

# THE COMPENDIUM OF HEXAPOD CLASSES AND ORDERS

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## Phylogenetic Listing

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# EPHEMEROPTERA



## Mayflies

The name Ephemeroptera is derived from the Greek "*ephemera*" meaning short-lived, and "*ptera*" meaning wings. This is a reference to the short lifespan of most adult mayflies.

### Life History & Ecology:

The immature stages of mayflies are aquatic. They generally live in unpolluted habitats with fresh, flowing water. Some species are active swimmers, others are flattened and cling to the underside of stones, a few are burrowers who dig U-shaped tunnels in the sand or mud. Most species are herbivorous. Their diet consists primarily of algae and other aquatic plant life scavenged from surrounding habitat. Some species mature quickly, in as little as four weeks, while others develop more slowly (one to four years per generation).

Once a mayfly completes development as a naiad, it leaves the aquatic environment, often rising to the water surface in a bubble of air. It quickly molts to a winged form (the **subimago**) and flies to a nearby leaf or stem. The subimago is a brief transitional stage that molts again into a sexually mature adult (**imago**). The imago usually has transparent wings and a smooth, shiny exoskeleton in contrast to the cloudy wings and dull, pubescent body of the subimago. Mayflies are the only living insects that molt again after they have wings.

Most adults are delicate insects with a very short lifespan. They do not feed (mouthparts are vestigial), and some species emerge, reproduce, and die in a single day. Males generally fly in swarms that undulate in the

air 5-15 meters above the ground. Females fly into the swarm and are quickly grabbed by a male. Copulation takes place in flight, and the female usually lays her clutch of eggs within minutes or hours. Males die shortly after mating; females usually die soon after oviposition.

### **Distribution:**

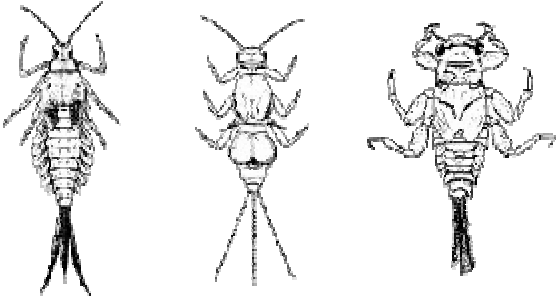
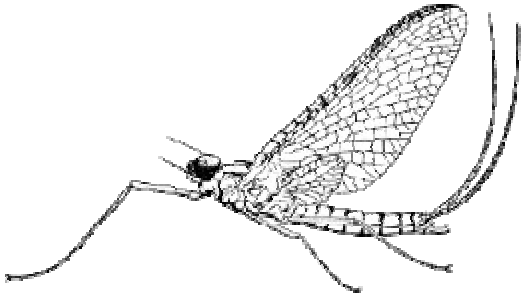
**Common in freshwater habitats worldwide.**

	<b>North America</b>	<b>Worldwide</b>
<b>Number of Families</b>	<b>17</b>	<b>19</b>
<b>Number of Species</b>	<b>611</b>	<b>&gt;2000</b>

### **Classification:**

Hemimetabola  
incomplete development (egg, nymph, adult)  
immatures are aquatic (naiads)  
Paleoptera  
primitive wing venation  
unable to fold the wings over the back.

## Physical Features:

	
<p style="text-align: center;"><b>Immatures</b></p>	<p style="text-align: center;"><b>Adults</b></p>
<ol style="list-style-type: none"><li>1. Antennae short and bristle-like</li><li>2. Four to nine pairs of leaf-like or fan-like gills along the sides of the abdomen</li><li>3. Three long filaments at rear of abdomen</li></ol>	<ol style="list-style-type: none"><li>1. Antennae short and bristle-like</li><li>2. Front legs long and often held out in front of body</li><li>3. Compound eyes large, usually covering most of the head</li><li>4. Wings: four membranous wings with many veins and crossveins front wings large, triangular hind wings smaller, fan-shaped</li><li>5. Abdomen slender, bearing two (or sometimes three) long terminal filaments</li></ol>

## Economic Importance:

Many northern lakes and rivers (in both the United States and Europe) support unbelievably large populations of mayflies. The naiads are "ecological indicators" of good water quality and are an important source of food for fish and other aquatic wildlife. Anglers often use mayflies as bait, or tie "flies" that are made to resemble the imago (spinners) or subimagos (dun).

In some mayfly species, summer emergence of winged stages is a sudden and dramatic event that occurs almost simultaneously throughout the entire population. These mass emergences are often regarded as a major nuisance. The insects are attracted to city lights and blown inland

by the wind. Their dead bodies pile up in drifts on porches and windowsills; they plaster car windshields and slicken highways. Europeans are often more sanguine than Americans about mass emergences -- in some communities the dead insects are diligently gathered up, dried, and sold as bird food, fish bait, or fertilizer. Although mass emergences still occur, the populations are not as large as in the past. Urban development and water pollution in major lakes and streams has dramatically reduced mayfly populations over the past 50 years.

### Major Families:

- **Baetidae** -- These insects are usually small (less than 10 mm). The naiads are typically found in warm water.
- **Heptageniidae** -- Naiads of this common family are usually found under stones in fast-moving water.
- **Ephemeridae** -- Adults are among the largest of mayflies. Naiads of this family burrow into the sand.

### Fact File:

- The subimagos of mayflies are the only insects that molt when they have wings.
- Mayflies are a favorite bait of fishermen, and many popular fishing "flies" are tied to resemble mayflies. Anglers have names for the stages -- *dun* is the subimago and *spinner* is the imago.
- Mayflies have paired genital openings. During copulation, the two penes of the male are inserted simultaneously into the two openings of the female. Sperm is transferred quickly (there is no spermatophore) and eggs are fertilized immediately.
- A few species of mayflies reproduce parthenogenically -- no males have ever been found.
- Although most mayflies are herbivores, a few are predaceous -- e.g. Siphoneuridae and Oligoneuriidae.
- Adult mayflies do not feed. Their digestive system is filled with air, making them light enough to float.
- In the Congo, there is one species of mayfly that excavates tunnels in fresh-water sponges.

- Some mayfly species require up to four years to complete development. In that time they may molt more than 20 times.

### Hot links and Illustrations:

- [Gordon Ramel's Plecoptera Page](#)
- [Ohio State University Factsheet](#)
- [Ecowatch Ephemeroptera Page](#)
- [Tree of Life Web Project - Ephemeroptera](#)
- [Discover Life - Ephemeroptera](#)

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# ODONATA



## Dragonflies and Damselflies

The name Odonata, derived from the Greek "*odonto-*" meaning tooth, refers to the strong teeth found on the mandibles of most adults.

## Life History & Ecology:

Dragonflies and damselflies are predaceous both as immatures and adults. The adults are quick, agile fliers that are generally considered beneficial because they feed on large numbers of small, flying insects like gnats and mosquitos. Legs are used either as a basket for catching prey or as grapples for clinging to emergent vegetation. Eggs are laid singly in fresh water; females often hover over open water and dip their abdomen as they oviposit.

Eggs hatch into aquatic immatures (naiads) that feed opportunistically on other forms of aquatic life including mayfly naiads, small crustaceans, annelids, and mollusks. Some of the large dragonfly naiads will even attack small fish and tadpoles. All immature Odonata have a specialized labium for catching prey. Folded under the head and thorax when not in use, the labium can be extended rapidly toward potential prey. Hooked lobes at the tip of the labium grasp or impale the prey and draw it back to the mouth as the labium retracts.

Damselfly naiads are usually more slender than dragonfly naiads and have three leaf-like gills at the end of the abdomen. Dragonfly gills are located internally, within the rectum, where bellows-like contractions of the rectal muscles cause oxygenated water to circulate in and out.



## Distribution:

Common in fresh-water habitats worldwide.

	North America	Worldwide
<b>Number of Families</b>	<b>11</b>	<b>29</b>
<b>Number of Species</b>	<b>407</b>	<b>&gt;5000</b>

## Classification:

Hemimetabola

incomplete development (egg, nymph, adult)

immatures are aquatic (naiads)

Paleoptera

primitive wing structure and venation

lacking the ability to fold the wings over the back

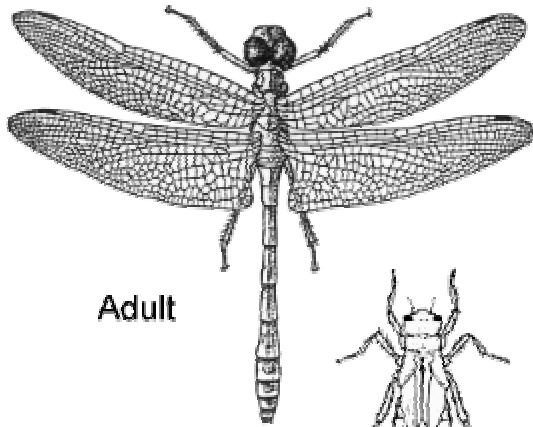
The Odonata are divided into two suborders:

**Zygoptera** (damselflies) -- front and hind wings are similar in shape

**Anisoptera** (dragonflies) -- hind wings are broader near the base than the front wings

## Physical Features:

### Dragonflies



Adult

Naiad

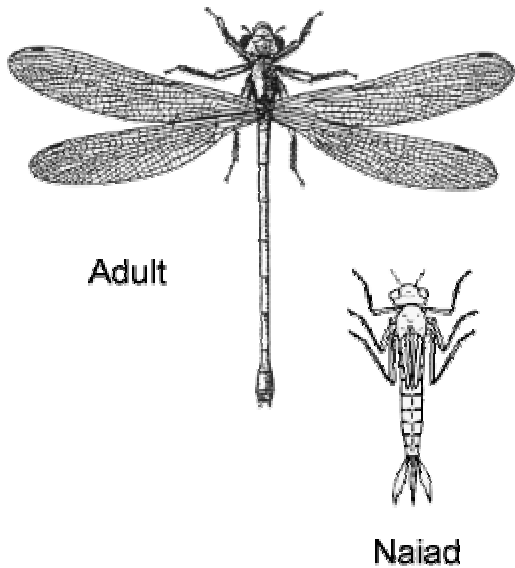
#### Immatures:

1. Labial "mask" adapted for catching prey
2. Body robust
3. "Rectal gills" located within abdomen

#### Adults:

1. Antennae short and bristle-like
2. Compound eyes large, often covering most of the head
3. Four membranous wings with many veins and crossveins
4. Base of hind wing broader than forewing
5. One distinctively pigmented cell (stigma) on leading edge of wing
6. Abdomen: long and slender

### Damselflies



**Immatures:**

1. Labial "mask" adapted for catching prey
2. Three leaf-like gills at rear of abdomen
3. Body usually long and slender

**Adults:**

1. Antennae short and bristle-like
2. Compound eyes large, often covering most of the head
3. Four membraneous wings with many veins and crossveins
4. Base of wings narrow, stalk-like
5. One distinctively pigmented cell (stigma) on leading edge of wing
6. Abdomen: long and slender

**Economic Importance:**

Most dragonflies and damselflies are regarded as beneficial insects because they feed on small flying insects such as mosquitoes. They may also catch and eat honey bees -- then they are regarded as pests by the beekeepers.

In some parts of Europe, dragonflies are considered a threat to the poultry industry because they transmit *Prosthogoniums pellucidus*, a parasitic flatworm. Dragonfly naiads become infected by ingesting cysts of the flatworm. These cysts survive into adulthood of the dragonfly and may spread to birds (particularly poultry) that catch and eat the adult dragonflies. The flatworm cysts dissolve in the bird's intestine and infection spreads into the cloaca and reproductive organs. The Dutch have a maxim: "Hide the hens, the dragonflies are coming."

## Major Families:

- **Aeshnidae** (Darners) -- These insects are notable for their large size and brilliant blue or green coloration. Includes the common green darner (*Anax junius*).
- **Libellulidae** (Common Skimmers) -- This is the largest family in the order. It contains many species with dark spots on the wings.
- **Calopterygidae** (Broadwinged Damselflies) -- The wings of these insects are shaped like the seeds of a maple tree.
- **Coenagrionidae** (Narrowwinged Damselflies) -- Small, delicate insects. The body is usually black with blue markings.

## Fact File:

- The compound eyes of some dragonflies may have up to 28,000 facets.
- Some naiads can shoot out their labium and catch prey in only 25 milliseconds.
- Scientists have documented large-scale migrations of dragonflies. One swarm was observed 1,400 km off the coast of Australia.
- Some immature damselflies establish feeding territories, areas that are defended against invasion by other conspecifics. Territorial species develop more rapidly and produce larger adults than other non-territorial species.
- Many adult male dragonflies establish and defend territories along the perimeter of a lake or stream. Females will mate only with males that hold a territory, so population density is somewhat regulated by territory size.
- Male Odonata have claspers at the end of their abdomen, but no external genitalia. Before finding a mate, a male attaches a spermatophore to his second abdominal segment. He then grabs a female around the neck with his claspers and she retrieves the spermatophore with the genital opening of her abdomen.
- Most dragonfly naiads can move forward by "jet propulsion". Rapid contraction of the rectal muscles forces water out the rear end and shoots the insect forward.
- Male damselflies (and perhaps some dragonflies) have a special flagellum associated with the copulatory organ that can reach into a female's body and remove sperm deposited by another male in a previous mating.

- Dragonflies are known by many interesting common names, including "snake doctors", "devil's darning needles", and "mosquito hawks".

### Hot Links and Illustrations:

- [University of Michigan's Odonata Photo Archive](#)
- [Gordon Ramel's Odonata Page](#)
- [Bishop Museum's Megalagrion Damselflies](#)
- [The University of Puget Sound Odonata Photo Gallery](#)
- [The Digital Dragonfly Museum](#)
- [Ecowatch Odonata Page](#)
- [Tree of Life Web Project - Odonata](#)
- [Discover Life - Odonata](#)

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# PLECOPTERA



## Stoneflies

The name Plecoptera, derived from the Greek "*pleco*" meaning folded and "*ptera*" meaning wing, refers to the pleated hind wings which fold under the front wings when the insect is at rest.

## Life History & Ecology:

Stoneflies are generally regarded as the earliest group of Neoptera. They probably represent an evolutionary "dead end" that diverged well over 300 million years ago. Immature stoneflies are aquatic nymphs (naiads). They usually live beneath stones in fast-moving, well-aerated water. Oxygen diffuses through the exoskeleton or into tracheal gills located on the thorax, behind the head, or around the anus. Most species feed on algae and other submerged vegetation, but two families (Perlidae and Chloroperlidae) are predators of mayfly nymphs (Ephemeroptera) and other small aquatic insects. Adult stoneflies are generally found on the banks of streams and rivers from which they have emerged. They are not active fliers and usually remain near the ground where they feed on algae or lichens. In many species, the adults are short-lived and do not have functional mouthparts. Stoneflies are most abundant in cool, temperate climates.

## Distribution:

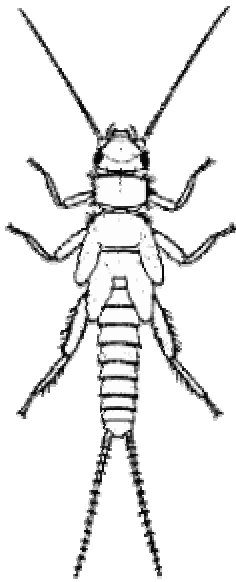
**Common in and around fast-moving streams in temperate and boreal climates.**

	North America	Worldwide
Number of Families	10	15
Number of Species	465	>2000

## Classification:

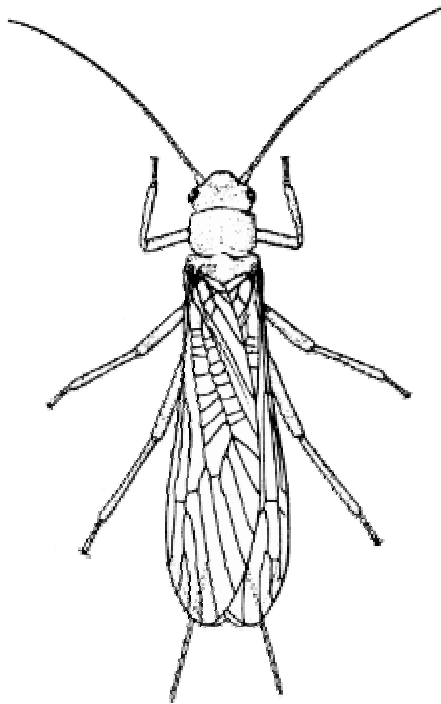
Hemimetabola  
incomplete development (egg, nymph, adult)  
Orthopteroid  
closely related to Orthoptera and Embioptera

## Physical Features:



### Immatures:

1. Antennae long, filiform
2. Body flattened, legs widely separated
3. Tracheal gills present as "tufts" behind the head, at base of legs, or around the anus
4. Each segment of thorax is covered by a large dorsal sclerite
5. Cerci long, multi-segmented



**Adults:**

1. Antennae long, filiform
2. Front wings long and narrow; M-Cu crossveins form distinctive boxes near center of front wing
3. Hind wings shorter than front wings; basal area of hind wing enlarged and pleated
4. Cerci long, multi-segmented

**Economic Importance:**

Stoneflies require clean, well-oxygenated water to survive. They are extremely sensitive to water pollution and are used by ecologists as indicators of water purity. Stoneflies are also an important source of food for game fish (e.g., trout and bass) in cold mountain streams.

**Major Families:**

- **Perlidae** (Common Stoneflies) -- largest family in the order
- **Taeniopterygidae** (Winter Stoneflies) -- adults emerge January to April; often seen on snow banks
- **Nemouridae** (Spring Stoneflies) -- adults emerge April to June



## Fact File:

- In some species, a male attracts a female by drumming his abdomen against the substrate.
- Stonefly eggs are coated with a sticky slime that adheres to rocks and keeps the eggs from washing away in fast moving water.
- Adults of some Australian stoneflies consume rotten wood as part of their diet. The wood apparently contains a nutrient that is essential in egg production.
- A secondarily wingless species (family Capniidae) passes its entire life cycle in the depths of Lake Tahoe, U.S.A.

## Hot links and Illustrations:

- [Gordon Ramel's Plecoptera Page](#)
- [Ecowatch Plecoptera Page](#)
- [Tree of Life Web Project - Plecoptera](#)
- [Discover Life - Plecoptera](#)

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# NEUROPTERA

## Lacewings / Antlions / Dobsonflies / Alderflies / Snakeflies

The name Neuroptera is derived from the Greek word "*neuron*" meaning sinew and "*ptera*" meaning wings. The modern English translation "nerve-wings" is appropriate because it alludes to the extensive branching found in the wing veins of most Neuroptera.



## Life History & Ecology:

The order Neuroptera includes the lacewings and antlions (suborder Planipennia), dobsonflies and alderflies (suborder Megaloptera) and snakeflies (suborder Raphidoidea). "Splitters" prefer to assign each of these groups to a separate order (Neuroptera, Megaloptera, and Raphidioptera, respectively), based on differences in structure and development.

The Megaloptera are always aquatic as immatures. They live under stones or submerged vegetation and feed on a variety of small aquatic organisms. Large species, often called hellgrammites, may require several years of growth to reach maturity. Adults usually remain near water, although they are attracted to lights at night. In most species, the adults live only a few days and rarely feed.

Except for larval spongillafly (family Sisyridae) which feed on fresh-water sponges, all members of the suborders Planipennia and Raphidoidea are terrestrial. 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.

### **Distribution:**

**Common worldwide, but seldom abundant. Aquatic species are frequent inhabitants of streams and rivers.**

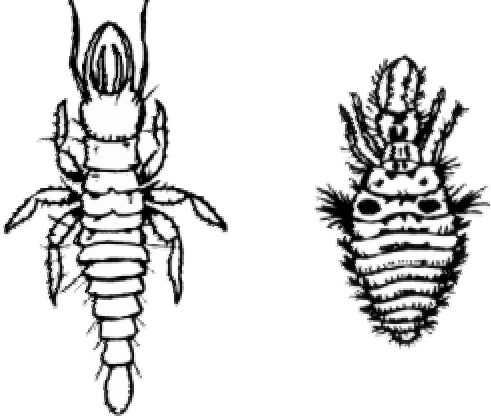
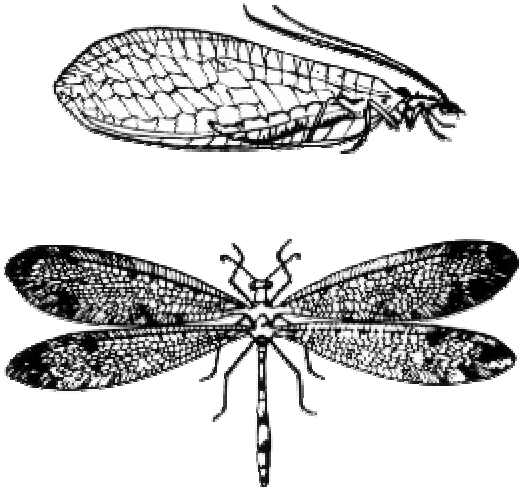
	<b>North America</b>	<b>Worldwide</b>
<b>Number of Families</b>	<b>15</b>	<b>21</b>
<b>Number of Species</b>	<b>349</b>	<b>~5,500</b>

### **Classification:**

Holometabola  
complete development (egg, larva, pupa, adult)  
Neuroptera is divided into three suborders:  
Planipennia (antlions, lacewings and their relatives)  
Megaloptera (alderflies and dobsonflies)  
Raphidioidea (snakeflies)

In adults, the suborders are distinguished by the shape of the wings and the length of the prothorax. In larvae, the suborders are separated by habitat and characteristics of the mouthparts.

### Physical Features:

	<p><b>Immatures:</b></p> <ol style="list-style-type: none"><li>1. Head well-developed with ocelli, antennae, and chewing or pinching mouthparts</li><li>2. Three pairs of thoracic legs; tarsi 1-segmented; claws paired</li><li>3. Aquatic forms have thread-like gills on most abdominal segments</li></ol>
	<p><b>Adults:</b></p> <ol style="list-style-type: none"><li>1. Antennae filiform, multisegmented</li><li>2. Chewing mouthparts</li><li>3. Front and hind wing membranous, similar in size</li><li>4. Extensive branching of venation in all wings; crossveins abundant especially along leading edge (costal margin)</li></ol>

## Economic Importance:

Larvae of Megaloptera are important predators in aquatic ecosystems. They also serve as food for fish and other aquatic vertebrates. Lacewing larvae are beneficial as predators of agricultural pests (aphids, whiteflies and scale insects). Some species are reared and sold commercially as biocontrol agents.

## Major Families:

Suborder Megaloptera -- aquatic predatory larvae

- **Corydalidae** (Dobsonflies) -- adults generally longer than 5 cm
- **Sialidae** (Alderflies) -- adults are smaller than dobsonflies

Suborder Raphidoidea -- terrestrial predatory larvae

- **Raphidiidae** (Snakeflies) -- long-necked predators of small arthropods

Suborder Planipennia -- mostly terrestrial predatory larvae

- **Chrysopidae** (Green lacewings) -- aphid predators
- **Hemerobiidae** (Brown lacewings) -- aphid and mite predators
- **Myrmeleontidae** (Antlions) -- doodlebugs, ant predators

## Fact File:

- A lacewing's egg sits atop a slender stalk secreted by the female's reproductive system. For many years, biologists thought these eggs were the fruiting bodies of a fungus they called *Ascophora ovalis*. The true nature of these eggs was first discovered in 1737 by Rene Reaumur, a French physicist, biologist and inventor.
- Some lacewing larvae camouflage themselves by attaching the dead bodies of their prey to spines on their back. Other species use bits of bark, moss, etc.
- Adult lacewings in the subfamily Chrysopinae can detect the sound of bats with auditory organs in the large veins of their front wings.
- Larvae of spongillaflies, family Sisyridae, are predators of freshwater sponges.

- As larvae, lacewings and antlions do not have a complete digestive system: the midgut ends in a dead end. Waste materials accumulate in the midgut throughout larval development and are finally expelled only after a connection is made with the anus near the end of the pupal stage. The accumulated fecal material is called a **meconium**.
- Antlion larvae are sometimes known as doodlebugs. The name is apparently derived from the squiggly trails these insects make when they move around in the sand.
- When they pupate, larvae of lacewings and antlions dig a small cavity in the soil and spin a loose silken cocoon around themselves. Many holometabolous insects exhibit similar behavior, but neuropterans are unusual because their silk is produced by Malpighian tubules (excretory organs) and spun from the anus. In contrast, most other endopterygote insects produce silk in modified salivary or labial glands and spin it with their mouthparts. Only one other order, the Coleoptera, makes silk in the same manner as Neuroptera.

### Hot Links and Illustrations:

- [Ecowatch Neuroptera Page](#)
- [Tree of Life Web Project - Neuroptera](#)
- [Discover Life - Neuroptera](#)
- [The Antlion Pit](#)
- [AntLionFarms.com](#)
- [Gordon Ramel's Neuroptera Page](#)

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# TRICHOPTERA

## Caddisflies

The name Trichoptera, derived from the Greek words "*trichos*" meaning hair and "*ptera*" meaning wings, refers to the long, silky hairs that cover most of the body and wings.



## Life History & Ecology:

The order Trichoptera (caddisflies) is another likely descendant of the Mecopteran lineage. Adults are mostly nocturnal, weak-flying insects that are often attracted to lights. During the day, they hide in cool, moist environments such as the vegetation along river banks. The body and wings are clothed with long silky hairs (setae) -- a distinctive characteristic of the order. In flight, the hind wings are coupled to the front wings by specially curved hairs. At rest the wings are held tent-like over the abdomen. Many caddisflies have reduced or vestigial mouthparts. Few species have actually been observed feeding, and most adults are relatively short-lived.

All caddisfly larvae live in aquatic environments; they may be herbivores, scavengers, or predators. In most cases, the predatory species are free-living or spin silken structures in the water (webs or tunnels) to entrap prey. The scavengers and herbivores live within protective "cases" which they build from their own silk and stones, twigs, leaf fragments, or other natural materials. Case design and construction is distinctive for each family or genus of caddisfly. The case is usually portable, dragged around like a snail shell as the insect moves, and held in place by a pair of hooked prolegs at the tip of the abdomen. Most species have thread-like abdominal gills and get oxygen from water that circulates inside the case. All larval growth and development (including pupation) occurs within the case.

## **Distribution:**

**Common worldwide. Larvae are aquatic and may be abundant in some cool, fresh water habitats. Adults are less conspicuous, usually nocturnal.**

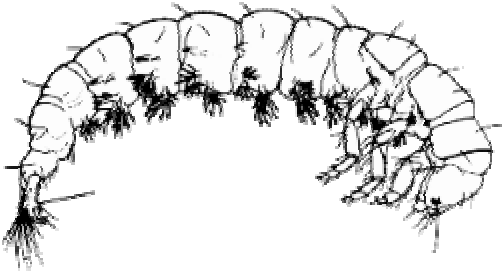
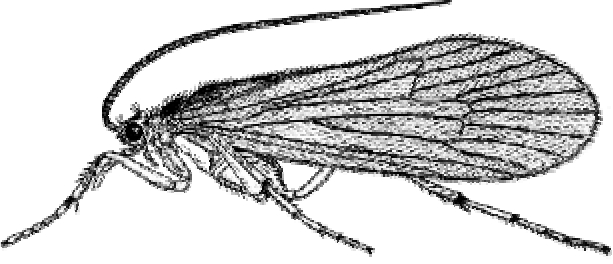
	<b>North America</b>	<b>Worldwide</b>
<b>Number of Families</b>	<b>18</b>	<b>43</b>
<b>Number of Species</b>	<b>1,261</b>	<b>&gt;7,000</b>

## **Classification:**

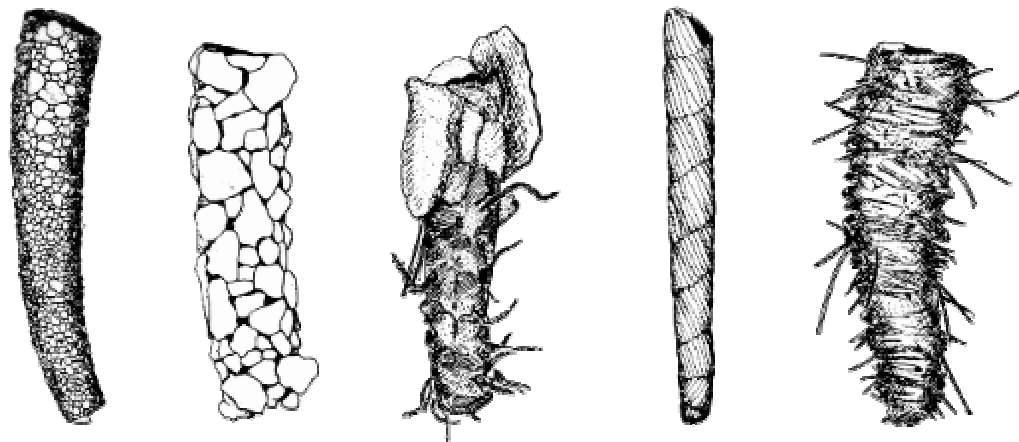
Holometabola  
complete development (egg, larva, pupa, adult)



## Physical Features:

	
<p style="text-align: center;"><b>Immatures</b></p>	<p style="text-align: center;"><b>Adults</b></p>
<ol style="list-style-type: none"> <li>1. Eruciform (caterpillar-like) body; abdomen usually enclosed in a case made of stones, leaves, twigs, or other natural materials.</li> <li>2. Head capsule well-developed with chewing mouthparts</li> <li>3. Thread-like abdominal gills usually present in case-makers</li> <li>4. One pair of hooked prolegs often present at tip of abdomen</li> </ol>	<ol style="list-style-type: none"> <li>1. Filiform antennae</li> <li>2. Mouthparts reduced or vestigial</li> <li>3. Two pairs of wings clothed with long hairs</li> <li>4. Wings held tent-like over the abdomen</li> </ol>

## Examples of Caddisfly Cases



## Economic Importance:

Caddisfly larvae may serve as food for fish and other aquatic vertebrates. Fishermen often gather them for use as bait for trout and other game fish. Although a few species have been recorded as pests in rice paddies, most caddisflies have very little economic importance.

## Major Families:

- **Hydropsychidae** -- Most larvae are filter feeders. They build silk nets in swift water to snare food particles. A few species are predatory.
- **Hydroptilidae** -- Larvae make purse-like cases of silk, often with small stones attached.
- **Limnephilidae** -- Larvae build tubular cases from a variety of natural materials.
- **Phryganeidae** -- Larvae construct tubular cases with plant fragments arranged in a spiral orientation.

## Fact File:

- Many species of Trichoptera are very similar in appearance, both as larvae and as adults. It is often easier to identify a species by the structure of its case than by the features of its body.
- While still in their pupal case, caddisfly adults have sharp mandibles used for cutting through the pupal case. Once they emerge, their mandibles degenerate and become nonfunctional. From this time on they do not feed (or ingest food only in liquid form).

## Hot Links and Illustrations:

- [Gordon Ramel's Trichoptera Page](#)
- [Ecowatch Trichoptera Page](#)
- [Tree of Life Web Project - Trichoptera](#)
- [Discover Life - Trichoptera](#)

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# DIPTERA

## True Flies / Mosquitoes / Gnats / Midges

The name Diptera, derived from the Greek words "*di*" meaning two and "*ptera*" meaning wings, refers to the fact that true flies have only a single pair of wings.



## Life History & Ecology:

The order Diptera includes all true flies. These insects are distinctive because their hind wings are reduced to small, club-shaped structures called halteres -- only the membranous front wings serve as aerodynamic surfaces. The halteres vibrate during flight and work much like a gyroscope to help the insect maintain balance.

All Dipteran larvae are legless. They live in aquatic (fresh water), semi-aquatic, or moist terrestrial environments. They are commonly found in the soil, in plant or animal tissues, and in carrion or dung -- almost always where there is little danger of desiccation. 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 advanced suborders (Brachycera and Cyclorrhapha) where the larvae, known as maggots, have worm-like bodies and only a pair of mouth hooks for feeding.

Adult flies live in a wide range of habitats and display enormous variation in appearance and life style. Although most species have haustellate mouthparts and collect food in liquid form, their mouthparts are so diverse that some entomologists suspect the feeding adaptations may have arisen from more than a single evolutionary origin. In many families, the proboscis (rostrum) is adapted for sponging and/or lapping. These flies survive on honeydew, nectar, or the exudates of various plants and animals (dead or alive). In other families, the proboscis is adapted for cutting or piercing the tissues of a host. Some of these flies are predators of other arthropods (e.g., robber flies), but most of them are external parasites (e.g., mosquitoes and deer flies) that feed on the blood of their vertebrate hosts, including humans and most wild and domestic animals.

**Distribution:**

**Abundant worldwide. Larvae are found in all fresh water, semi-aquatic, and moist terrestrial environments.**

	<b>North America</b>	<b>Worldwide</b>
<b>Number of Families</b>	<b>108</b>	<b>130</b>
<b>Number of Species</b>	<b>16,914</b>	<b>~98,500</b>

**Classification:**

Holometabola  
complete development (egg, larva, pupa, adult)

The Diptera have traditionally been divided into three suborders:

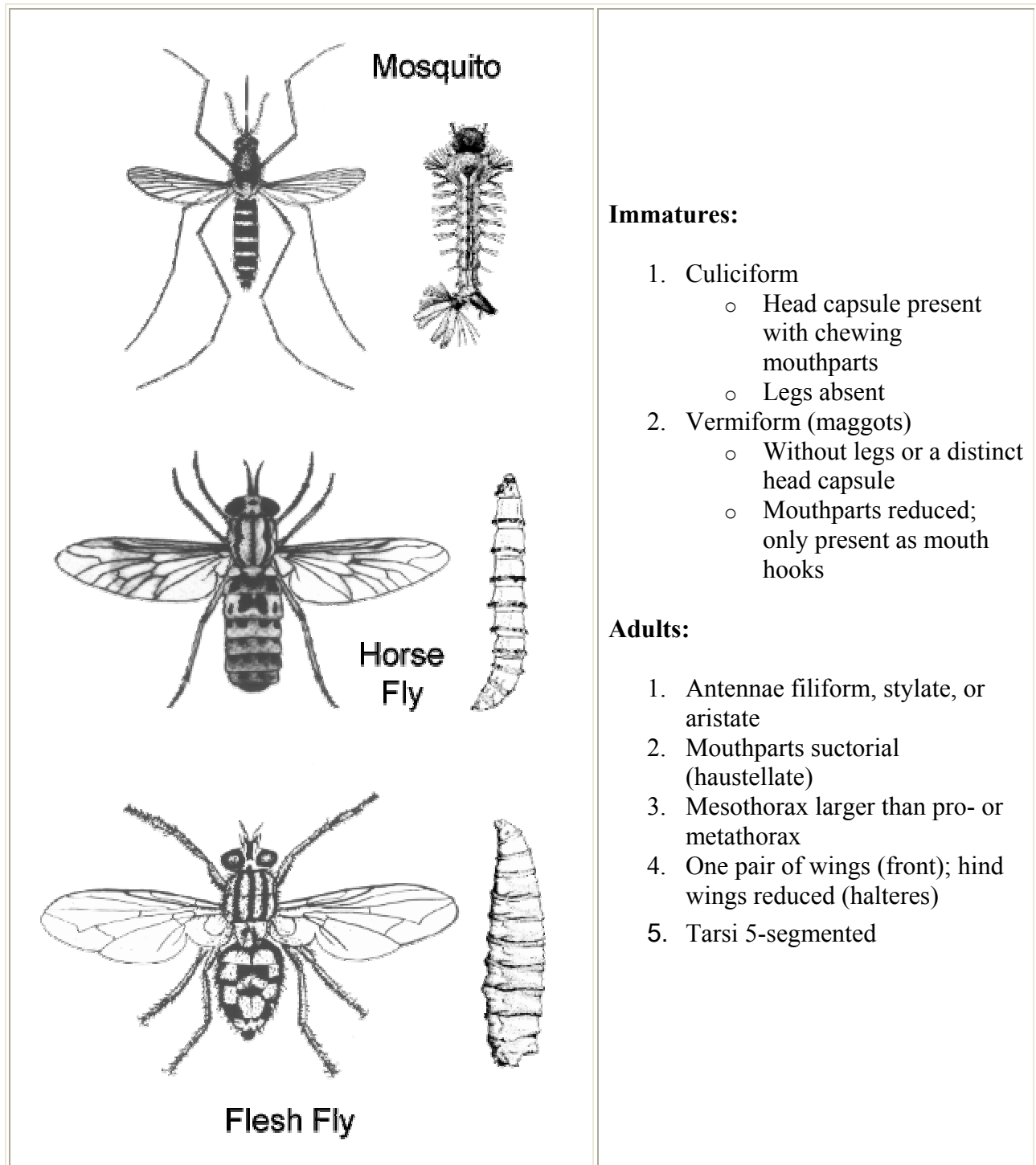
Nematocera (flies with multisegmented antennae)

Brachycera (flies with stylate antennae)

Cyclorrhapha (flies with aristate antennae)

In some newer classifications, Brachycera includes the Cyclorrhapha.

## Physical Features:



### Immatures:

1. Culiciform
  - Head capsule present with chewing mouthparts
  - Legs absent
2. Vermiform (maggots)
  - Without legs or a distinct head capsule
  - Mouthparts reduced; only present as mouth hooks

### Adults:

1. Antennae filiform, stylate, or aristate
2. Mouthparts suctorial (haustellate)
3. Mesothorax larger than pro- or metathorax
4. One pair of wings (front); hind wings reduced (halteres)
5. Tarsi 5-segmented

## Economic Importance:

The Diptera probably have a greater economic impact on humans than any other group of insects. Some flies are pests of agricultural plants, others transmit diseases to humans and domestic animals. On the other hand, many flies are beneficial -- particularly those that pollinate flowering plants, assist in the decomposition of organic matter, or serve as biocontrol agents of insect pests.

## Major Families:

**Biting flies:** In most cases, only the adult females take blood meals.

- **Culicidae** (mosquitoes) -- may spread malaria, encephalitis, yellow fever, filariasis, and other diseases.
- **Tabanidae** (horse flies / deer flies) -- may spread tularemia, loiasis, trypanosomiasis, and other diseases.
- **Simulidae** (black flies) -- may spread human onchocerciasis and leucocytozoon infections of poultry.
- **Psychodidae** (moth flies) -- may spread leishmaniasis, sand fly fever, and other diseases.
- **Ceratopogonidae** (punkies, no-see-ums) -- small but vicious biters that have been linked to the spread of several roundworm, protozoan, and viral pathogens in humans and other animals.
- **Muscidae** (House flies) -- these are among the most cosmopolitan of all insects. Some species have biting mouthparts, others are merely scavengers. Diseases such as dysentery, cholera, and yaws may be transmitted on their feet and mouthparts.

**Herbivores:** larvae feed on plant tissues.

- **Cecidomyiidae** (gall midges) -- some induce the formation of plant galls; others are scavengers, predators, or parasites. This family includes the Hessian fly, *Mayetolia destructor*.
- **Tephritidae** (fruit flies) -- many species are agricultural pests; such as the apple maggot, *Rhagoletis pomonella*.
- **Agromyzidae** -- most larvae are leaf miners, some are stem and seed borers. Several species are agricultural pests.
- **Anthomyiidae** -- many species are root or seed maggots.

**Scavengers:** larvae feed in dung, carrion, garbage, or other organic matter.

- **Drosophilidae** (pomace flies) -- feed on decaying fruit.
- **Tipulidae** (crane flies) -- larvae live in soil or mud.
- **Calliphoridae** (blow flies) -- larvae feed on garbage and carrion; includes the screwworm, *Cochliomyia hominivorax*.
- **Sarcophagidae** (flesh flies) -- larvae typically feed on carrion. Some species may cause human myiasis.

**Predators:** adults and/or larvae attack other insects as prey.

- **Asilidae** (robber flies) -- general predators of other insects.
- **Bombyliidae** (bee flies) -- predatory larvae; adult bee mimics.
- **Empididae** (dance flies) -- adults are predatory.
- **Syrphidae** (flower flies) -- some larvae are aphid predators; most adults mimic bees or wasps.

**Parasites:** larvae are parasites or parasitoids of other animals.

- **Tachinidae** -- parasitoids of other insects. Several species are important biocontrol agents.
- **Sciomyzidae** (marsh flies) -- larvae parasitize slugs and snails.
- **Oestridae** (bot flies / warble flies) -- larvae are endoparasites of mammals, including humans.
- **Hippoboscidae** (louse flies) -- adults are blood-feeding ectoparasites of birds and mammals.

### Fact File:

- Although they have only two wings, flies are among the best aerialists in the insect world - they can hover, fly backwards, turn in place, and even fly upside down to land on a ceiling.
- Flies have the highest wing-beat frequency of any animal. In some tiny midges, it may be as high as 1000 beats per second. Male mosquitoes are attracted by the wing-beat frequency of a virgin female.
- Larvae of some shore flies (family Ephydriidae) live in unusual habitats that would kill other insects. For example, *Ephydra brucei* lives in hot springs and geysers where the water temperature exceeds 112 degrees Fahrenheit; *Helaeomyia petrolei* develop in pools of crude oil; and the brine fly, *Ephydra cinera*, can survive very high concentrations of salt.



- The arista in the antenna of higher flies is an air speed indicator. It allows the insect to sense how fast it is moving.
- As they mature, black fly pupae become inflated with air. Upon emergence, the pupal skin pops open and the adult fly floats to the water surface inside a bubble of air. It never even gets its feet wet!
- The little scuttle fly, *Megaselia scataris* (Phoridae), is truly an omnivore. It has been reared from decaying vegetation, shoe polish, paint emulsions, human cadavers pickled in formalin, and even lung tissue from living people.

### Hot Links and Illustrations:

- [Iowa State's Entomology Image Gallery](#)
- [Flies -- USDA Systematic Entomology Laboratory](#)
- [California State University's Virtual Fly Lab](#)
- [Gordon Ramel's Diptera Page](#)
- [Ecowatch Diptera Page](#)
- [Tree of Life Web Project - Diptera](#)
- [Discover Life - Diptera](#)
- [iStudy Flies](#)

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