells cannot be "upscaled" to much larger sizes. Insects transport oxygen in air-filled tubes, called tracheae. There is a limit to how long these tubes can be, and have sufficient oxygen diffuse through them to support internal body cells.

Sources:

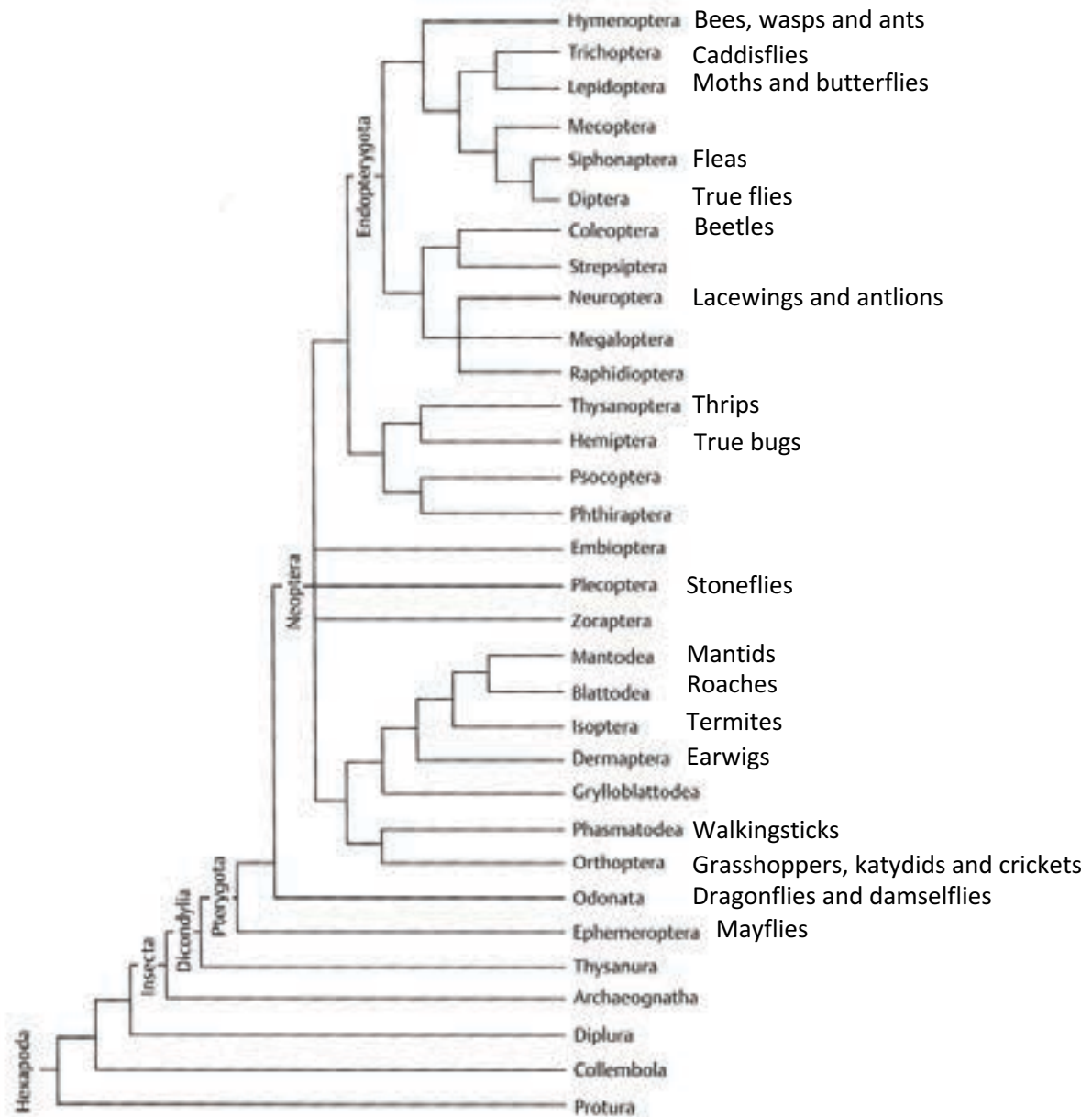
Introducing the Arthropods. Understanding Evolution website.

<http://evolution.berkeley.edu/evolibrary/article/3_0_0/arthropods_toc_01>

Triplehorn, C.A. and N.F. Johnson. 2005. Borror and DeLong's Introduction to the Study of Insects. 7th Edition. Thomson.

Photographs came from the Tree of Life Web <<http://tolweb.org>>

A Tree of Insect Relationships



The seven largest orders

ORDER	# families worldwide	# species in North America	# species worldwide
ODONATA (dragonflies and damselflies)	29	400	>5000
ORTHOPTERA (crickets, katydids, grasshoppers)	28	1100	>10,000
HEMIPTERA (true bugs)	133	10,000	>82,000
COLEOPTERA (beetles)	166	24,000	> 300,000
DIPTERA (flies)	130	17,000	>100,000
LEPIDOPTERA (butterflies and moths)	135	11,000	> 110,000
HYMENOPTERA (bees, wasps, ants)	90	18,000	> 100,000

Sweet Briar Field Guide Field Natural History

Common names: Dragonflies and Damselflies

Insect order: ODONATA

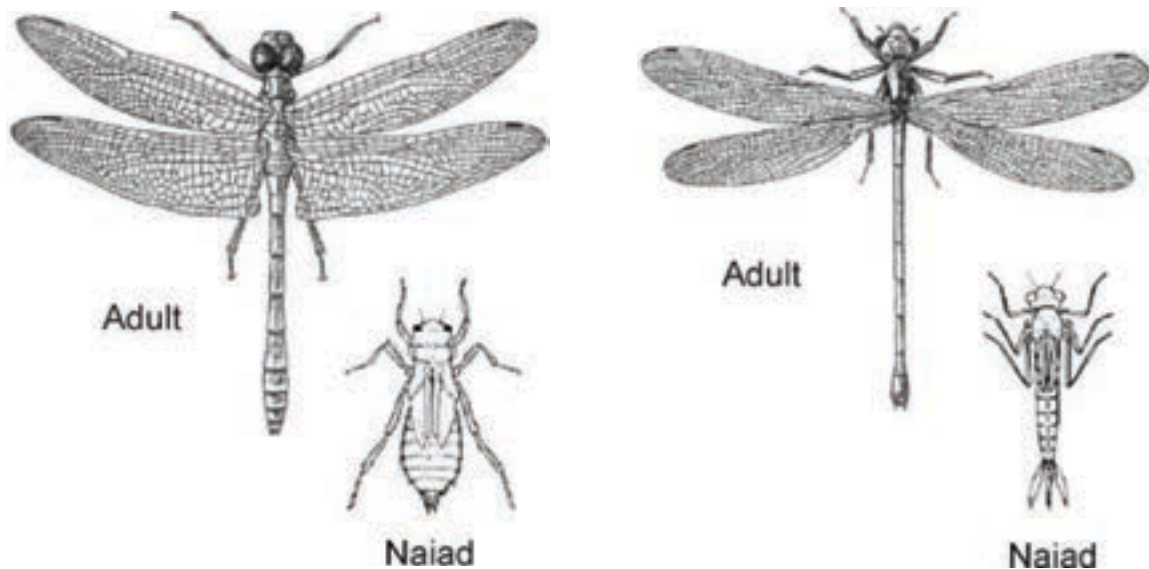
Suborder: Anisoptera (dragonflies) [below left]

Suborder: Zygoptera (damselflies) [below right]

Class: Insecta

Phylum: Arthropoda

Page creator: L.S. Fink March 2010



ADULTS are easily recognized by the following characters:

Conspicuous **at or near fresh water**, 1-1/4 to more than 6 inches in length (some tropical species are larger)

Four large membranous wings, with a large number of veins and crossveins. Usually a dark, pigmented spot (called a stigma) on the leading edge of both wings.

Cannot fold their wings over the abdomen, the way most insects can (think of a beetle or bug or moth). The ability to fold wings was an important evolutionary innovation; the odonates maintain the ancestral condition. They are "paleopterous" while the majority of insects, which can fold up their wings, are "neopterous." Because of this, their **wings are always outspread or held directly over their back.**

Odonates are **visual, aerial hunters of other insects.** They have **large eyes** and, unlike most insects, flexible necks. Very short, bristle-like antennae.

Thorax is strong and boxy. **Abdomen is long, slender and flexible.**

Adults are **excellent aeronauts.** Some species are rapid fliers and difficult to catch.

Weak legs. Used for perching and, sometimes, for holding prey, but not for walking.

NYMPHS (also called naiads) are easily recognized by the following character:

All odonate nymphs are **aquatic predators** that capture prey by shooting out their "**lower lip**" (**labium, or mask**) which is **hinged and has hooklike, grasping lobes at the tip**. At rest, the mask is folded under the head and thorax.



The two suborders are differentiated by the following characters:

Characteristic	Anisoptera (Dragonfly)	Zygoptera (Damselfly)
Adult size	robust, larger	more delicate, smaller
Wings held at rest	out to the sides	up, held together over the thorax
Hind wing shape	Base of hind wing broader than forewing	Base of both sets of wings narrow
Nymph shape	often broad, robust	usually slender, elongate
Nymph gills	not visible: internal in rectum	three leaflike appendages at posterior

Life cycle and reproductive behavior:

Males in many species are highly territorial.

Adults have **distinctive mating behavior**. The male curls his abdomen ventrally and transfers sperm from his posterior genitalia to secondary genitalia at the base of the abdomen. Using claspers at the posterior of his abdomen, he holds the female behind her head and they **fly in tandem** (below). Some species copulate rapidly in flight; others land on vegetation and copulate for minutes to hours. To copulate, the female bends her abdomen forward to the male's secondary genitalia, and the two **form a distinctive "wheel" position** (right).





The female lays eggs in the water. In some species the female dips the tip of her abdomen in the water while in flight; in other species she clings to vegetation. In some species the male continues clasping the female while she lays her eggs (left); in other species he hovers over her or perches nearby.

The immature nymph molts 10-20 times as it grows, taking 3 months to 10 years to mature. Odonates do not go through a pupal stage; the wings develop gradually, externally, and are visible as dorsal *wing pads* in older nymphs. When mature, the nymph climbs out of the water and clings to a support while shedding its cuticle. The newly emerged adult, called a *teneral* adult, is unable to fly for several hours, until its exoskeleton hardens.

Other natural history facts:

Because odonates cannot fold up their wings and protect them, they are always found out in the open, rather than hiding in crevices, under bark, or other such tight spaces.

Some dragonflies are migratory.

Diversity: Worldwide, about 6500 species. North America, > 400 species.

Usually considered to be beneficial insects because they are major predators of mosquitoes and other small biting flies.

Distinguishing odonates from similar insects:

Adults: The only adult insects that you might confuse with odonates are the mayflies (Ephemeroptera). Mayflies are smaller and much more delicate. Their hindwings are triangular, and they have two long, hairlike filaments at the tip of the abdomen.

Nymphs: Mayfly nymphs may be confused with damselfly nymphs. Mayfly nymphs have 2 or 3 filaments at the tip of the abdomen, rather than gills. Their gills are along the sides of their abdomen. Mayfly nymphs have weak mouthparts, and do not have the distinctive mask. Stonefly nymphs have long antennae, two long anal filaments (cerci), and tuftlike gills usually at base of legs.

Sources

McGavin, G.C. 2001. Essential Entomology. Oxford.

Meyer, John. 2009. General Entomology (online text). <http://www.cals.ncsu.edu/course/ent425/index.html>

Trueman, John W. H. and Richard J. Rowe. 2009. Odonata. Dragonflies and damselflies. Version 16 October 2009. <http://tolweb.org/Odonata/8266/2009.10.16> in The Tree of Life Web Project, <http://tolweb.org/>

Images from Meyer and from Trueman and Rowe, and from Takashi Aoki (<http://www.kobe-c.ed.jp/shizen/tombo/oviposit/index.html>)

Sweet Briar Field Guide Field Natural History

Common names: Crickets, Grasshoppers, Katydid



Insect order: ORTHOPTERA

Class: Insecta

Phylum: Arthropoda

Page creator: L.S. Fink, 2002, revised 2010

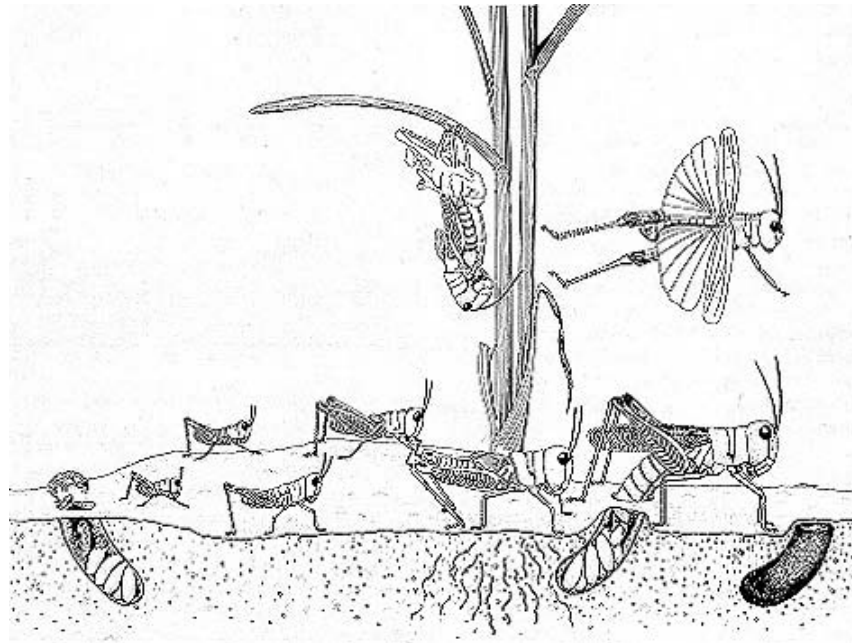
The ORTHOPTERA are recognized by the following characters:

Wing structure: Most orthoptera have four wings. The front wings are long, many-veined, may be somewhat thickened. The hind wings are membranous, broader. At rest they are usually folded fanwise under the front wings. Several groups have evolved winglessness.

Simple (incomplete) metamorphosis.

Mouthparts: chewing.

Legs: Several groups have enlarged hind legs that enhance the insects' **jumping** ability.



A grasshopper life cycle. Female on right, with tip of abdomen and ovipositor in the soil, is laying eggs in batches. The newly hatched nymphs (left) look similar to adults but body proportions differ (head is larger) and they lack wings and reproductive organs. Gradual development. Image from http://www.sidney.ars.usda.gov/grasshopper/ID_Tools/F_Guide/life.htm

Ecology and Behavior:

Orthoptera are almost all **plant feeders**.

Life cycle: Immature nymphs and mature adults are usually found in the same habitats, consuming the same foods; there is little ecological separation by developmental stage. Most orthoptera have annual life cycles, overwintering as eggs laid in the soil or in plant tissues. Nymphs and adults feed on aboveground vegetation.

Sound production: The best insect 'singers' are the grasshoppers and katydids. Their **noise is produced by stridulation**, or rubbing two body parts together. Most singing is done by males, at night, to attract females. Many species "chorus" so that when one individual sings, others nearby sing as well. Some grasshoppers produce up to five different types of song during courtship and mating.

Crickets and Tettigoniid katydids produce songs by rubbing the sharp edge of the base of the front wing along a ridge on the ventral side of the other front wing. When singing, the front wings are elevated and move back and forth producing pulses of sound. The pulse rate is temperature dependent.

Acridid grasshoppers sing by rubbing their hind legs across the front wings.

The insects' **ears** are on the base of the front legs (long-horned [tettigoniid] grasshoppers, and crickets) or on the side of the first abdominal segments (short-horned [acridid] grasshoppers).

Seasonality of singing: In temperate regions most Orthoptera become sexually mature in the late summer, and therefore **most singing is heard in the late summer through fall**, with each species having its own seasonal pattern. This is in contrast to most birds and frogs that court and do most of their singing in the spring and early summer.

Groups of the Orthoptera you are likely to encounter:

Suborder Caelifera: Antennae are usually short, ears are on the side of the first abdominal segment, stridulation uses the hind legs, and the ovipositor is short.

- **Short-horned grasshoppers (Caelifera, Family Acrididae):** most common grasshoppers you find in meadows and roadsides. Antennae usually shorter than the body. Most are brown or gray, and some have brightly colored hind wings. Most sing during the day. The family includes the large lubber grasshoppers (up to 7cm) found in the south and west, and dissected by generations of high school biology students.

Suborder Ensifera: Antennae long and hairlike. Ears on the front legs. Stridulation by rubbing front wings together. Most females have a long ovipositor, either sword-shaped or cylindrical, with a pair of valves that can cut into plants or push into the soil. In some locusts the female expands her abdomen as she digs from 3 to 13.5 cm, allowing her to put her eggs deep in the soil.

- **Long-horned grasshoppers and katydids (Ensifera, Family Tettigoniidae)** have their ovipositor flattened laterally. Most sing at night. Katydids have their hindwings longer than their front wings. They are usually green, arboreal (living in trees and shrubs), and prolific singers. Other long-horned grasshoppers are found in diverse terrestrial habitats including tall grass, wet meadows, and dry forests. A few species are predatory.
- **Crickets (Ensifera, Family Gryllidae)** are good singers, with some singing during the day and others at night. Some subfamilies are arboreal, others terrestrial. The ovipositor is needlelike or cylindrical rather than flattened, and the front wings bend down at the sides of the body.



L-R: Acridid grasshopper, Tettigoniid katydid, Cricket. Note the longer antennae in the katydid. Cricket is a female with a long, cylindrical ovipositor. All three images: Ted Kroplewnicki, photographer. <http://bugguide.net>. Photo 1st page shows a tettigoniid with a long, sword-shaped ovipositor. http://farm4.static.flickr.com/3011/3080657749_f94f02929c.jpg

Related insect groups that at one time were included in the Orthoptera but usually are put into their own orders: mantids (O. Mantodea), walkingsticks (Phasmida), cockroaches (Blattaria).

Sources:

Borror, DJ, Triplehorn, CA, Johnson, NF. 1989. An Introduction to the Study of Insects. Saunders.
Brown, V.K. 1983. Grasshoppers. Naturalists' Handbooks 2. Cambridge U. Press.
Dethier, V.G. 1992. Crickets and Katydids, Concerts and Solos. Harvard U. Press.
Klots, A., Klots, E. Insects of North America. Doubleday.

Sweet Briar Field Guide Field Natural History

Common names: Bugs, True bugs

Insect order: HEMIPTERA **Suborder:** Heteroptera

Class: Insecta

Phylum: Arthropoda

Page creator: L.S. Fink, last revised March 2010

The Hemiptera (Heteroptera) are recognized by the following characters:

Front wing structure: the basal portion is thickened and opaque, while the apical portion is thinner, membranous and often transparent. This kind of wing is called a **hemelytron** (plural hemelytra; vs. the elytron of the beetles). When the wings are folded, the membranous tips are visible near the posterior end of the abdomen.

Mouthparts: a slender, segmented **beak** that is used for **piercing and sucking** arises from the front part of the head. In use it is extended downward or forward; **when not in use it is folded against the ventral surface** of the head and some or all of the thorax (photo below right).

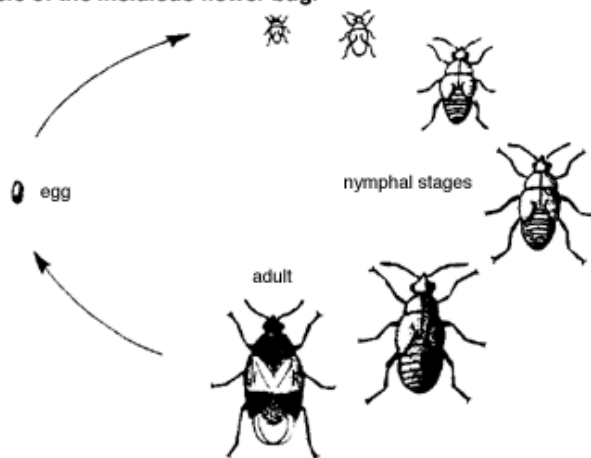
Scent glands: Many bugs have scent glands that open on the sides of the thorax (in adults) or on the dorsal surface of the abdomen (in nymphs). Characteristic strong odors may be given off when the bugs are disturbed. (One family is called the "stink bugs" for good reason.)

Other structures are variable. The antennae are usually long and narrow, and the compound eyes are usually well developed.

Natural history notes:

- The Hemiptera do not go through a pupal stage. They hatch from eggs as nymphs, with the same feeding behavior as the adults, and frequently occur in the same habitats. External wing pads grow with each molt. Insects with this "simple" developmental pattern are called *exopterygotes* ("external wings") or *hemimetabolous*.

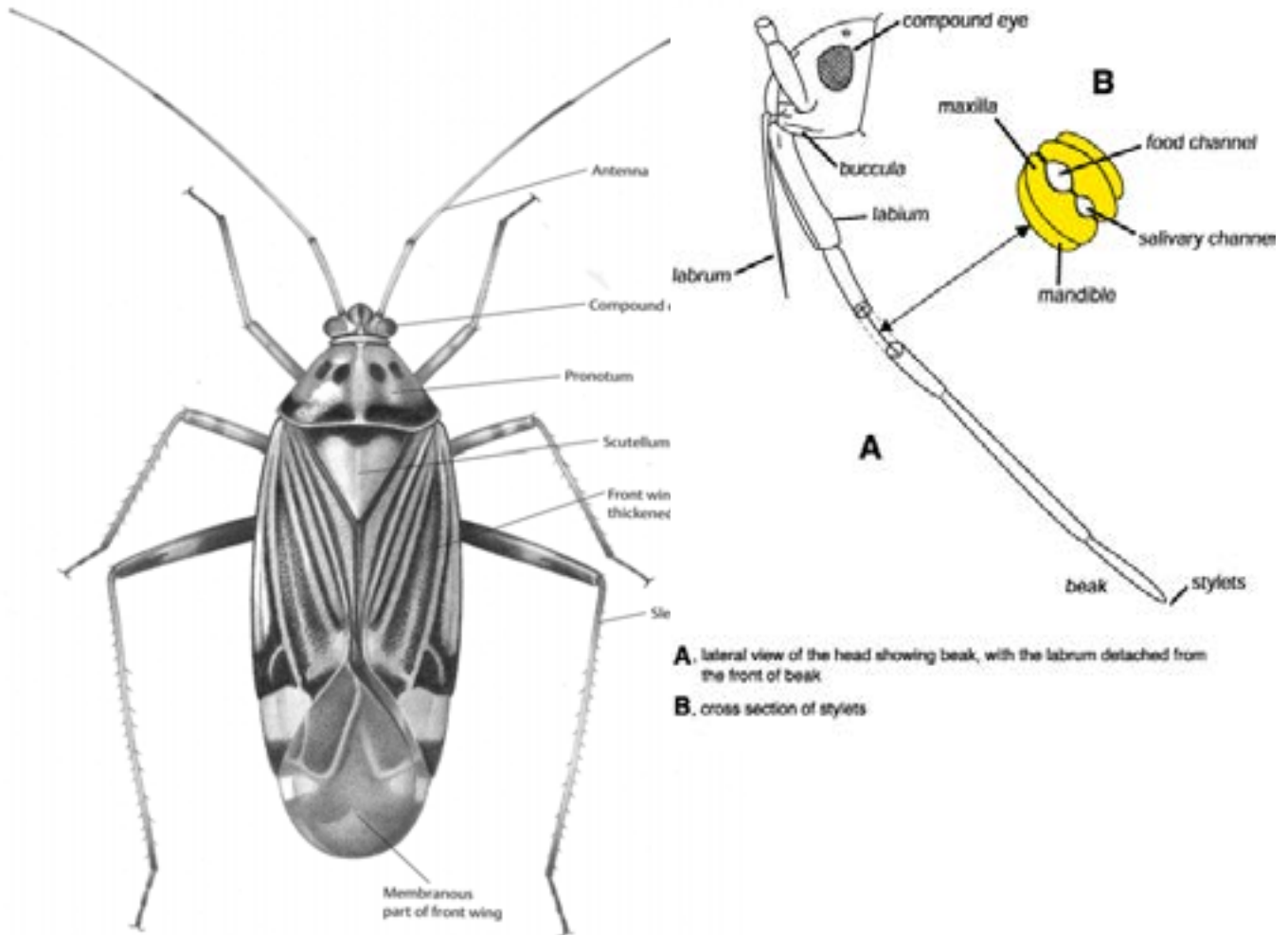
Life cycle of the insidious flower bug.



- All bugs pierce their food with their beak and suck fluids. Many bugs are herbivorous, feeding on plant phloem, including a number of major agricultural pests. Predatory bugs primarily attack other insects, and some are used for biological pest control. A few bugs feed on vertebrate blood, and can be serious disease vectors.
- Several families are primarily or exclusively aquatic.
- Many bugs lay their eggs in groups and nymphs may be gregarious for part or all of their development, so you may encounter many individuals together, but the adults are almost always solitary.

Sources

Borror, DJ, Triplehorn, CA, Johnson, NF. 1989. *An Introduction to the Study of Insects*. Saunders.
 Brown marmorated stink bug. <http://www.invasive.org/species/subject.cfm?sub=9328>. Accessed March 2010.
 McGavin, G.C. 2001. *Essential Entomology*. Oxford.
 Klots, A., Klots, E. *Insects of North America*. Doubleday.
 Most images from Tree of Life Web (<http://tolweb.org>), <http://entomology.ifas.ufl.edu>, or McGavin.



A picture guide to aquatic families you may meet at Guion Pond, the Beaver Marsh, or the lakes. These families are widespread and easy to recognize by shape and behavior. Most are predaceous, and are capable of inflicting painful bites -- be careful handling them.

Nepidae (waterscorpion)

Note the long body, raptorial (grasping) front legs, and long breathing tube at the posterior end of the abdomen, to get oxygen from the air. Predator. Slow moving.



Belostomatidae (giant water bug)

Local species may be 2-1/2 inches long. Elongate-oval, flattened, with raptorial front legs, hind legs fringed for swimming. Predator. Adults are attracted to lights at night. In some species, the female lays her eggs on the back of the male, and he carries them around until they hatch.



Corixidae (water boatman)

Common in ponds and lakes. Usually dark gray. Dorsal surface may have faint horizontal lines. Hind legs are long, flat and fringed; front feet are scoop-shaped. Swim quickly, erratically. May look shiny because they carry an air bubble with them. Most eat algae, a few are predators. Large eyes.



Gerridae (water strider)

Long-legged, live on the water surface, skating over it. Feed on insects that fall onto the water. Short front legs capture food. Usually dark, long and narrow. Communicate by setting up vibrations on the water surface.



Notonectidae (backswimmer)

Predators, often attack tadpoles or fish larger than themselves. Swim upside down, and may rest at the water surface with the head downward. Similar in shape to corixids, but dorsal surface is usually pale and more convex.



Common terrestrial families of the Hemiptera

Stink bug (Pentatomidae)

A large family (>200 spp in North America). Roundish shape with a prominent triangular shield (scutellum) between the wings. Many species are brightly colored, others are camouflaged green, brown or grey. Predatory and plant-feeding species. Eggs are shaped like little barrels, usually laid in groups, and the tops pop open like lids when the nymphs hatch. Usually gregarious when young. A common species in local gardens is the orange, black and white harlequin bug (*Murgantia histrionica*) which feeds on plants in the cabbage family. The stink bug invading local buildings is a recently arrived exotic from Asia, the brown marmorated stink bug, *Halymorpha halys* (below). It feeds on plants, overwinters in buildings.



Leaf-footed bug (Coreidae)

About 80 NA spp. Give off a strong odor when handled from scent glands between the legs. Elongate, with head narrower than the pronotum (first segment of the thorax). Most local species have the hind leg broadly expanded, giving the family its common name. Plant feeders, some species are agricultural pests.



Bed bug (Cimicidae)

Flat, oval, wingless, about 6mm long. Feed on blood of birds and mammals. *Cimex lectularius* attacks people, and has been resurging as a pest in U.S. hotels, dormitories and homes in the last few decades. Feeding at night, it hides in crevices during the day.



Assassin Bug (Reduviidae)

Large family with more than 160 NA spp. All are predators or blood feeders (including some that feed on mammals). Head is long, and constricted behind the eyes into a "neck". Beak is short and when the bug is not feeding, the beak fits into a groove on the ventral side of the thorax. In some species, the lateral margins of the abdomen are wider than the wings and therefore visible from above. *Triatoma* assassin bugs are sometimes called "kissing bugs" because they bite people around the lips; in South America, they are vectors of the protist that causes Chagas disease.



Sweet Briar Field Guide Field Natural History

Common name: Beetles
Insect order: COLEOPTERA

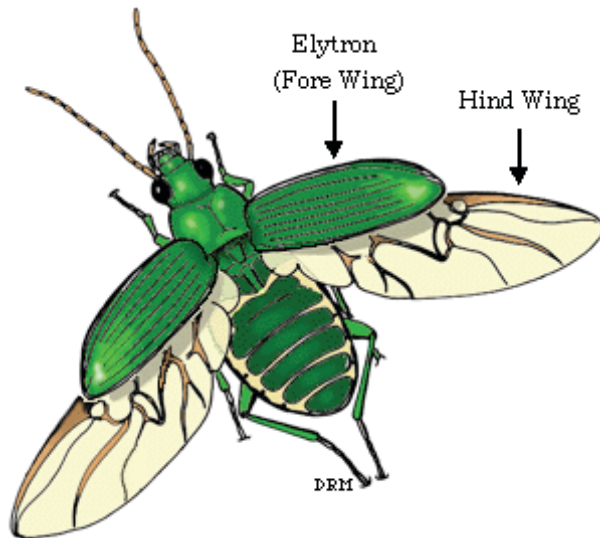
Class: Insecta
Phylum: Arthropoda

Page creator: L.S. Fink March 2010

Beetles are the **largest order of insects**. More than 350,000 species have been described. This represents about 40% of all insect species, and 30% of all animal species!



Adult beetles frequently live in concealed, tight spaces. The body and hind wings are protected by the **forewings, modified into hardened elytra** (singular: elytron), that meet in a straight line along the middle of the dorsum. The forewings contribute little to flight ability. Hindwings are folded under the elytra when not used in flight.



Larvae and adults have strong, **chewing mouthparts**.

The **life cycle is complete (holometabolous)** with four developmental stages (egg, larva, pupa, adult)

Other than these characters, **the beetles are most distinctive for their diversity**. They range in size from 1/3 mm to greater than 15 cm. Most species are associated with plants, but others are predators, fungus feeders, and scavengers on dung and carrion. Several families are aquatic. Adults vary in shape, color, structure of antennae and legs ... if you name an anatomical or behavioral feature, you'll find that it varies within this group.

Larvae usually live in hidden microhabitats (leaf litter, under bark, in soil, etc.). Typically drab in color, they come in many shapes (illustration on next page)

Sources (including images)

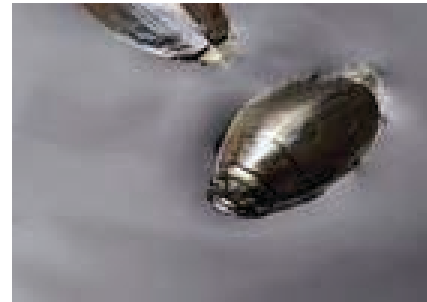
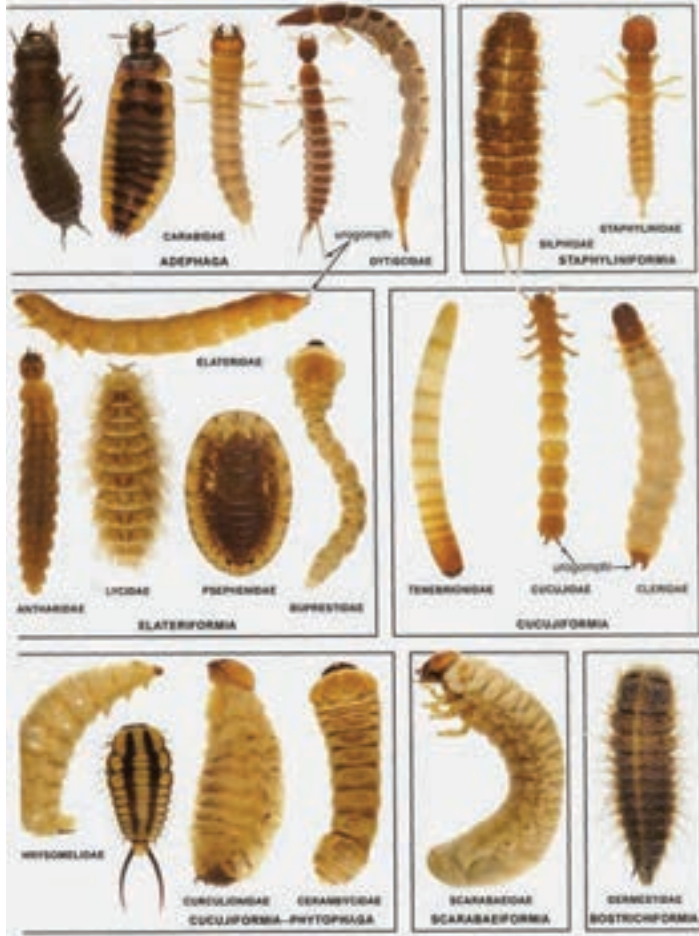
McGavin, G.C. 2001. *Essential Entomology*. Oxford.

Meyer, John. 2009. *General Entomology* (online text). <http://www.cals.ncsu.edu/course/ent425/index.html>

Maddison, David R. 2000. *Coleoptera. Beetles*. Version 11 September 2000 (under construction).

<http://tolweb.org/Coleoptera/8221/2000.09.11> in *The Tree of Life Web Project*, <http://tolweb.org/>

Examples of beetle diversity: larvae (below) and adults



Rove beetles (family Staphylinidae) have short elytra



Weevils (fam. Curculionidae) have mouthparts at the tip of an elongated proboscis. Many are important grain pests.



Sweet Briar Field Guide Field Natural History

Common names: Bees, Wasps, and Ants

Insect order: HYMENOPTERA



Class: Insecta

Phylum: Arthropoda

Page creator: L.S. Fink, 2002, revised 2010

The Hymenoptera are recognized by the following characters:

Wing structure: Four membranous wings, or wingless. Hind wings smaller than front wings.

Wings with relatively few veins.

Antennae usually 10+ segments, relatively long.

Ovipositor well developed in females. May be modified into a **sting** (only in some groups).

Sizes of adults range from 0.1mm to 50mm

Hymenoptera other than the sawflies have a very narrow "**wasp waist**" which is actually a constriction and a specialized hinged joint, or **pedicel**, between the first and second segments of the abdomen. This joint gives the adult great flexibility in egg laying and defense, and maneuverability in tight burrows.

Complete metamorphosis. Larvae grublike, except sawfly larvae which look somewhat like caterpillars (but can be differentiated from caterpillars by the absence of crochets on their prolegs and by having more pairs of prolegs).

Mouthparts: chewing; in many bees, modified into tongue-like structure for drinking liquid.

Subgroups of the Hymenoptera you are likely to encounter:

Bees: Superfamily Apoidea, Family Apidae (honey bees, bumble bees), family Anthophoridae (carpenter bees)

Ants: Superfamily Formicoidea, Family Formicidae

Paper wasps: Superfamily Vespoidea, Family Vespidae (paper wasps, yellow jackets, hornets)

Parasitic wasps: Families Ichneumonidae, Braconidae, Chalcidae

Gallmaking wasps: Family Cynipidae

Solitary wasps: Family Sphecidae (sphecids, cicada-killers, mud-daubers)

Natural history notes:

- Hymenoptera are of major ecological and economic importance as detritivores (ants), pollinators (bees and some wasps), predators and parasites of other arthropods (all groups), and herbivores (sawflies).
- Hymenoptera are **haplodiploid**: diploid females develop from fertilized eggs. Haploid males develop from unfertilized eggs. The female can control the sex of her offspring.

- The order contains groups with different degrees of sociality.

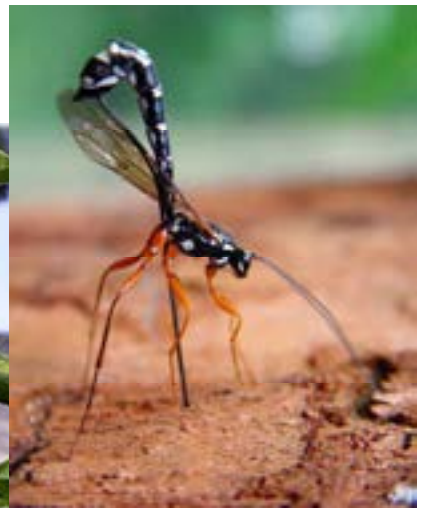
Solitary wasps: The mated female constructs a **nest** and **provisions it with prey** (photo right) but does not provide direct care to her offspring. Nests may be in the ground, in or on vegetation, or in wood. There is little or no social interaction among individuals.

Example: The **pipeorgan mud-dauber, *Trypoxylon politum*** (Family Sphecidae, photo left), is an elegant shiny blue-black wasp, 12-15mm long, with white tarsi (feet). The female constructs a vertical mud tube with a closed top and open bottom, on a rock, palm frond, or other vertical surface (photo last page). She provisions the nest with 6-10 paralysed spiders, lays her egg on the last one, and closes over the cell with mud. The larva feeds on the spiders and pupates in the cell, and then chews out the side of the tube. One tube may contain 2-6 cells.



Parasitic wasps: The mated female places her eggs or newly-hatched larvae in, on, or near a potential host, which is another arthropod. Larvae develop internally in the host, pupate in or out of the host, and are free living as adults. The correct term for these insects is **parasitoid** rather than parasite. Parasitoids vary widely in size, shape, length of ovipositor, etc.

Example: ***Trichogramma*** are tiny wasps (adult length <1mm) that develop within the eggs of other insects. Imagine a wasp small enough that four can grow up inside one butterfly egg!



Parasitoid laying eggs in a gypsy moth caterpillar; parasitized hornworm caterpillar with braconid wasp cocoons; *Megarhyssa* drilling her ovipositor into wood to reach insect larva within.

Eusocial hymenoptera share three characteristics: adults care for the young, two or more generations of adults live together in the same nest, and there are two distinct **castes**, of reproductives and sterile workers. All ants, and a minority of bees and wasps, are eusocial. (In addition, all termites, which are in the order Isoptera, are eusocial.)

Examples:



Honey bee: *Apis mellifera*, Apidae. Golden brown with hairy thorax, 10-12 mm long. Adult females forage for nectar and pollen from a wide range of flowers; you can see clumps of pollen packed on their hind legs. Honey bee hives contain one queen and 5000-30,000 developing larvae (brood) and sterile female workers. Nectar is converted to honey and stored in wax cells in the hive, to feed the developing brood. Workers will sting intruders to defend their nests, but they are not aggressive while foraging.

Paper wasps: Family Vespidae. Most are strongly marked with brown, yellow, black, and/or white. Wings are usually folded longitudinally at rest, or held up in a V. Live in a colony with one or two queens, many female workers, and, seasonally, males. Workers forage for insects. Nests may be made of paper (wood chewed into pulp) above ground (paper wasps, hornets) or below (yellow jackets). Nests may be a single horizontal comb of cells, or may be in several layers and enclosed in paper covering.



Ants: Family Formicidae. Approx. 9500 species identified. Identifying characteristics: usually wingless, with elbowed antennae and a humped pedicel between the thorax and abdomen. All are eusocial. Ant colonies may have a few dozen to many thousand members. Ants may be granivorous, carnivorous, or may feed on fungi, nectar, or honeydew.



Examples of nests

Left: pipe organ mud dauber (Sphecidae)

Top right: *Mischocyttarus* (Vespidae) starting a nest;
note egg within open cell

Bottom right: Bald-faced hornet (Vespidae)



Sources:

Borror, DJ, Triplehorn, CA, Johnson, NF. 1989. An

Introduction to the Study of Insects. Saunders.

Holldobler, B. & E.O. Wilson. 1994. Journey to the Ants. Harvard.

Imes, R. 1992. The Practical Entomologist. Fireside, Simon & Schuster.

Klots, A., Klots, E. Insects of North America. Doubleday.

Seeley, T.D. 1985. Honeybee Ecology. Princeton.

Images (most downloaded 11 Apr 2010; some from unidentified sources, on my computer already)

Tree of Life Web (<http://tolweb.org/images/Hymenoptera>)

Ant photos: myrmecos.net (Alex Wild, photographer)

T. politum nest: <http://www.animalpicturesarchive.com/ArchOLD-7/1189650064.jpg>

Baldfaced hornet nest: <http://www.ipm.iastate.edu/ipm/iiin/node/167>

Mischocyttarus & nest, photographer: S. McCann (source unknown)

Sweet Briar Field Guide Field Natural History



Common names: Flies

Insect order: DIPTERA

Class: Insecta

Phylum: Arthropoda

Page creator: L.S. Fink, 2002, revised 2010

The DIPTERA are recognized by the following characters:

Wing structure: One pair of functional wings (the fore wings). The hind wings are modified into tiny knobbed halteres, which help with balance. (See halteres in crane fly photo above; <http://bugguide.net>)

Complete metamorphosis.

Larvae are called **maggots**, and are **legless** and wormlike.

Mouthparts: sucking. In some groups they are used for piercing and sucking; in others they are used for sponging or lapping.

Most flies are small and soft-bodied. Some are minute.

Naming convention: Since many insects have "-fly" as part of their name (butterfly, dragonfly, mayfly), in the common names of Diptera "fly" is a separate word (house fly, black fly).



L-R: Adult syrphid, tabanid, tachinid. All photos from <http://bugguide.net>

Ecology and Behavior:

Maggots may feed on plants, in which case they usually live within the plant tissue as leaf miners, gall insects, or borers.

Others are predators, parasitoids or scavengers, and are found in water, soil, or dead wood.

Adult flies feed on a variety of plant and animal fluids, including nectar and blood. They may drink small quantities of blood from animals that are much larger than they are, or they may be predaceous on other insects

Gall formers: Family Cecidomyiidae: 1-5 mm long, delicate. Form a variety of distinctive galls on many plant species.

Flies are important to humans other than naturalists or entomologists as pollinators, disease vectors (malaria, yellow fever, typhoid fever), agricultural pests, nuisances (biting flies).

Groups of Diptera you are likely to encounter:

Nematocera ("long-horned flies"): about 1/3 of the North American fly species. Antennae are long, with many segments. Most of these flies have delicate bodies and long legs; many have aquatic larvae. The maggots have well developed heads and mandibles. Group includes mosquitoes (family Culicidae), crane flies (Tipulidae, adults look like enormous delicate mosquitoes with elongated wings, while the aquatic larvae often indicate polluted water), midges, black flies and gnats.

Mosquito larva, pupa and adult



Black fly (Simuliidae) life cycle.
orc.ncf.ca/bitmaps/blackflycycle.jpg

Brachycera ("short-horned flies") have short, three-segmented antennae and are typically stouter than the Nematocera. Some maggots have hardened head capsules that can be retracted, while others have no hard parts on their heads other than the inconspicuous mouthparts; in these maggots it is sometimes difficult to determine which end is which! More photos on first page.

Tabanidae: horse flies and deer flies. Females suck blood. Males feed on pollen and nectar. Larvae are aquatic predators.

Asilidae: robber flies. Adults are insect predators and will attack insects larger than themselves (wasps, dragonflies, grasshoppers, other flies). They catch their prey in the air, holding it in their legs and biting it. Some robber flies are mimics of bees and wasps. Larvae are predators on other insect larvae, and typically live in soil or rotting wood.

Bombyliidae: bee flies. Stout, hairy, medium-to-large flies. Found near flowers or hovering over the ground. Fast fliers. Hold the wings outstretched at rest. Larvae are insect parasites or egg predators.

Syrphidae: Flower flies or hover flies. Large, brightly colored adults are often mimics of bees and wasps. They hover around flowers and feed on nectar, and are important pollinators. Some are also auditory mimics, buzzing like bees. In the field they can be differentiated from bees and wasps by their ability to hover, staying in one place in the air without bobbing up and down. Larvae are insect predators in ant nests, decaying vegetation,

polluted water, and plants. The rat-tailed maggot, *Eristalis*, lives in very polluted water and has a very long posterior siphon to obtain oxygen.

Tachinidae: the second largest family in the order. Larvae are parasites of other insects. The female lays eggs or larvae in, on, or near a host insect, the tachinid larva feeds internally, then kills the host and pupates either internally or externally. Tachinids are economically and ecologically important. For example *Compsilura concinnata*, a non-native parasitoid of caterpillars, was released in the U.S. to help control gypsy moths and other pest lepidoptera. Unfortunately *Compsilura* is not discriminating, and happily parasitizes hundreds of native Lepidoptera, too. It has been implicated in driving down populations of some giant silk moths (Saturniidae) in New England, and we have found high parasitism rates on our local saturniids.



Tachinid parasite: two larvae dissected out of abdomen of a walkingstick. Adult walkingstick with fully-grown maggot emerging above hind leg. Photos: L.S. Fink

Sources:

Borror, DJ, Triplehorn, CA, Johnson, NF. 1989. An Introduction to the Study of Insects. Saunders.
Klots, A., Klots, E. Insects of North America. Doubleday.
Kneidel, S. 2000. Stinkbugs, Stick Insects and Stag Beetles. Wiley.
Images are from //bugguide.net, from myrmecos.net (Alex Wild, photographer) and from Dr. Fink

Sweet Briar Field Guide Field Natural History

Common names: Butterflies and Moths

Insect order: LEPIDOPTERA

Class: Insecta

Phylum: Arthropoda



The LEPIDOPTERA are recognized (by a naturalist) by these characteristics:

Complete metamorphosis. Life stages: egg, five (usually) larval stages, pupa, adult

Adult:

Wings: Two pairs of broad wings covered with flat, overlapping scales, which may come off readily when the insect is handled. Wings may be similar in size, or front wings may be larger than hind wings.

Mouthparts: Adults in most families have a tubular, sucking mouthpart called a proboscis that is coiled when not in use. (Some adults do not feed, and may not have functional mouthparts.)

Antennae variable, usually prominent. **Large compound eyes.**



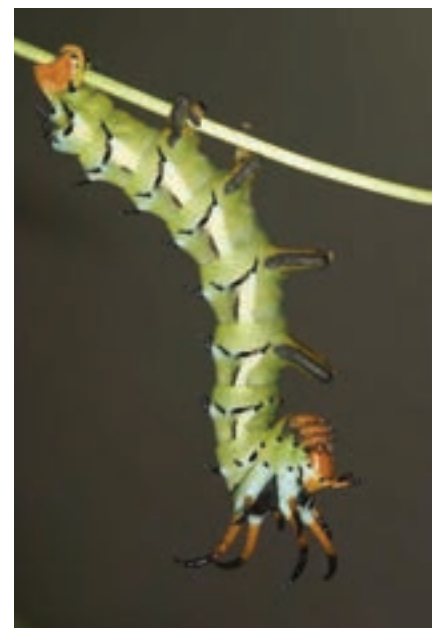
Larva (caterpillar):

Herbivorous. Caterpillars have a rigid head with simple eyes, very short antennae and chewing (mandibulate) mouthparts. Three pairs of walking legs on the thorax, and up to five pairs of muscular prolegs on the abdomen.

Prolegs have hooks, called crochets, that help them hold onto a plant (photo below right).



Caterpillars produce silk in glands that open near the mouth. Silk may be used to make shelters, webs or tents, and droplines. Caterpillars spin silk buttons, girdles or cocoons in preparation for pupation.

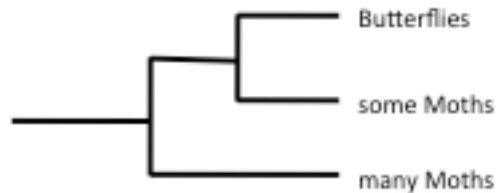


Pupa: Pupa of butterflies is called a **chrysalis** and attaches to a substrate with silk (photo left, black swallowtail butterfly); it is not contained within a cocoon, and may have complex coloration and a sculpted shape. **Pupa of moths may be naked** (center) or **covered with a silk cocoon** (below right); pupa is usually brown and relatively smooth. ***A cocoon is not a pupa!** A caterpillar spins a silk cocoon around itself and pupates within the cocoon.*



Butterflies versus moths

"Butterflies" are a unified group (or clade) within the Lepidoptera sometimes called the Rhopalocera, but "moths" are not a clade:



Butterflies *typically* flying during the day, are brightly colored, and have antennae that are slightly clubbed at the tip.

Moths are *typically* nocturnal, but some groups are diurnal. Coloration, antennae, body size and proportions are highly variable.

Diversity. One of the largest groups of insects, with more than 150,000 described species worldwide, more than 11,000 in the U.S. and Canada.

Sources:

BugGuide.net Butterflies and Moths of North America. www.butterfliesandmoths.org. Accessed 18 March 2012.

Tree of Life Web Project. 2003. Lepidoptera. Moths and Butterflies. Version 01 January 2003 (temporary).

<http://tolweb.org/Lepidoptera/8231/2003.01.01> in The Tree of Life Web Project, <http://tolweb.org/>. Accessed 18 March 2012.

Triplehorn, C.A. and N.F. Johnson. 2005. Borror and DeLong's Introduction to the Study of Insects. 7th edition. Thomson.

Images from: bugguide.net, tolweb.org/Lepidoptera, <http://www.alaska-in-pictures.com>, North Carolina Museum of Life and Science

Sweet Briar Field Guide Field Natural History

Common ARACHNIDS (A) Spiders and (B) Mites and ticks

A. Common name(s) **SPIDERS, Order ARANEAE**

Class Arachnida

Phylum Arthropoda Page creator: L.S. Fink, 2002, revised 2010

Key characters for recognition:

As **Arthropods**, they have **external skeletons** and **paired, jointed limbs**.

As **Arachnids**, they have jaws (**chelicerae**), one pair of leglike **pedipalps** (segmented structures between the chelicerae and the first pair of legs), **4 pairs of walking legs**, and **no antennae or wings**.

Among Arachnids, **Araneae** have the following characters:

- Body in two regions, a **cephalothorax** and a usually unsegmented **abdomen**, with a narrow attachment between.
- Usually have **eight simple eyes**
- **Poison glands** in the cephalothorax open near the tips of the chelicerae.
- **Silk**, produced in glands in the abdomen, is released via six posterior spigotlike **spinnerets**.
- In males, the pedipalps are clubbed and modified into copulatory organs.

Ecology and behavior:

All spiders are **predaceous**, primarily on insects. Prey capture behavior varies widely.

Silk is used in various families for *prey-catching* webs, *egg cases*, webs for spiderlings, *wrapping prey*, *draglines*, and spiderling dispersal by *ballooning*. Different types of silk, produced in different silk glands, are spun for these different functions; an egg case usually requires several kinds of silk. The spinnerets are mobile and well controlled by muscles, giving the spider control over the placement of the silk.

Courtship and mating: Before searching for a mate, the male spider spins a small sperm web and releases a drop of sperm onto it from his genital opening. He then dips his pedipalps into the drop and takes up the sperm.

Courtship in spiders can be extensive and involve visual displays, vibrations on silk lines, and pheromones.

During copulation the male inserts his palps one at a time or simultaneously into the female's genital opening at the base of the ventral surface of her abdomen.

Maternal care is widespread. In some families the female attaches a tough, waterproof silk egg case to vegetation or another solid substrate and abandons it. In other families she carries her egg case in her jaws or attached to her spinnerets, or stays with it in a fixed location. Some spiders provide protection or food to spiderlings after hatching.

Diversity:

Spiders are one of the most diverse groups of arthropods. There are several thousand species in North America.

Orthognath spiders (Mygalomorphs) have chelicerae that move forward. Includes tarantulas, trapdoor spiders (photo left, below), funnelweb spiders, purseweb spiders.

Labidognath spiders (True spiders) have chelicerae that open sideways (photo right). Includes most common spiders.



A selective list of commonly encountered families:

Agelenidae (funnel weavers) spin a flat, dense silk web with a funnel in which it hides. If an insect walks across the web, the spider runs out, bites it and carries it back to the funnel.

Araneidae (orb-weavers), photos below: 3500 species worldwide, about 180 in the U.S. Most spin an orb-web with three components: radial threads, converging at a central hub; frame threads around the outside; and a catching spiral sticky with droplets of glue. Have poor vision, locate prey by vibrations and tension of web threads. Wrap prey in silk before eating it. Inedible objects or unpalatable insects are cut out of the web.



Linyphiidae (sheetweb spiders) build a dome-shaped or flat web and hang upside down underneath it. When an insect is entangled, the spider bites from below and pulls it through the sheet. The spider's abdomen usually patterned, and longer than it is wide. The filmy dome and bowl and doily spiders are common in our forests.

Lycosidae (wolf spiders) hunt prey on the ground. They are usually nocturnal, and most dig tunnels or burrows or hide under rocks during the day. They have good vision, with four small eyes in a row below four larger eyes. Courtship involves leg-waving and palp-waving displays by males. In late summer a female is often seen with her egg sac attached to her spinnerets. After hatching, spiderlings are carried on her back for several days before dispersing. Most wolf spiders are patterned with stripes of brown, black, grey.

Pisauridae (nursery web or fishing spiders) can be quite large (body >1 inch). *Dolomedes* are found near water and are able to run across the water surface and dive below the surface if chased. A female carries her huge egg sac in her jaws. When the spiderlings are ready to hatch, the female attaches the egg sac to vegetation, spins a 'nursery web', and guards it.



Bowl-and-doily spider web (linyphiid); jumping spider (salticid); crab spider (thomisid)

Salticidae (jumping spiders) leap onto their prey and can jump many times their own length. They are diurnal, and have excellent color and image-forming vision. They usually attach a silk dragline before jumping, but do not use silk otherwise in prey capture. Males use leg displays in courtship. Many species have bright markings, including iridescent chelicerae.

Theridiidae (cobweb or combfooted spiders) are sedentary, hanging upside down in the center of an irregular cobweb. They may make small web under leaves, stones, or loose bark. They have spherical abdomens. Includes the black widow, *Latrodectus mactans*.

Thomisidae (crab spiders) sit on flowers or leaves of plants holding their legs out to the sides, crablike. Many are bright pink or yellow and sit in flowers of the same colors. They are ambush predators, grabbing insects that pass by, and do not use silk in prey capture.

Non-spider arachnids include the mites and ticks (Acari), daddy longlegs (Opiliones) and scorpions (Scorpiones).

Sources

Borror, D.J., C.A. Triplehorn, N.F. Johnson. 1989. An Introduction to the Study of Insects. 6th edition. Saunders.

Foelix, R.F. 1982. Biology of Spiders. Harvard.

Levi, H.W., L.R. Levi and H.S. Zim. 1990. Spiders and Their Kin. Golden Press.

Image sources:

Trapdoor spider: <http://bugguide.net/node/view/179666>

labidognath spider feeding: <http://animals.howstuffworks.com/arachnids/spider7.htm>

Orb web: <http://animaldiversity.ummz.umich.edu/site/resources/arttoday/anotherorbweb.554608.jpg/view.html>

Argiope feeding:

http://animaldiversity.ummz.umich.edu/site/resources/hubert_pan/argiope_aur_feeding1.JPG/view.html

Micrathena: <http://bugguide.net/node/view/31249>

Crab spider: http://animaldiversity.ummz.umich.edu/site/resources/phil_myers/araneae/spider4370.jpg/view.html

Jumping spider: <http://www.halverson-photography.com/images/Jumping-Spider1.jpg>

Linyphiid: Bowl-and-doily: http://www.marylandinsects.com/images/Bowl_and_Doily_Spider_--

[_Frontinella_communis.jpg](http://www.marylandinsects.com/images/Bowl_and_Doily_Spider_--_Frontinella_communis.jpg)

B. Common name(s) **MITES AND TICKS, Order ACARI**

Class Arachnida

Phylum Arthropoda Page creator: L.S. Fink, 2002, revised 2010

"The average mite is a tiny animal, scarcely visible to the unaided human eye. Because they are literally beneath our notice, we are often able to forget mites...In these lives lived at a microscale there is much left to discover." (Walter and Proctor, p. 268)

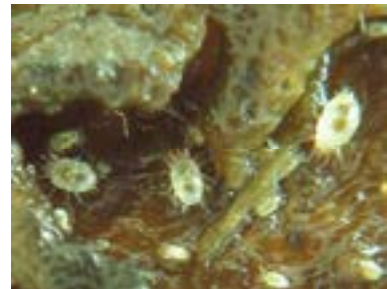
Key characters for recognition:

As **Arthropods**, they have **external skeletons** and **paired, jointed limbs**.

As **Arachnids**, they have jaws (**chelicerae**), one pair of **pedipalps** (segmented structures between the chelicerae and the first pair of legs), **4 pairs of walking legs** (as adults), and **no antennae or wings**.

Among Arachnids, **Acari** have the following characters:

- Body fused into an oval, with **no separation between cephalothorax and abdomen**.
- Adults have **four pairs of legs**, like other arachnids, but **larvae have only three pairs** until their first molt.
- Body size of most is quite **small** (<0.5mm to 3-4mm). Some species of ticks, the largest mites, can reach 3cm length when fully fed.



Ecology:

The mites are an abundant, diverse, and ecologically and economically important group.

Lifestyles: parasites (both vertebrates and invertebrates can serve as hosts), herbivores, gall-formers, scavengers, predators.

Habitats: especially abundant in soil and organic debris, and may be the most abundant arthropods in these habitats. Aquatic mites are found in fresh water and salt water.

Diversity:

More than 40,000 species have been described, and this may represent only 5-10% of the worldwide diversity. There may be five times as many kinds of mites as there are spiders. In the U.S. and Canada there may be about 30,000 species.

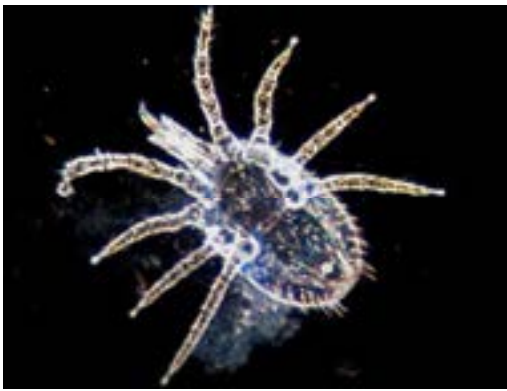
Commonly encountered groups of mites include:

Chiggers: larvae are parasites, adults are insect predators. Fewer than 50 of 700 species attack humans. They drop off after feeding.

Spider mites: tiny (0.3-0.8mm) crop pests, have silk glands near mouth and make a loose web among leaves.

Velvet mites: several thousand species. Adults (to 4mm) are velvety red and eat insect eggs. Larvae are insect parasites.

Ticks (suborder Ixodida): among the largest mites, are external parasites of mammals, birds, and reptiles. Eggs are not laid on the host. Most species have three individual hosts: the first instar larva feeds on one host, drops off and molts. The second instar feeds on a second host, and the adult on a third. They stay on the host for a few days and then drop off to molt. After a molt, the tick waits on leaves with its forelegs outstretched to attach to any animal brushing past. Young ticks may attack different host species than adults.



Natural history: three reasons to study, and be impressed by, mites:

A. Sex. Mites have incredible reproductive diversity. For example:

Sex determination: Many mites are similar to us in having separate sexes with sons and daughters both produced from fertilized eggs. Others are haplodiploid, with haploid sons produced from unfertilized eggs. Quite a few groups of mites are parthenogenetic, with no males and diploid females produced asexually. Sexual reproduction has been 'lost' evolutionarily repeated times within the group; in fact there are a number of species with both sexual and asexual populations.

Mate competition: In many sexual species, males fight for access to females and destroy one another's spermatophores. Many males guard or attach to pre-adult females and copulate as soon as the female molts. At least two groups of mites have harems, in which a male sequesters a group of females and guards them from other males.

Sperm transfer: Among sexual taxa, sperm may be transferred directly, via copulation, or indirectly. Copulation: a male releases a packet of sperm, a spermatophore, from his genital opening, takes it up into one of his chelicerae, and then puts it into or near the female's genital opening. A variety of copulatory positions have been observed. Indirect transfer: a male places a spermatophore on a substrate and the female picks it up with her genital opening. Some males produce chemical pheromones or silk signals to guide females to the spermatophore.

B. Mites are often the most abundant arthropods in forest soils and litter

Mite densities can reach more than 100,000 per square meter in the top 10 cm of soil. While the highest diversity and abundance of mites is in these upper layers, many little-known mites occur as far down in the soil as roots penetrate. They are very important in forest food webs, energy transfer and biogeochemical cycles.

Scavenging mites process vast amounts of organic material, making it available to fungal and bacterial decomposers. When microbivore mites feed on bacteria and fungi, they move microbes from patches where organic material has been depleted and deposit them in rich fecal pellets elsewhere.

Some mites are major predators of root pests such as nematodes (roundworms), and a variety of other soil invertebrates. Mites themselves are prey of centipedes, spiders, ants, other mites, and amphibians.

C. Mites use our bodies

Walter and Proctor (1999, pp. 200-201) list "The 22 most astonishing mite-animal associations" and include genera found in the subcutaneous fat of pigeons, on the corneas of fruit bats, in the tracheae of honey bees, and in the digestive systems of sea urchins. All animal taxa larger than mites have some mites that live with them, permanently or temporarily, acting as commensals, mutualists, or parasites. Photos below: mites on a dragonfly and on a beetle.

On mammals, mites may be consuming dead skin or skin secretions, or feeding on blood or lymph. For example, *Demodex* mites feed on secretions in the follicles and glands on your face. In one study *Demodex* were found on the faces of 55% of human volunteers; the rate increased with the person's age.

A small proportion of mites and ticks are vectors of diseases of plants and animals, including humans. Tick-borne pathogenic diseases in the U.S. include Rocky Mountain spotted fever (caused by *Rickettsia rickettsii*), Lyme disease (caused by a spirochete bacteria, *Borrelia burgdorferi*), tularemia, relapsing fever, babesiosis, and ehrlichiosis.



Sources:

Borror, D.J., C.A. Triplehorn, N.F. Johnson. 1989. An Introduction to the Study of Insects. 6th edition. Saunders.
Drummond, R. 1990. Ticks and what you can do about them. Wilderness Press, Berkeley.
Levi, H.W., L.R. Levi and H.S. Zim. 1990. Spiders and Their Kin. Golden Guide.
Walter, D. and H. Proctor. 1999. Mites: Ecology, Evolution and Behaviour. UNSW Press.

All images were taken from BugGuide (<http://bugguide.net>)



Cherry pouch galls produced by mites