CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FACULTY OF FORESTRY AND WOOD SCIENCES

General and Systematic ENTOMOLOGY

doc. Ing. Oto Nakládal, Ph.D.

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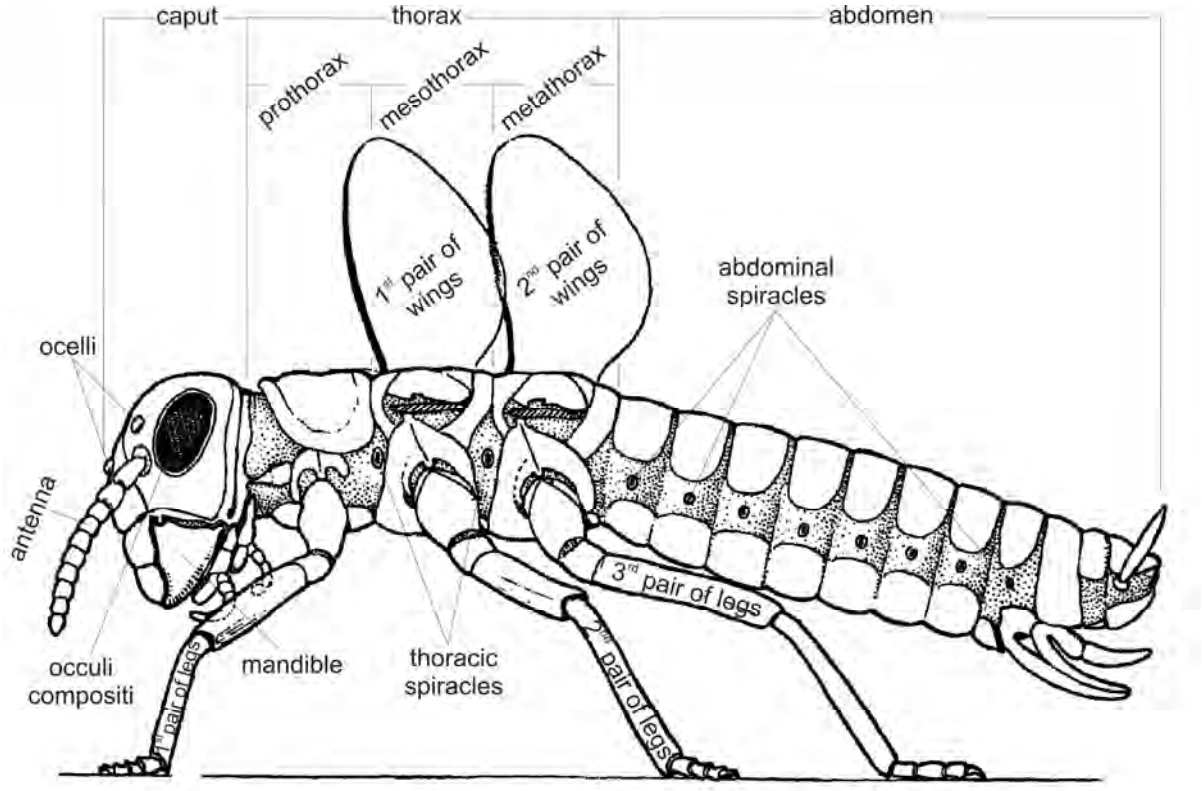
GENERAL ENTOMOLOGY

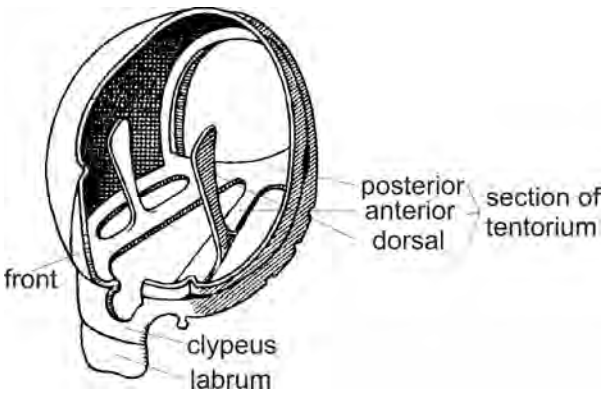
External Insect Morphology

The insect body consists of three basic, more or less well-distinguishable units:

- **head** (caput or cephalon),
- **thorax**, and
- **abdomen**.



Head (caput)

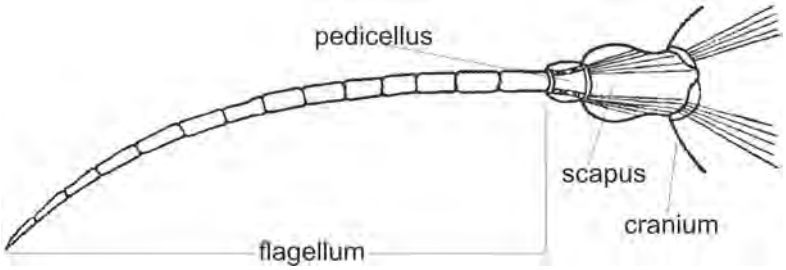


The head is encased in an external **head capsule (cranium)**. The cranium forms its own exoskeleton of the head and is formed by **coalescence of 6 original anterior body segments**. Although more or less distinct sutures may be found on various insect species (and especially their larvae), they no longer conform in any way to the original segmentation

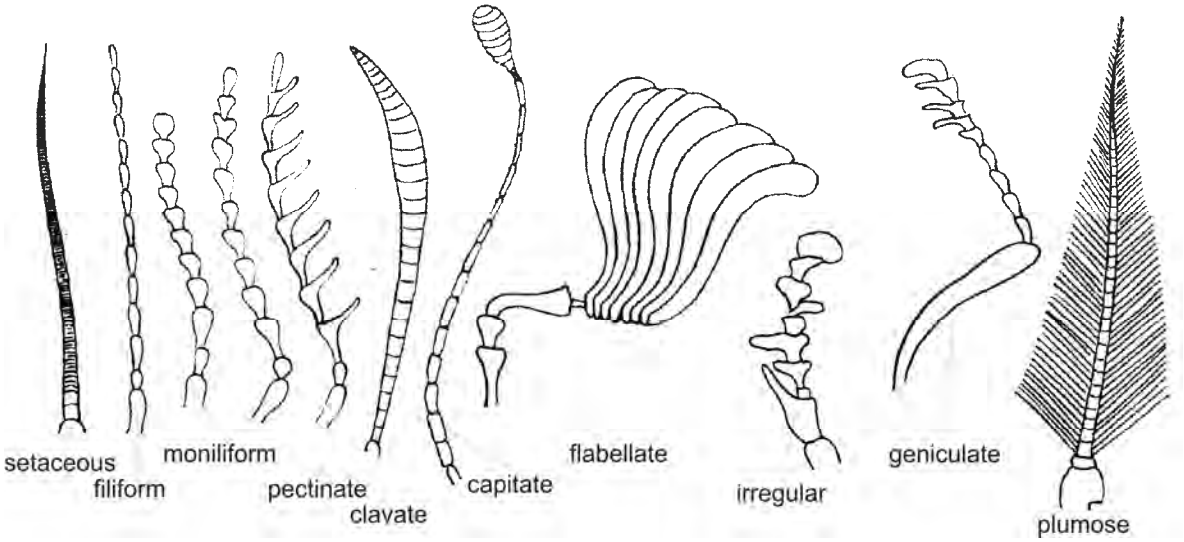
and have evolved secondarily. The cranium is also reinforced inside, however, where the **tentorial bridge** is formed, possibly also with upward-protruding arms. The cranium thus protects the internal organs of the head and provides support to the muscles controlling the individual organs located on the head.

The head bears certain paired and non-paired appendages and organs – specifically, sensory organs and organs for the intake of food.

Antennae



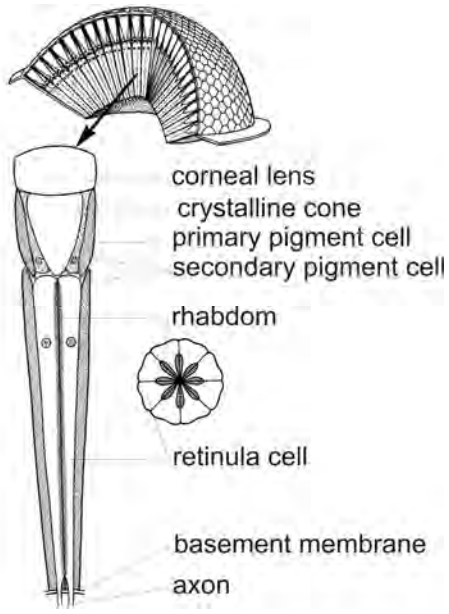
Antennae are paired, segmented, and serve primarily as olfactory organs. They are situated on the front of the head and consist of varying numbers of segments. The scape (**scapus)** is the basal segment of antennae, connected to the head by the antennal socket (fovea antennalis). The scape is controlled by muscles originating from the tentorium and contains the muscles controlling the second antennal segment, the pedicel (**pedicellus)**. The remaining segments do not have their own musculature. Together, they comprise the **flagellum**. Antennae vary greatly in their morphological form (e.g. setaceous, filiform, moniliform, pectinate, clavate, capitate, flabellate, irregular, geniculate, and plumose).



Compound eyes (oculi compositi)

Compound eyes are distinct true organs of sight. These so-called facet eyes are usually composed of a large number of simple eyes (**ommatidia**), each capturing a larger or smaller area, whereby the full image is composed of a mosaic of such captured points. The number of ommatidia varies considerably among various species – from just a few up to 30,000.

Such an eye's sharpness of vision depends primarily on the number of ommatidia, but it is also affected by such other factors as the pigment isolation between individual ommatidia. Significant isolation (in forms active under strong light) provides higher acuity at the expense of the eye's luminosity, and vice versa. A certain adaptation enabling movement of the isolation pigment between the individual ommatidia enables use of the eye both in strong light and in semi-darkness. A more or less "normal" insect eye with approximately 2,500 facets (ommatidia) reaches only ca 1/80 of the sharpness of human sight, although it detects movement up to 10x better.



The eyes are fixed to the surface of the head and are therefore immobile. The movable connection between the head and thorax somewhat compensates for this fact.

Simple eyes (ocelli)

Ocelli are situated at the top of the head, on the crown or forehead. They serve, however, as receptors of light intensity and movement rather than to form a proper image. There tends most frequently to be three of them present (although often they are fewer in number or may even be absent).

Lateral simple eyes (stemmata)

These occur in insect larvae with complete metamorphosis.

Mouthparts and their appendages

Mouthparts evolved from the last three appendages of the head region (giving rise to the mandibles, maxillae and labia) and the labrum (which is the only such part not of appendage origin) from the upper lip.

- **Mandibles (mandibulae)**

Mandibles are paired, never segmented and usually strongly sclerotized. They are connected by one joint, in the case of the primitive Archeognatha (jumping bristletails), and by two joints (**condyles**) in all other orders. The development and shape of the mandibles (including the shape of the internal masticatory areas) is highly varied and reflects to a considerable extent the animal's way of life. It serves for rough processing of food, capturing food, and in males of certain species for fighting over a female. Each mandible is operated by just two (albeit usually massive) muscles that allow only pincer-like movement.

- **Maxillae**

Maxillae are also paired, but segmented and controlled by a much larger number of muscles. Their movement is, as a result, much more varied, as are their functions. Besides processing food, they also serve in sensory evaluation. The basal segment's point of articulation (**cardo**) is connected to the head

and on the opposite end carries the **stipes**, which bear the inner lobate structure (**lacinia**), outer lobate structure (**galea**), and maxillary palp (**palpus maxillaris**).

- **Lower lip (labium)**

The labium is an organ originally fully paired and with segmentation similar to the maxillae. By partial fusing in the basal section, it became an unpaired organ. The basal segment is the **mentum**, which is further divided into the postmentum and praementum. The labial palps (**palpus labialis**), as well as two pairs of lobes – the inner (**glossae**) and outer (**paraglossae**) lobes – are laterally connected to the mentum (more precisely the praementum). In its basal section, the labium crosses into the oral cavity through the lower palate (**hypopharynx)**, where spinning glands can discharge.

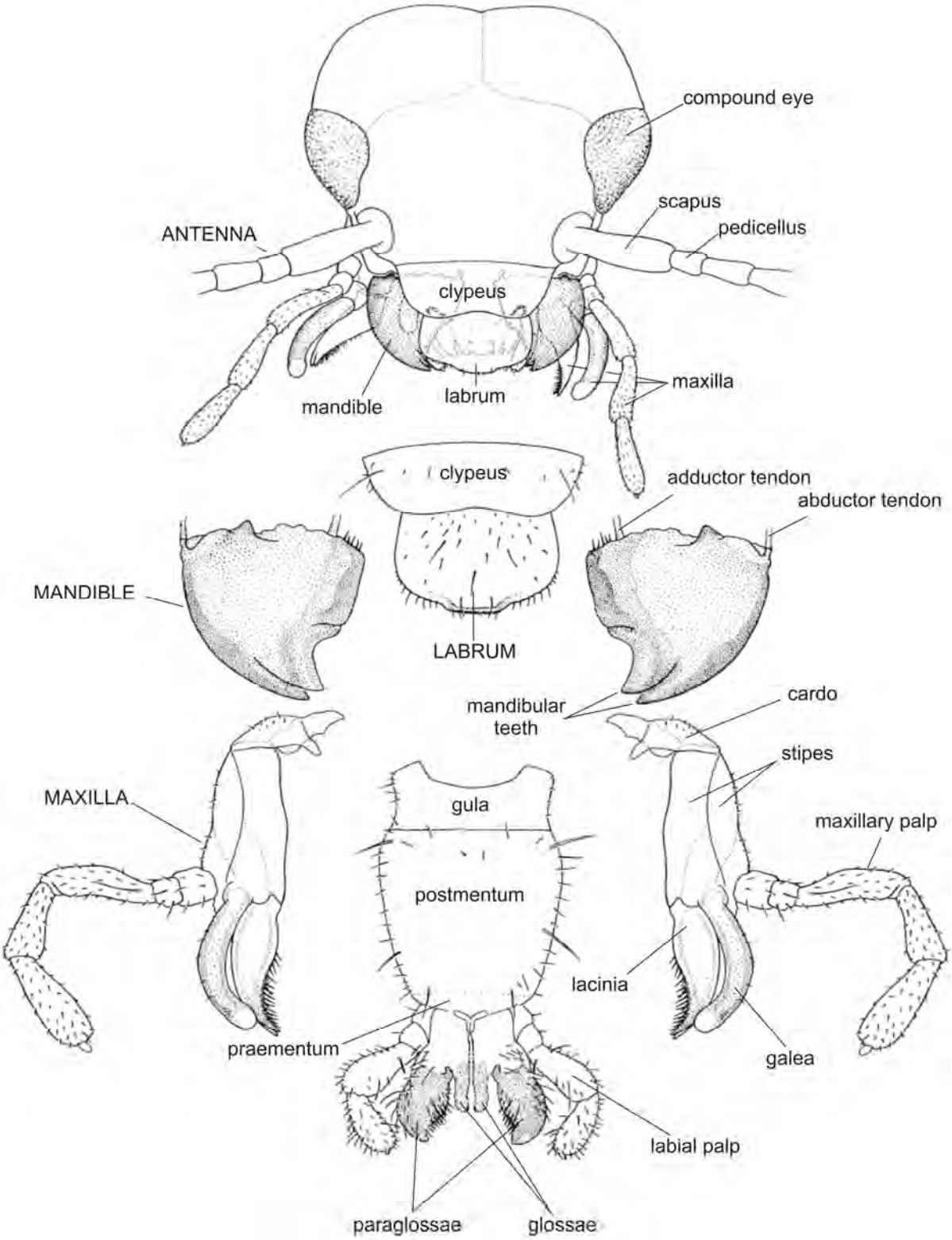
- **Upper lip (labrum)**

The labrum is an unpaired, unsegmented organ and is not of appendage origin. The labra serve for handling food inside the oral cavity, wherein they pass through the soft epithelium of the upper palate (**epipharynx**).

Types of mouthparts

The arrangement and modification of the aforementioned mouthparts are quite varied. These can be divided into several basic groups connected by various transitional forms – chewing-lapping, suctorial feeding, and piercing-sucking mouthparts. This division is only a matter of principle and, therefore, especially in the case of the piercing-sucking mouthparts, different parts can, to various degrees and by various forms, contribute considerably to the composition of the mouthparts.

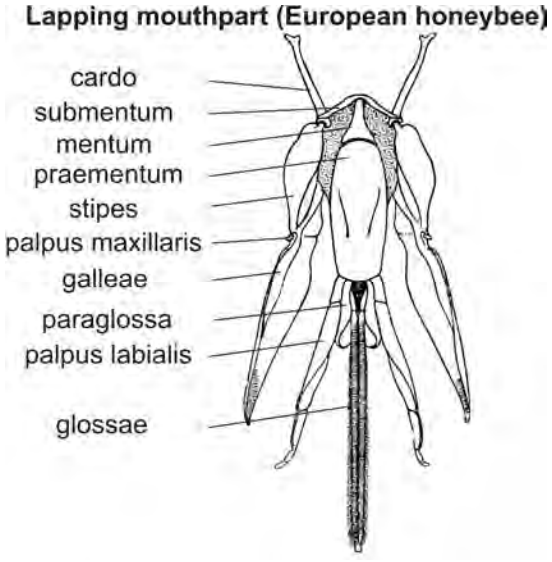
Chewing mouthparts

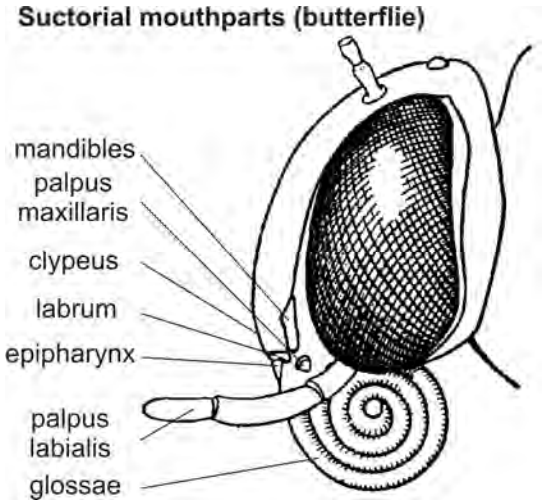


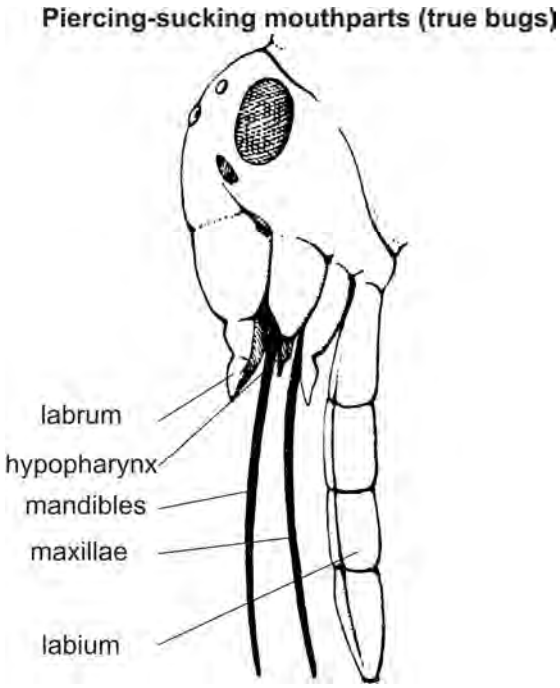
- **Lapping mouthpart**, as encountered for example in bees, is formed by much elongated galeae of maxillae and labium (glossa – extends to the end, paraglossa, labial palp).

- **Suctorial mouthparts** are characterized by a reduction of the mandibles. These are found in the orders Lepidoptera (butterflies), Trichoptera (caddisflies), and part of the order Diptera (true flies).
    - Diptera (true flies) have a proboscis formed for the most part by the labium and labrum.
    - Lepidoptera (butterflies) have a proboscis formed only by maxilla (more precisely their galeae).
    - Trichoptera (caddisflies) have a proboscis formed by the labrum, labium, and maxillae.

- **Piercing-sucking mouthpart** is used for piercing plant or animal tissues. **Stylets** formed by the maxillae and mandibles serve for this function. Channels for inflow of saliva to the wound and channels for separate intake of liquid food are formed from the remaining mouthparts. The relative sizes of the individual mouthparts to this organ vary considerably – differing, for example, in the order Hemiptera, in mosquitoes (Diptera: Culicidae), in certain families of sucking lice, and in the order Thysanoptera (thrips). An interesting type of the piercing-sucking mouthpart can be found in larvae of Dytiscidae (a predaceous diving beetle), which is formed by hollow mandibles by which digestive enzymes are dispatched into the prey and then sucked back into the oral cavity. No true orifice is developed here.





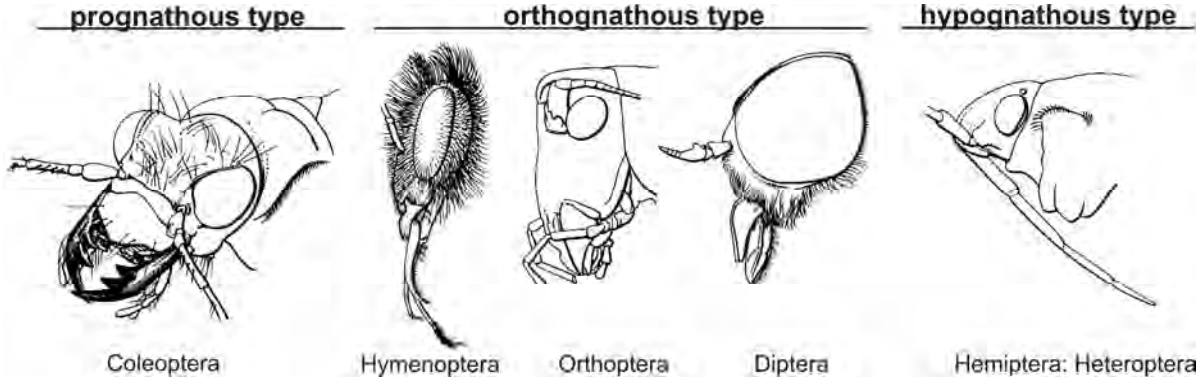


Types of head positions in relation to the thorax

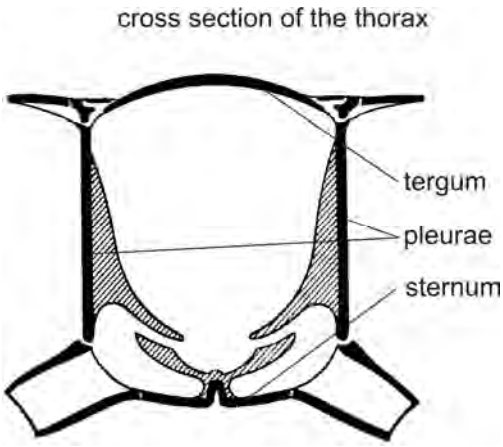
According to the position of the oral orifice and depending upon the position of the head in relation to the thorax (more precisely to the longitudinal body axis), one can generally differentiate 3 basic types of head position:

- **prognathous** – head with the mouthpart directed forward in the direction of the body axis (e.g. Dermaptera [earwigs], Raphidioptera [snakeflies], and others);

- **orthognathous** – head with the mouthpart directed perpendicularly to the body axis e.g. Orthoptera and others); and
- **hypognathous** – head with the mouthparts directed under the body in the direction of the body axis (e.g. Blattodea [cockroaches], certain Heteroptera [typical bugs], and others).



Thorax

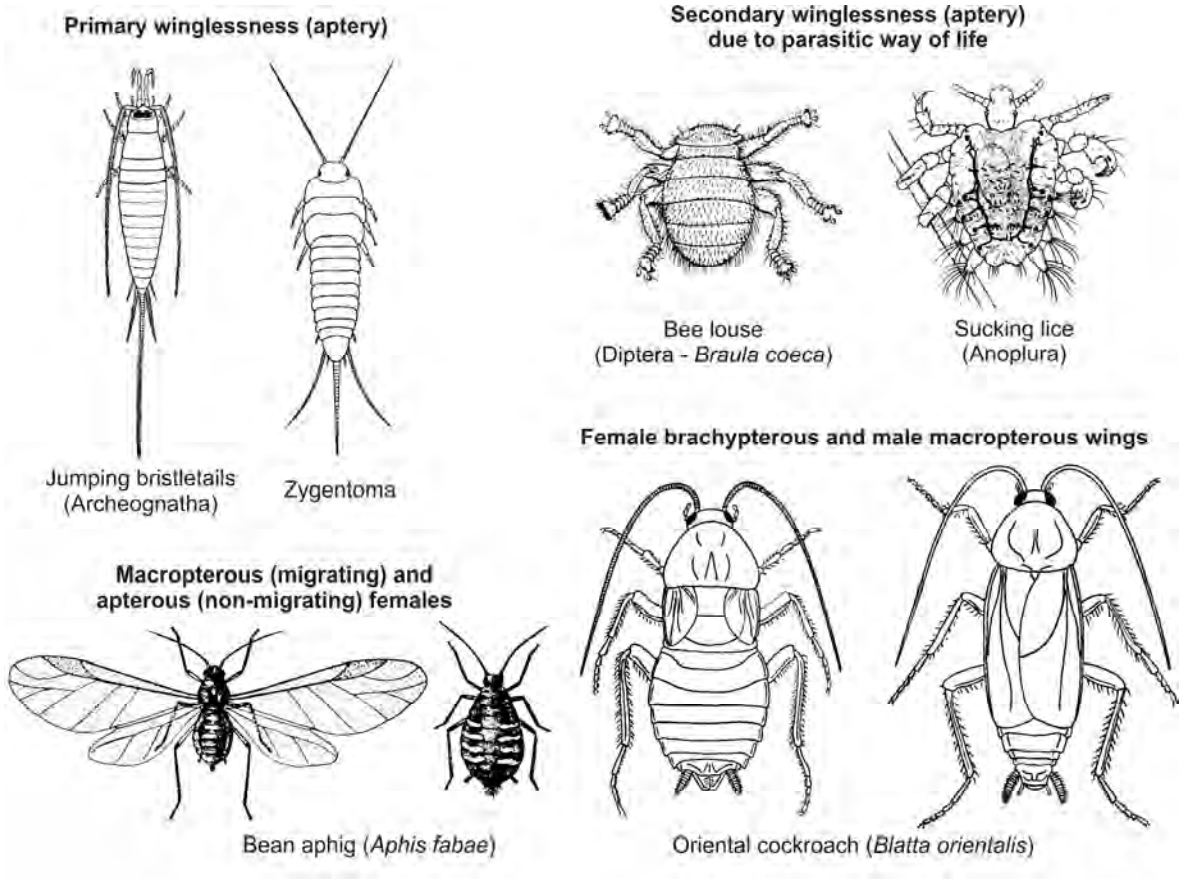


The thorax is composed of three, usually externally quite distinctly separated segments: the **prothorax**, **mesothorax**, and **metathorax**. In adults, each of the three segments has 1 pair of legs. The mesothorax and metathorax may also have 1 pair of wings. Dorsoventrally, it is possible to distinguish on the thorax the **tergum** (dorsal sclerite), **pleurae** (2 lateral sclerites), and **sternum** (ventral sclerite).

Wings (alae)

Only Archeognatha (jumping bristletails) and Zygentoma are primarily wingless. Other orders (subclass Pterygota [winged insects]) are primarily winged. If winglessness occurs here, it is only secondary (e.g. Siphonaptera [fleas]). In secondarily wingless groups one often sees that their closest relatives nevertheless have developed wings to various degrees.

Aptery (the state of being entirely without wings) can occur in only one sex (such as scale insects [Hemiptera: Coccoidea]), in one part of a generation cycle (e.g. aphids [Hemiptera: Aphidoidea]), or it can be a permanent result of adaptation to a parasitic way of life (order Strepsiptera [twisted-wing parasites]) or other environmental conditions. Only certain individuals may have wings (Hymenoptera: Formicidae [ants], Isoptera [termites]) and only for a certain time (usually related to reproduction). Females of certain geometer moths (Lepidoptera: Geometridae) and many beetles (Coleoptera) and cockroaches (Blattodea) are so-called **brachypterous**, which means that the wings are visible but strongly reduced and not enabling flight. The majority of insects, however, are macropterous, which means that they have fully developed wings enabling active flight (most butterflies [Lepidoptera] and Hymenoptera).



In relation to the development of wings and the massive musculature that controls them, the corresponding thoracic segments are developed with varying strength.

Most common in insects is the case where both posterior thoracic segments carry 1 pair of wings each. In various orders and also lower taxonomic units, however, only 1 pair of wings may be developed, while the other pair is strongly reduced and transformed for other purposes (or only transformed).

In insects, one may encounter the following wing modifications:

- Diptera (true flies) have a second pair of wings transformed into so-called **halteres**, which are used as stabilizing organs during flight.
- Strepsiptera (twisted-wing parasites) have males in which the opposite occurs – the forewings are transformed into analogous halteres, but they do not have a stabilizing function.
- Coleoptera (beetles) have forewings transformed into **elytra**.
- Heteroptera (typical bugs) have only partially sclerotized forewings (only in the basal section) and form characteristic **hemelytra**.
- Dermaptera (earwigs), Orthoptera, Mantodea (mantises), and Blattodea (cockroaches) have more or less sclerotized forewings, with only varying degrees of the same process of hardening of those forewings, which are called **tegmina**.
- Hymenoptera, Mecoptera, and many other orders have both or just one pair (Diptera [forewings], Strepsiptera [hind wings]) of wings in a typical membranous state.

In a number of orders, both pairs operate concurrently, increasing flight capability. Synchronous functionality is ensured by a connection between the front edge of the hind wing with the back edge

of the forewing (e.g. Lepidoptera [butterflies], Hymenoptera, Aphidoidea [aphids]). In other orders, the two pairs move independently (Odonata: Zygoptera).

The frequency of wing flapping also affects flight capacities. In some groups, individual wing flaps are very slow and easily recorded by sight (certain Lepidoptera [butterflies]). In others, a wing can go through approximately 1,000 flaps per second (certain Hymenoptera or Diptera [true flies]).

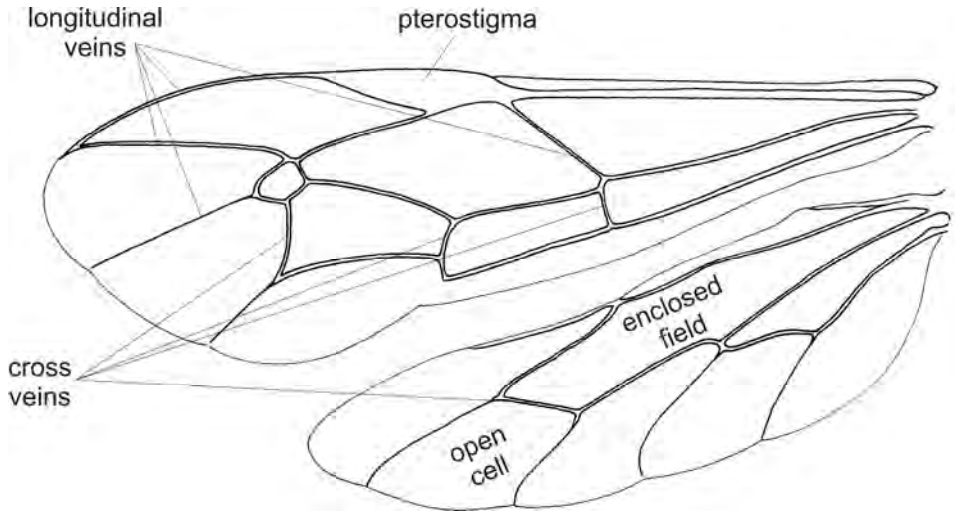
Wings evolved as epidermal diverticula and are therefore two-layered. They are reinforced by venation, which is of tracheal origin. Venation is very characteristic for individual groups of insects from the higher taxonomic units, often even in individual species.

Wing venation is quite complex and the individual veins bear their own markings. In principle, there are two types of veins:

- **longitudinal veins** (costa, subcosta, radius, media, cubitus, anal, and jugal), and
- **cross-veins** (humeral, radial, sectoral, radiomedial, medial, mediocubital).

Cross-veins and longitudinal veins separate individual fields, which are designated according to the longitudinal vein behind which they are situated and according to order (e.g. medium radial field, basal cubital field). The fields may be:

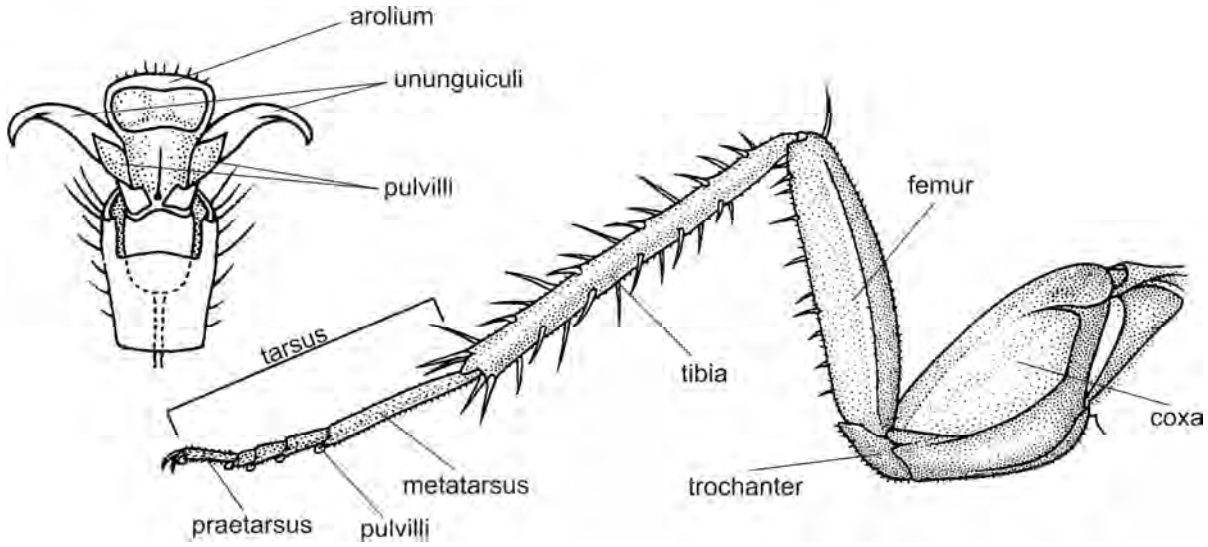
- **open**, or
- **closed.**



This basic scheme can be considerably modified by multiplication, or mostly by reduction of the original venation. A distinct reduction of wing venation is recorded in a number of families of small species of Hymenoptera, such as chalcid wasps (Chalcidoidea), and many beetles (Coleoptera), such as feather-winged beetles (Ptiliidae).

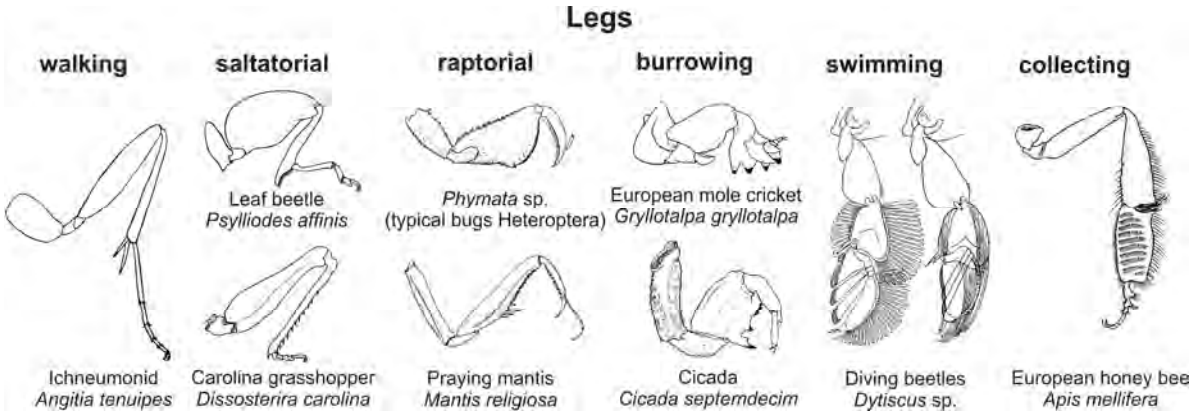
Legs

The leg is typically composed of the **coxa**, **trochanter** (which may have an appendage), **femur**, **tibia**, and segmented **tarsus**. The number of tarsal segments varies, ranging from 1 to 5. The first tarsal segment extending to the tibia is called the **metatarsus** and the distal one the **praetarsus**. The tarsal segments may bear variously formed structures increasing the adhesion of the tarsus (e.g. **pulvilli**). The distal segment has 1–2 ungues (**unguiculi**) at the end, and possibly an **arolium**.

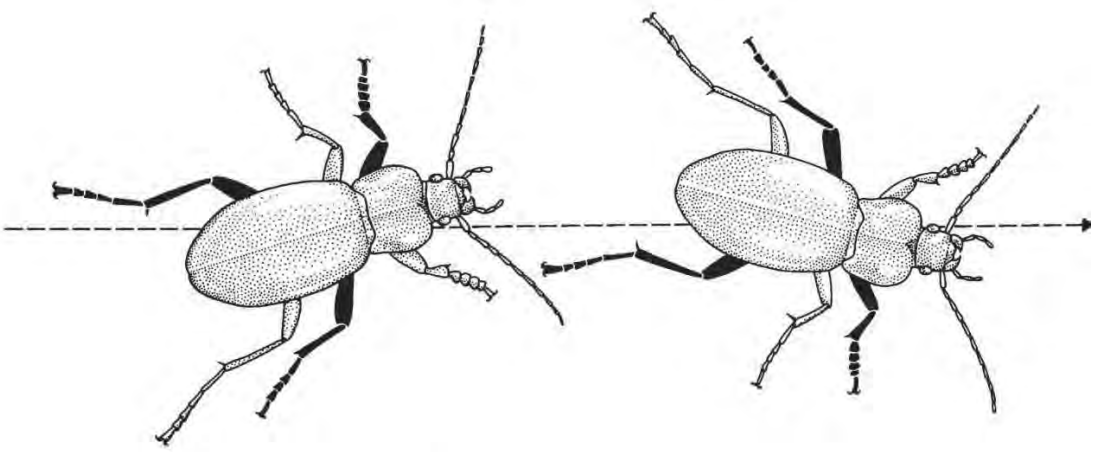


Even though the basic leg structure is the same for all insects, it is modified in various ways for the most diverse functions, depending on the way of life and the environment in which the insect lives. One can distinguish the following basic leg types:

- gressorial (cursorial),
- saltatorial (particularly pronounced in hind legs),
- raptorial (usually forelegs),
- fossorial,
- natatorial,
- pollen-carrying, and others.



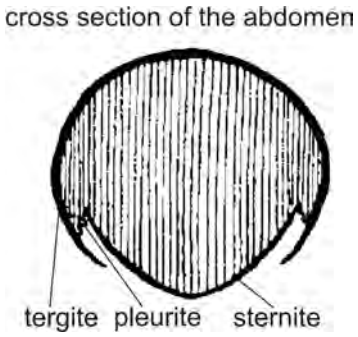
During body movement, the first leg of the middle pair on one side and the fore and hind leg on the opposite side work simultaneously.



Abdomen

The abdomen originally has **11 segments**. The original ordering is found only very rarely, as at least the end segments tend to be significantly reduced. The number of segments in different groups thus varies considerably.

Each abdominal segment is comprised of a system of three sclerites:



- dorsal sclerite **(tergum)**, which is in most cases strongly sclerotized, as it forms the abdomen's exoskeleton (terga are relatively weakly sclerotized in beetles [Coleoptera], as the abdomen is protected by elytra);
- ventral sclerite **(sternum)**, which is sclerotized similarly to the tergum; and
- lateral sclerites **(pleurites)**, which are membranous, connecting the sternum and the tergum and enabling their mutual mobility, thus allowing the abdomen to change in volume (e.g. for respiratory movement, food intake, or in females the increase in volume during the period of egg maturation).

The abdomen may carry various appendages, mostly of limb origin. The hind segments, due to their participating in the creation of the ovipositor and the male copulation apparatus, are often drawn inside and strongly transformed. The end of the abdomen often carries variously developed appendages, known as styli (cerci).

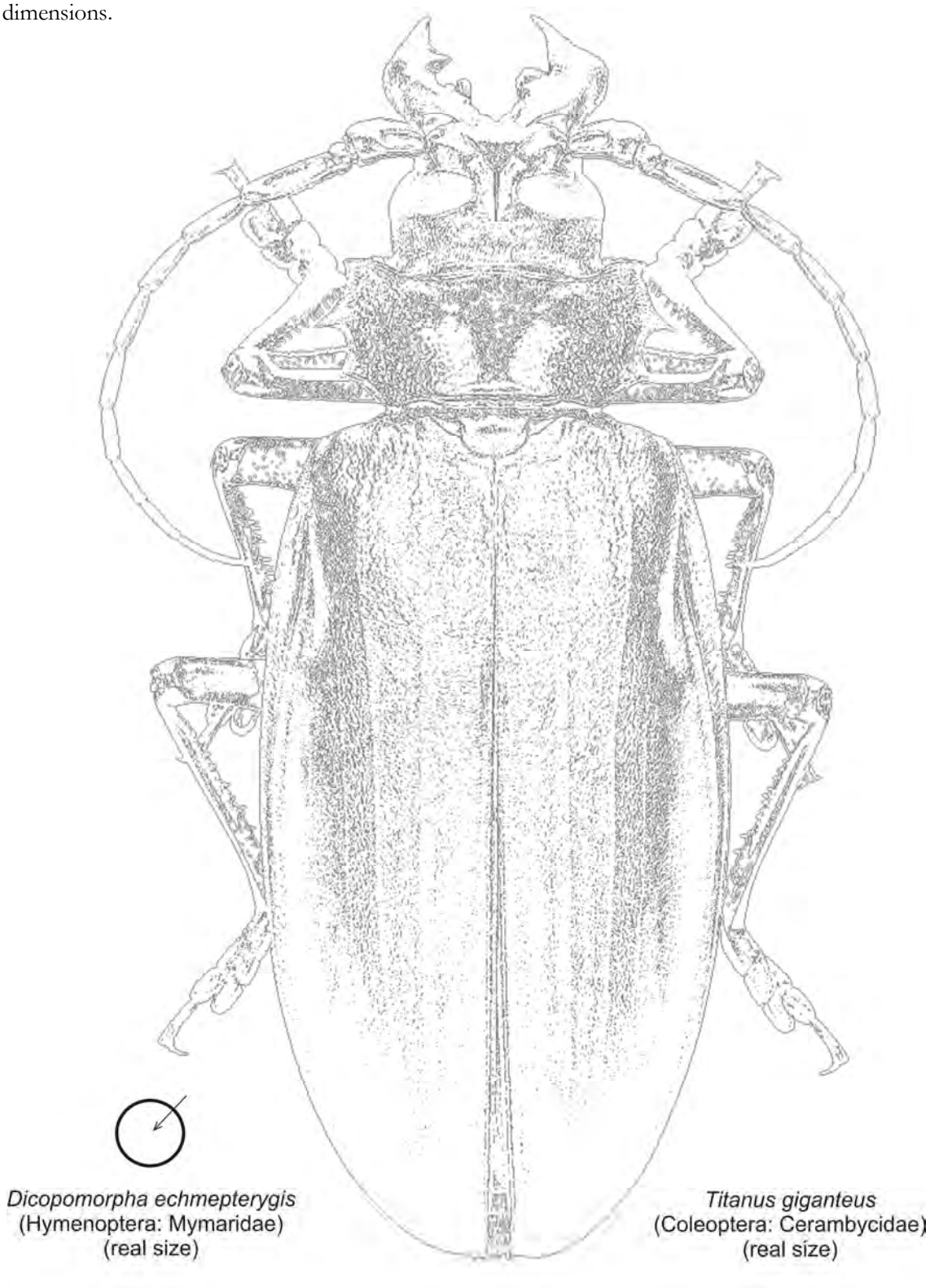
Insect size

Taking insects as a group and considering the sizes of individual species, it is clear that the differences are immense.

The smallest insect species known to date is *Dicopomorpha echmepterygis* (Hymenoptera: Mymaridae). The body length of this Central American wasp comes to **only about 0.139 mm**, which means it is smaller than some single-cell organisms (such as *Paramecia*). A body size of around 0.3–0.5 mm is encountered quite frequently in certain beetles (Ptiliidae [feather-winged beetles]) and the tiny parasitic wasps from the family Trichogrammatidae.

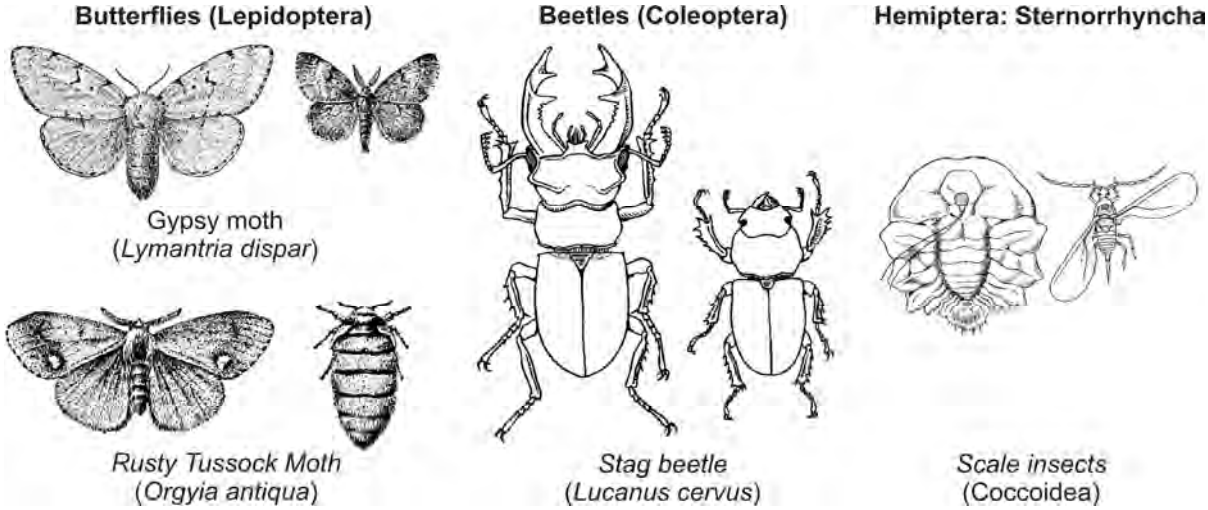
On the other hand, for example, the robust South American longhorn beetle *Titanus giganteus* reaches a maximum body length of around 20 cm. The slender Phasmida have **body lengths up to 30 cm**. The tropical moth *Thysania agrippina* has a **wing span of up to 30 cm**.

Apart from these recent species, one may recall certain fossil species (e.g. the predecessors of today's dragonfly) that reached body lengths of up to 30 cm and wing spans of around 75 cm. The exoskeleton, which is an ideal support organ up to a certain size, probably reaches its natural limits at these dimensions.



Sexual dimorphism

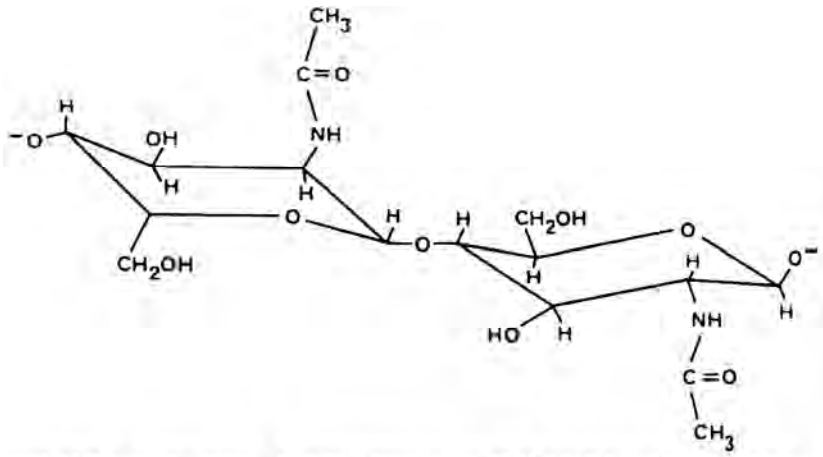
Sexual dimorphism is a phenomenon wherein females and males differ more or less by their morphologies and coloration. Sexual dimorphism is not developed to the same degree in all groups. While in certain groups one is unable to distinguish males from females without studying the anatomy of the reproductive organs, in other groups one is not able to classify the two sexes as the same species without studying their biology. Sexual dimorphism ensues from the ways of life of the two sexes. In species where the males fight over the females, the males tend to be significantly larger than are the females (e.g. the stag beetle *Lucanus cervus*). Considerable differences between males and females are found that correspond to differing requirements for movement. Males usually search for less mobile females, which is related to a reduction of the wings in females (certain cockroaches, certain butterflies) or even a reduction of most bodily appendages (e.g. scale insects, some twisted-wing parasites). Sexual dimorphism is more or less observable in most insects.



Internal Insect Anatomy

Exoskeleton

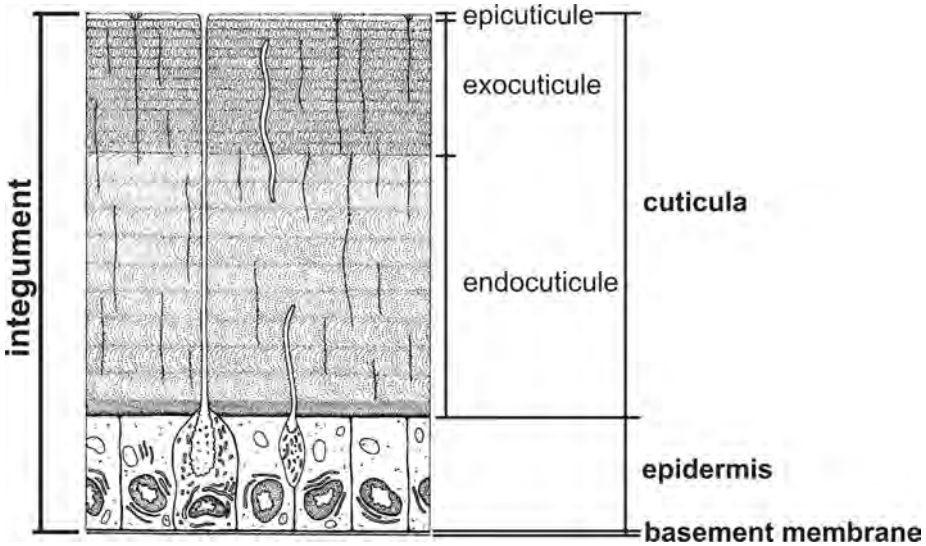
The body covering consists of **integument**. The external surface of the insect body consists of a complex compound of chitin and protein, called **sclerotin**. This substance, very close to cellulose, also consists of a long chain-like molecule. It is strong, resilient, elastic, does not puncture easily, and is resistant to abrasion. In addition, a thin surface film of a wax-like substance on the surface ensures a certain degree of water resistance and impenetrability.



part of the chitin chain two building units of N-acetyl-D-glucosamine

Integument essentially consists of 3 layers:

- basement membrane (**membrana basalis**) separating the exoskeleton from the internal body upon which lies the basement membrane,
- a layer of epidermal cells (**epidermis**), consisting of only a single layer of live cells and which produces above it the
- cuticle (**cuticula**), which is again layered and consists of the
    - endocuticle (**endocuticula**) – thicker internal layer containing chitin,
    - exocuticle (**exocuticula**) – thinner middle layer containing chitin, and
    - epicuticle (**epicuticula**) – thin surface layer not containing chitin.



The exoskeleton provides excellent support, protection, and even mobility (thanks to a system of various articular joints) to a body with no other internal support system.

In general, the body covering is only rarely seamless and smooth. As a rule, it has a highly variable structure and various protuberances upon it, while fine hairs, sensory cilia, and the like pass through it. The scales of, for example, butterflies, silverfish, and other groups of insects are of identical origin.

Insect coloration

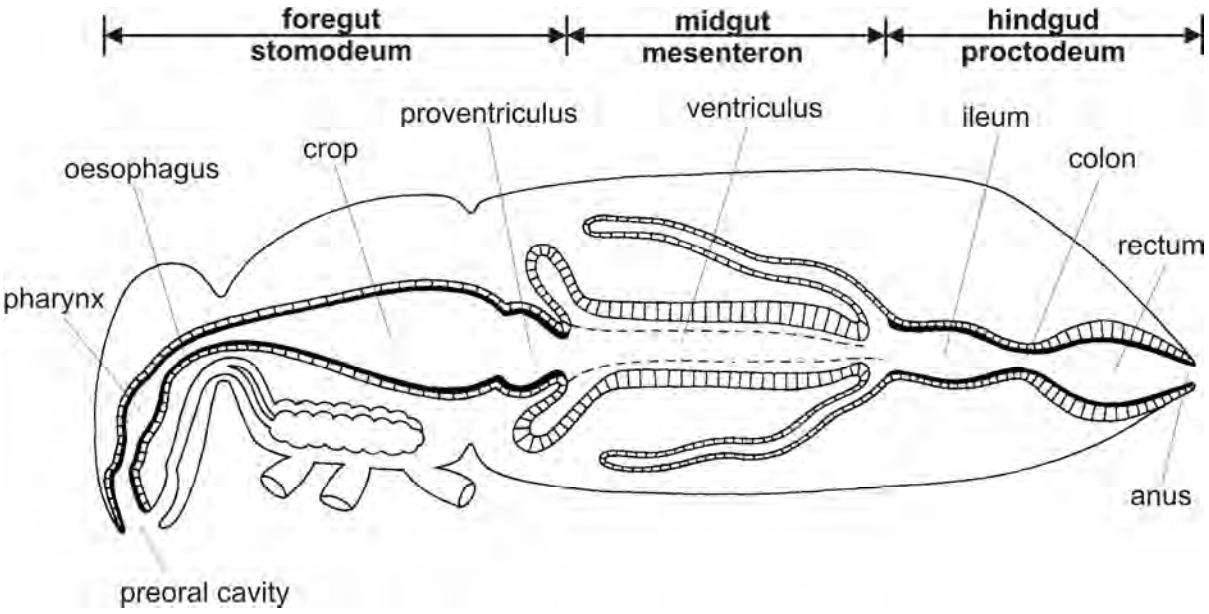
Coloration of the insect body can be produced by a combination of 3 different means:

- Coloration is created by **pigment cells stored in the cuticle.** These pigments are mostly of melanin by nature and thus create yellow, brown, red, and black coloration.
- Coloration is produced by **refraction, reflection, and interference of light beams** in the fine layers of cuticle separated by a microlayer of air (these are so-called structural colours, which include various shades of metallic reds, blues, bronze, and golden colours.
- Or coloration is simply caused by body content showing through the skin.

Digestive system

The digestive tract leads from the oral cavity to the anus. It is essentially divided into three sections:

- foregut (**stomodeum**),
- midgut (**mesenteron**), and
- hindgut (**proctodeum**).



Foregut

The foregut (stomodeum) starts with the oral cavity and continues through the intensely muscular pharynx and usually a relatively long oesophagus that continues into the so-called crop (ingluvies). Between the crop and the midgut, many species have a special segment – the gizzard or chewing stomach (proventriculus) having rigid teeth and plates and which serves for further grinding of food.

Midgut

The midgut (mesenteron) is a separate part of the digestive system and is called the glandular stomach. Enzymes are secreted here and nutrients are absorbed into the haemolymph.

The so-called **Malpighian tubules**, which comprise the insect's separate excretory organ, are attached at the crossing of the midgut to the hindgut. In the Malpighian tubules, unused nitrogenous compounds emerging from the decomposition of proteins are absorbed from the haemolymph and transferred to the hindgut, where they mix with faeces.

Hindgut

The hindgut (proctodeum) consists of the

- small intestine (**ileum**),
- large intestine (**colon**),
- **rectum**, and
- **anus**.

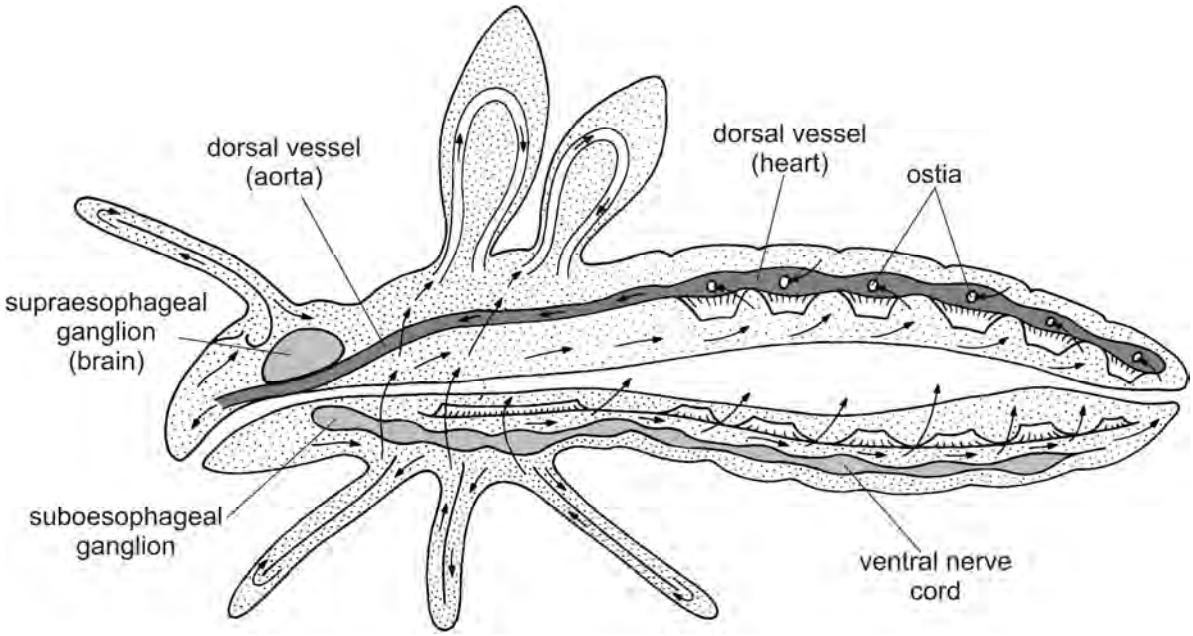
The rectal sac and rectum serve primarily for resorption, preventing excessive water loss. Points of high resorption ability are called rectal papillae. The largest part of the digestive system lies in the abdominal segments.

Circulatory system

Insects have a single blood fluid known as **haemolymph**. It moves through the circulatory system, which is open and located at the dorsal (upper) side of the body, above the digestive tract. It consists of

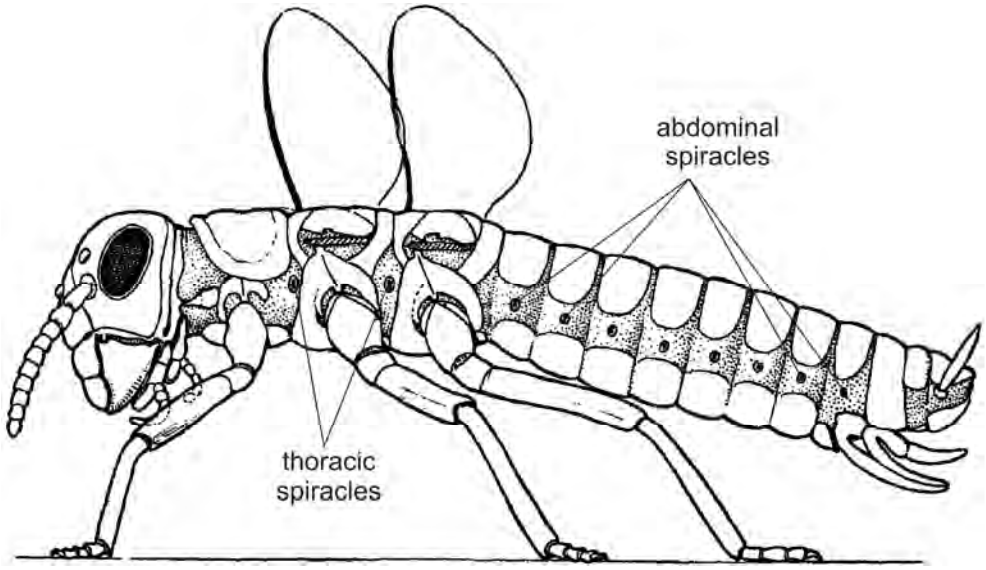
- a **tubular heart** in the abdomen. It narrows at each segment, and along the sides there are a number of apertures (ostia) that open inwards by means of valves. The heart is equipped with a powerful muscle that effects suction and extrusion of the haemolymph into the
- **aorta,** which proceeds through the thorax and runs by an open section into the cranial space (head capsule).

Here it flows out into the body cavity, washes the individual organs, and returns back to the abdomen, where it is sucked in again. **The haemolymph provides transport only of nutrients, hormones, and metabolic by-products. The transmission of O_2 and CO_2 occurs by means of a specialized respiratory system, the so-called tracheal system.** The haemolymph of an insect thus does not contain red blood cells, and it has a yellowish, greenish, or reddish colour. Of course, it contains a number of blood cells with similar functions (e.g. analogous to leucocytes) as in other animals.



Respiratory system

The respiratory system is externally open (only closed in some cases, such as in the case of larvae developing in the water) by air holes, so-called spiracles (**spiraculum stigma**). Originally, spiracles were located on the mesothorax, metathorax, and the first 8 segments of the abdomen. In a number of species, however, various numbers of spiracles are encountered as a result of some spiracles' disappearance. The respiratory system provides a direct supply of oxygen to the place of its consumption and the subsequent removal of carbon dioxide.

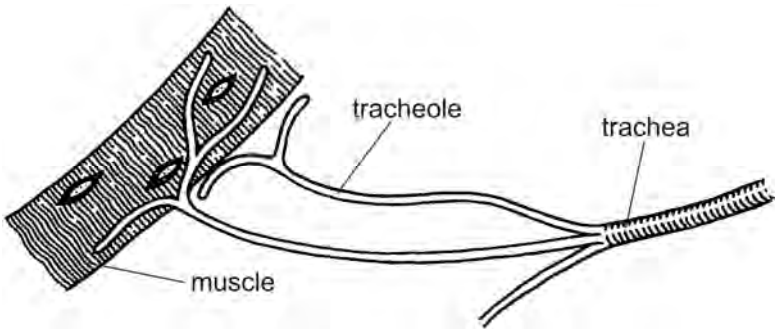


Spiracles are equipped with various mechanisms for preventing the entry of dust and foreign bodies into the respiratory system. Among larvae living in water and internal parasites, the spiracles are closed externally and breathing occurs directly through the epidermis, which can be extended for this purpose in the form of e.g. tracheal gills and papillae (dragonfly larvae [rectal gills]).

The widest tubes (tracheal trunks) extend to the spiracles. **Tracheal trunks** gradually branch off into **tracheal branches (trachea)** and then those into tracheal capillaries (**tracheoles**). The smallest capillaries of this system reach diameters of ca 1/1000 mm and even less. The tracheal trunks and branches are reinforced against internal pressure by a chitinous spiral, the so-called **intima**. The system of trachea and tracheoles permeates all organs of the entire body and provides direct exchange of gases.

Among good flyers, the tracheae are often extended, forming so-called air sacs that decrease the weight of the animal and increase the amount of available air.

In contrast to vertebrates, where inspiration is active and expiration passive, for insects the relationships are reversed (i.e. inspiration is passive and expiration active). Active expiration is provided by contractions of the entire elastic abdomen.



Fat body

The fat body (corpus adiposum) serves as energy storage. Extremely well-developed fat bodies can be encountered in insect larvae (serving for their further development) and adult females (for the development of eggs). Oval clusters of fat cells are usually whitish and are primarily stored in the abdomen.

Nervous system

The nervous system consists of

- **the central nervous system**,
- **peripheral nervous system**, and
- **sympathetic nervous system**.

Central nervous system

The central nervous system starts in the head, where the two largest ganglia by far are situated.

- The **supraesophageal ganglion** is also called the brain (cerebrum) and constitutes the centre for such higher nerve activities as coordination and memory. The supraesophageal ganglion innervates the antennae and sight organs. Two nerve branches run out of the supraesophageal ganglion, surrounding the oesophagus and joining the
- **subesophageal ganglion**. This is markedly smaller and innervates the mouthparts.

From the subesophageal ganglion, the central nervous system proceeds along the ventral side of the body beneath the digestive tract in the form of a **nerve cord**. This originally contained a pair of ganglia in each thoracic and the first 8 abdominal segments, connected by longitudinal connectives and in each segment transversely by commissures. This primitive state is, however, a very rare phenomenon. Usually, both ganglia in a pair (in one body segment) have wholly merged and reduced from behind to form stronger centres in the previous segments.

Peripheral nervous system

The peripheral nervous system conveys nerve impulses to the central nervous system from sensory cells lying just below the epidermis.

Sympathetic nervous system

The sympathetic nervous system ensures coordination of the internal organs.

Endocrine glands

Numerous endocrine glands can be found in insect bodies. During insect development, an important role is played by the following:

- **Prothoracic glands** are located in the prothorax of larvae (they are defunct in adults, with the exception of Apterygota) and produce the hormone **ecdysone**, which directly affects epidermal cells, where it activates upon chromosomes the genes responsible for starting and controlling ecdysis (moulting).
- Corpora cardiaca (**cardiac bodies**) are located behind the brain above the oesophagus and secrete neurohormones produced by neurosecretory cells of the brain into the haemolymph.
- Corpora allata are located behind the brain above the oesophagus and behind the corpora cardiaca and produce the **juvenile hormone neotenin**.

Each moulting and the subsequent pupation are controlled by a hormonal process. The entire process is directed from the brain, where it registers reaching a certain critical body size, which is essential for the start of the entire process. As soon as the critical size is reached, moulting begins with a drop in the level of juvenile hormone (in the last larval instar, the juvenile hormone is completely absent when starting metamorphosis) and production of the prothoracicotropic hormone from the brain's neurosecretory cells. The prothoracicotropic hormone affects the prothoracic glands and stimulates them to produce ecdysone (the moulting hormone proper). The moulting process is then controlled by 4

hormones, the last of which is bursicon. **Bursicon** is produced by abdominal ganglia and its function is to increase plasticity of the cuticle and initiation of its hardening and darkening. The production of bursicon ends with the discarding of the **exuviae**.

Muscles

There are two types of muscles in the insect body:

- **Skeletal muscles** ensure movement of the skeleton, maintaining of body position, and all types of locomotion. Both ends of the muscle are connected to integument.
- **Visceral muscles** allow movement of the internal organs. Visceral muscles connect to the body wall via a single insertion or connect to another muscle at both ends.

Both types of muscles are striated.

Reproductive system

Reproductive organs occur as paired organs. They consist of internal organs that deal with production of the germ cells and external organs that serve for joining the two individuals, transmission of sperm, and, in the case of females, also laying of eggs.

The composition of the internal reproductive organs is essentially similar in both males and females:

Males (♂♂)	➔	**Females (♀♀)**
paired testes	➔	paired ovaries (ovaria)
paired vas deferens (vasa deferentia)	➔	paired oviducts (oviductus lateralis)
seminal vesicles (vesiculae seminales)	➔	egg capsules (not necessarily present)
unpaired ejaculatory duct (ductus ejaculatorius)	➔	unpaired oviducts (oviductus communis) and vagina
accessory glands of mesodermal origin	➔	not developed
accessory glands of ectodermal origin	➔	accessory glands of ectodermal origin
no equivalent	➔	copulation chamber (bursa copulatrix) and spermatheca (spermatheca = receptaculum seminis)
external genitalia (aedeagus and related structures; not necessarily present)	➔	ovipositor (not necessarily present)

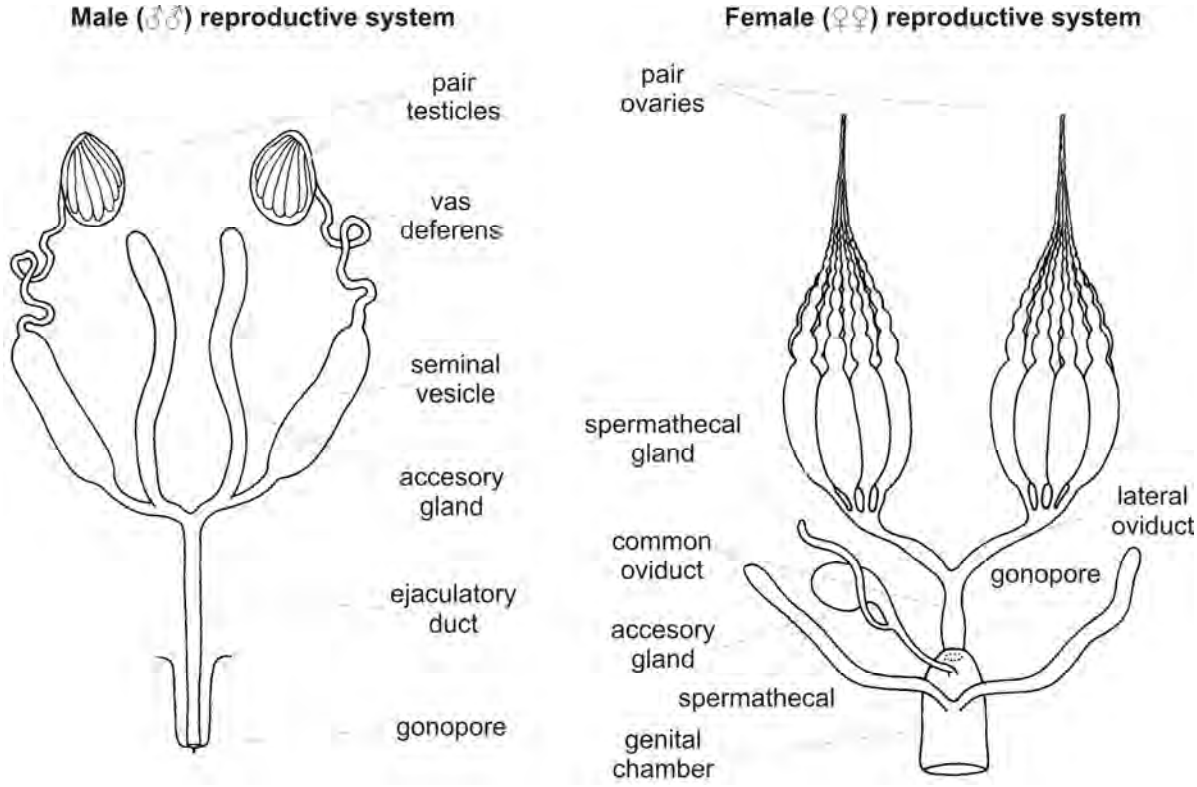
Male (♂♂) reproductive system

Sperm is formed in the **testes**. The testes are connected to the paired **vasa deferentia**, which lead the sperm into the **seminal vesicles** (vesiculae seminales) that are in fact enlargements of the vasa deferentia in which the sperm is gathered. In males, **accessory glands** (of mesodermal origin) are formed as a growth of the vasa deferentia. These accessory glands excrete a secretion that mixes with the sperm. The secretion then hardens on the surface and forms a sperm capsule (the **spermatophore**). The two vasa deferentia join the collective **ejaculatory duct** (ductus ejaculatorius) and then lead into the **genital opening** (gonoporus), which is connected to the external male genitalia.

The external male copulation organ itself is called the **aedeagus**. This is composed of the central part called the **penis** and paired **parameres**.

Female (♀♀) reproductive system

Paired **ovaries (ovaria)** are used for producing eggs. These then proceed to the **paired oviducts** (oviductus lateralis), which converge into the common **unpaired oviduct** (oviductus communis). This leads through the **genital pore** (gonoporus) into the **copulation** or genital **chamber** (bursa copulatrix). Its external opening is called the **vulva**. In many insects, the vulva is narrow and the copulation chamber is thus transformed into a closed tubular sack called the **vagina**. Two glands of ectodermal origin open into the copulation chamber (glands of mesodermal origin are not developed in females). The first is the **spermatheca with the spermathecal gland**. The purpose of this apparatus is to preserve live sperm until they are used for fertilizing the eggs. The second type is the **accessory gland**, which has diverse functions in various groups of insects. It can be used for attaching the egg to the substrate, and in certain groups even for the formation of egg casings (so-called **oothecae**).



The openings of the reproductive organs are situated below the anus – in males usually behind the 9th segment and in females in front of and behind the 8th or behind the 9th abdominal segment. The opening of the reproductive system is only rarely paired (e.g. in mayflies, male earwigs of the *Labidura* genus, and certain Apterygota).

Insect Reproduction and Development

Insect development involves so-called metamorphosis. One may therefore encounter each species in several morphologically (and often also biologically) widely differing forms, or developmental stages. The egg, larva, and adult stages are common to all insect species. This scheme, valid for insects with incomplete metamorphosis (**hemimetaboly**), is further extended by a resting pupal stage in insects with complete metamorphosis (**holometaboly**). Larvae (in insects with incomplete metamorphosis sometimes called nymphs) constitute the only stage in which growth occurs. Multiple moultings of the skin are connected with growth. The growth stage between two larval moultings is called an **instar**. The egg, larva, and possible pupa are called collectively the **juvenile stages**.

- Practically all insect species are **gonochorists**. In most species, one therefore encounters individuals of male and female sex, even though the sex ratio may be highly varied.
- The exotic Termitoxeniidae (Diptera [true flies]), which are **hermaphrodites**, constitute the only exception. In such individual, male gonads develop first, and then female, which is also connected with profound changes in body shape.

After finding a suitable mate, wherein the male is usually the active individual, copulation occurs and seminal fluid is transferred, even though in numerous cases the actual fertilization of the eggs occurs only a variously long time after copulation. Until such time, the sperm are stored and nourished in the female's spermathecae.

The copulation itself is often preceded by a more or less significant change in behaviour known as **epigamic displays**. Particularly conspicuous is the formation of swarms, as known, for example, in most mayflies, some butterflies and true flies, as well as phenomena wherein the male offers food and the like to the female.

Primarily olfactory organs are used for locating a partner. Frequently, however, sight, sound-producing, and auditory organs, as well as combinations of these and other sensations, are often significantly or crucially involved. Sperm is usually transferred directly into the female's sexual organs, mostly in the form of bundles of sperm protected by a protein capsule (**spermatophore**), more rarely in liquid form (certain Hemiptera: Heteroptera, Mecoptera, Diptera).

In certain primitive orders, however, physical contact is not even necessary for the two sexes, as **male sexual products are deposited freely** and the female herself actively accepts them into her own sexual organs. In certain Collembola, male sexual products are deposited even in the absence of a female. In addition to this usual transfer of sperm, however, one also exceptionally encounters cases in which sperm is dispatched directly into the body cavity after the rupturing of the body wall, and thus outside the sexual organs (Heteroptera of the Cimicidae family, Strepsiptera [twisted-wing parasites]).

For the overwhelming majority of insect species, fertilization is a necessary prerequisite for further development of the egg. Less frequently – although by no means rarely – there are cases when even an unfertilized egg can develop further and give rise to a fully fledged individual. This manner of development is called **parthenogenesis**.

Parthenogenesis developed in various insect orders. In certain species, parthenogenetic reproduction occurs generally in only certain areas while in other areas individuals of both sexes occur and the same species reproduces normally (i.e. sexually). This is referred to as **geographical**

parthenogenesis. The state in which the egg is not fertilized can occur when males of a given species are relatively scarce, and possibly absent altogether, or for other reasons.

According to what kind of individual develops from the unfertilized egg, the following types of parthenogenesis are differentiated:

- **arrhenotoky** – males hatch from unfertilized eggs and females from fertilized ones. This is a regular phenomenon, for example, in the European honey bee and certain sawflies (family Tenthredinidae).
- **thelytoky** – females hatch from unfertilized eggs. In a number of species from the orders of chewing lice (suborder Mallophaga), thrips (order Thysanoptera), bagworm moths (family Psychidae), certain beetles (e.g. weevils of the genus *Otiorhynchus*), and in certain Hymenoptera, the males are very rare and females emerge in just this way.
- **amphitoky** – both sexes may hatch from unfertilized eggs. This phenomenon is known, for instance, in aphids.

There are also insect groups wherein **alternation of generations (heterogony)** is known, consisting in alternation of generations of both sexes (**amphimictic**) reproducing sexually with one or several parthenogenetic generations. In case of heterogony, therefore, there are one or several thelytokous generations and one amphitokous generation, the latter of which again reproduces sexually. This type of reproduction is characteristic for aphids and the overwhelming part of phytophagous Cynipoidea.

So-called **paedogenesis** is a special type of reproduction. It is a rare form of parthenogenetic reproduction in certain representatives of true flies (Diptera) of the family of gall midges (Cecidomyiidae), where it is not the imagos that reproduce, but the larva.

A specific form of reproduction, known as **polyembryony**, occurs where a single egg separates into several individual embryos in the course of embryonic development. This phenomenon has been most studied in the miniscule representatives of chalcid wasps of the *Litomastix* genus, which parasitize in butterfly caterpillars and develop in a single caterpillar in such quantity that they are able to kill it (even though only a single egg is deposited into the host). Apart from this, the phenomenon is also known in certain Braconidae as well as in the parasitic order of twisted-wing parasites (genus *Halictoxenos*).

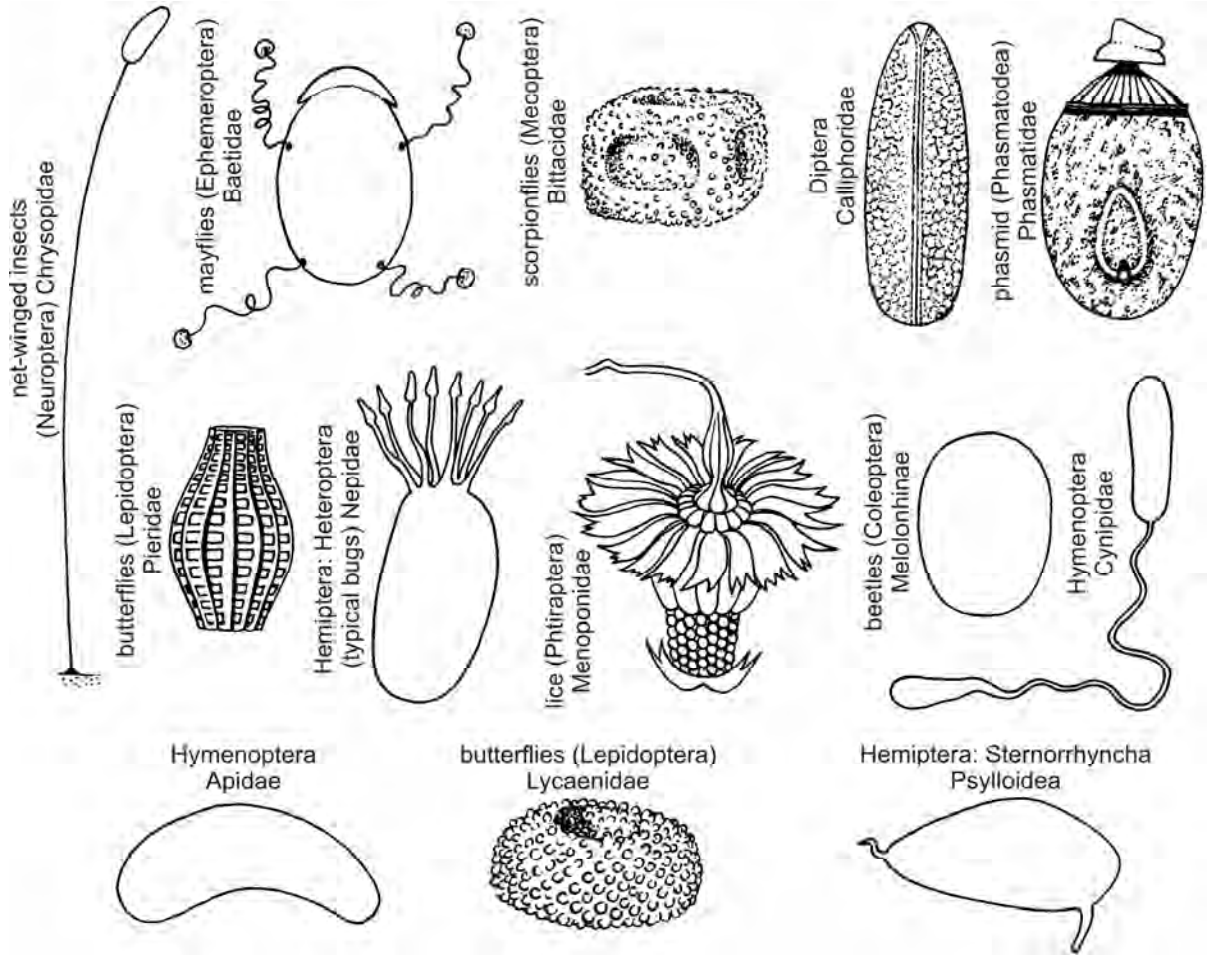
- **Ovipary** is a phenomenon during which embryonic development occurs in an egg outside the female body, and the larvae therefore hatch after a longer time from when the eggs are laid. It occurs in the vast majority of insects where the female lays eggs a relatively short time after copulation.
- **Ovovivipary** occurs in species where the eggs are retained in the terminal tracts of the female reproductive organs and a large part to almost the entire part of embryonic development occurs in the egg that is still inside the female body. The result is that the larva hatches in a relatively very short period after the egg is laid, and in extreme cases even immediately after the egg is laid.
- **Vivipary** is also known in insects. It is a state wherein the youngest larval instar (e.g. in Strepsiptera [twisted-wing parasites]) actually leave the female body; potentially also with part, or even all, of the larval development (including moulting) occurring inside the female body. A more developed, in extreme cases up to fully developed, larva of the final instar then leaves the female, which in the course of several dozen minutes or hours pupates without food intake. This state can be encountered in local Czech fauna, e.g. in a group of bloodsucking true flies (Diptera), including bat flies (Nycteribiidae), *Ornithomya* (feeding on birds), louse flies (*Lipoptena* feeding on ungulates), and among exotic species such as the well-known tsetse fly (carrier of sleeping sickness). In addition to these groups, vivipary is also known in other insect orders, most often in connection with a parasitic lifestyle.

Eggs are laid in various ways depending upon the species, in various numbers, and in variously grouped bunches as close as possible to sources of food, upon them, or within them. In the case of phytophages they are laid on or in the host plant. In the case of parasites, on or in the body of the host, or

in places where active (invasive) larvae may encounter the host species. In the case of saprophages, on decaying matter. In the case of predators, in places with an abundance of prey.

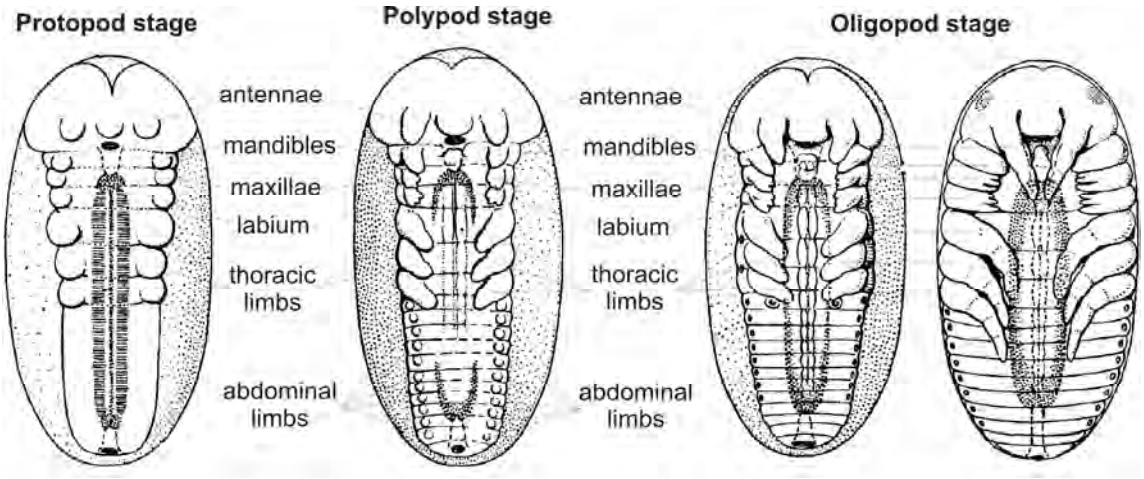
Egg and Embryonic Development

The great diversity of the insect class is reflected also in the diversity of eggs, be it regarding their number, size, shape, various morphological details, but also the individual course of cleavage and development of the embryo.



Eggs comprise the only developmental stage in which chitin does not contribute to construction. They are covered by an eggshell (**chorion**) and are by this phase rather highly resistant to all climatic influences. After a complex and often specific cleavage, the course of embryonic development arrives at the formation of the embryo and its subsequent segmentation. One can distinguish several phases in this final stage of embryonic development:

- **protopod phase** – development of four pairs of the bases of head appendages (antennae, mandibles, maxillae and labia) and the bases of three pairs of thoracic limbs. The abdomen remains unsegmented and without traces of limbs.
- **polypod phase** – the development of head and thoracic appendages continues, the abdomen is segmented, and each segment bears bump-like indications of a pair of appendages.
- **oligopod phase** – the indications of practically all appendages on the abdominal segments disappear (with the exception of the sometimes preserved appendages of the basal segment).



At the end of embryonic development there is a fully developed larva inside the egg, which leaves the egg case either by biting through it, by the case's cracking due to the larva's pressure, or because it is torn open by means of the so-called **egg tooth**. The latter, a rather strongly sclerotized formation most often on the larva's head, can be either part of the embryo's cuticle (in which case it remains with it in the egg case), or part of the young larva's skin and therefore visible through the entire first larval instar (i.e. up to the subsequent moulting).

Larva

After hatching from the egg, the larva takes in food and relatively intensive growth occurs. After a certain period, when the possibilities for further volume enlargement have been exhausted, the larva moults (so-called **ecdysis**). A complete change of the entire exoskeleton occurs, including all parts of ectodermal origin (epithelium of the fore and hindgut, tracheal system, and other smaller structures). Through the course of ecdysis, the epidermis, all muscular insertions, and all nerve endings separate from the exoskeleton. The largest part of the cuticle is broken away, the surface of the epidermis expands, a larger exoskeleton is constructed, and the organs are reattached to the exoskeleton. The larva of the next instar with a yet uncoloured and unhardened skeleton leaves the old larval skin (the so-called **exuviae**).

Ecdysis is characteristic of the larval stage. It is only rarely encountered in other stages – in winged insects only in the imagos of mayflies (Ephemeroptera) and certain twisted-wing parasites (Strepsiptera). In primarily wingless insects (Archeognatha [jumping bristletails] and Zygentoma), however, a considerable number of moultings during the life of the imago is also a common phenomenon

(the situation is similar in the classes Diplura [two-pronged bristletails] and Collembola [springtails]). The number of moultings varies widely by individual species – from 2 to 40. In certain groups, the number of moultings is constant (certain families of typical bugs [Heteroptera], Hymenoptera, true flies [Diptera], beetles, etc.). In other cases, it varies even within the same species depending on developmental conditions (e.g. the clothing moth), or the number of moultings is different in the two sexes (butterflies, Orthoptera).

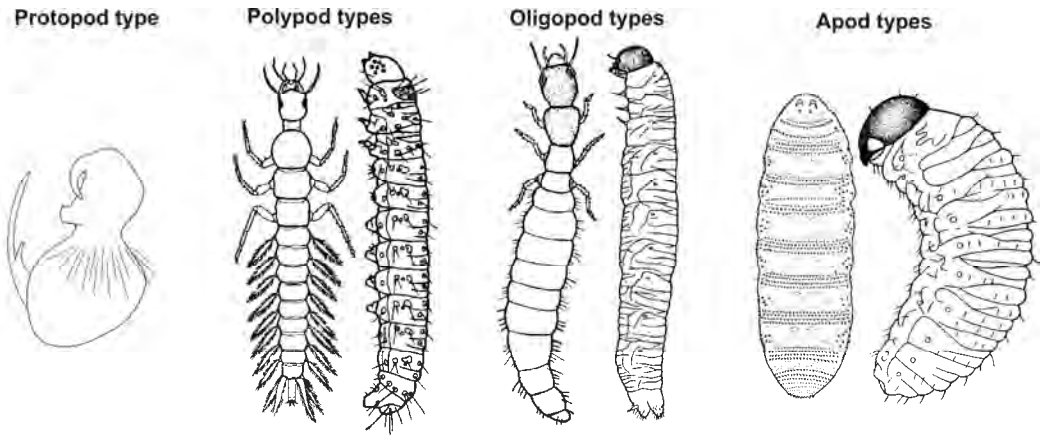
Larvae morphology

- Insect larvae with incomplete metamorphosis (hemimetaboly) are more or less similar to adults, from which they often differ, for example, only in the smaller number of tarsal, antennal, or possibly abdominal segments; and in primarily winged insects by the absence of fully developed wings and chaetotaxy, or otherwise.
- Insect larvae with complete metamorphosis (holometaboly) are, in contrast, very diverse and differ entirely from adults.

Insect larvae may be divided according to various perspectives. These divisions, however, are only general, as the characteristics of individual types are variously well-developed and numerous transitional forms exist.

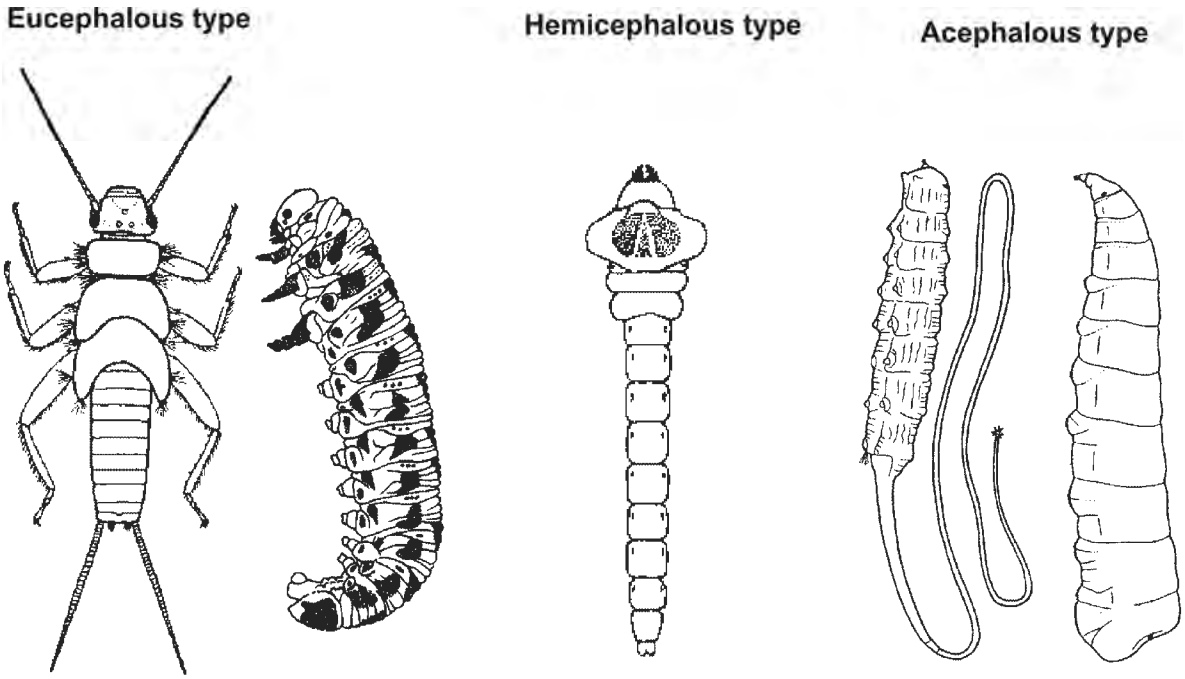
The most important is classification according to the development of appendages on the body segments. The names of these basic larva types are derived from the corresponding phase of embryo segmentation:

- **Protopod larvae** are bizarre forms with an unsegmented abdomen having no abdominal appendages and at most with rudiments of thoracic limbs. Head appendages are strongly reduced, with the exception of powerfully developed hook-shaped mandibles. This morphologically conspicuous type is known only in several parasitic Hymenoptera (Proctotrupoidea).
- **Polypod larvae** have perfectly segmented bodies and well-developed appendages of the head and thorax. There are well-developed appendages on at least some abdominal segments. Among species developing in water (Megaloptera, Neuroptera [the family Sisyridae – spongeflies]), they serve also as tracheal gills, and in terrestrial species for movement (e.g. Lepidoptera [butterflies], Hymenoptera [a considerable part of the species of the suborder Symphyta], and Mecoptera [scorpionflies]).
- **Oligopod larvae** retain only well-developed head and thoracic appendages; abdominal appendages are not developed. Very numerous and varied larvae of Neuroptera (net-winged insects), Coleoptera (beetles), and Trichoptera (caddisflies) belong to this type.
- **Apod larvae** have thorax and segmented abdomen without appendages. They also have very diverse shapes. Larvae of a number of beetles developing inside plant tissue (true weevils, bark beetles, jewel beetles, and other families), flea larvae, and larvae of Hymenoptera: Apocrita and Diptera belong to this group.



Larva type also can be specified by the characteristic degree of the head capsule's development:

- **eucephalous larvae** – with a well-developed capsule (larvae of beetles, butterflies, Hymenoptera, and members of the vast majority of other insect orders).
- **hemicephalous larvae** – the head is weakly, or only in the front section, sclerotized and more or less retracted into the first thoracic segment. The majority of Diptera: Brachycera larvae are hemicephalous.
- **acephalous larvae** – the head capsule is not developed. The larvae of circular-seamed flies (Diptera: Cyclorrhapha) are acephalous, apod larvae, commonly known as maggots.

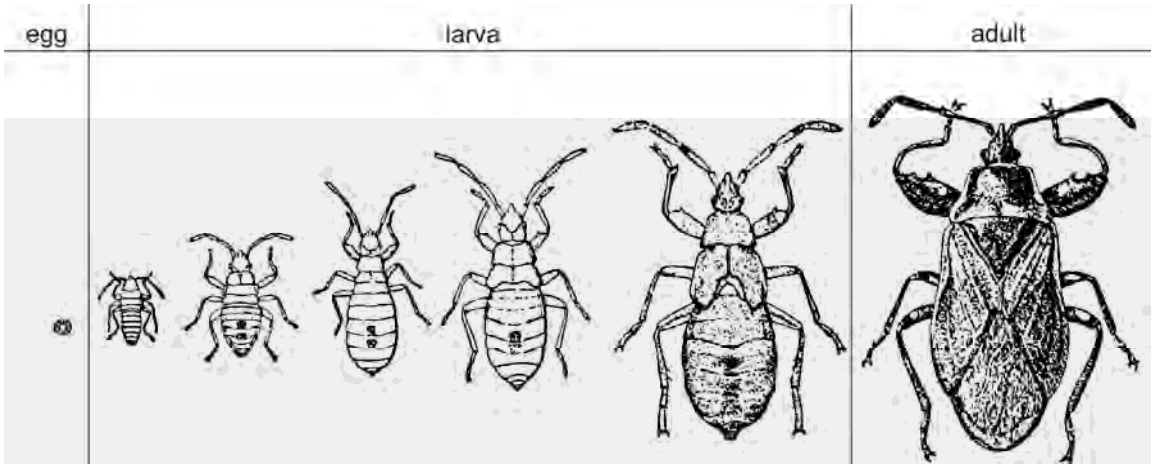


Metamorphosis and Its Modifications

As already noted, insect development occurs according to two basic schemes: incomplete metamorphosis (**hemimetaboly**) and complete metamorphosis (**holometaboly**). Given the immense species and biological diversity of the insect class, it is understandable that within the confines of these two basic types a whole range of variations can be distinguished.

1. HEMIMETABOLY – INCOMPLETE METAMORPHOSIS

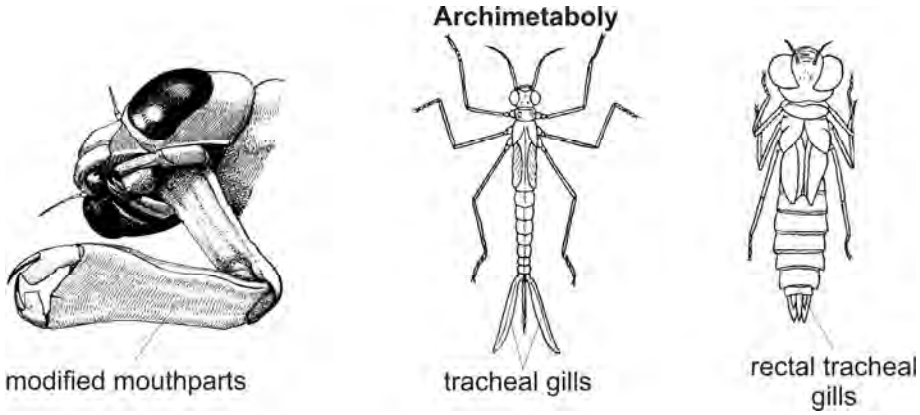
This is typical for relatively primitive orders. Larvae are to a considerable extent similar to imagos. In primarily winged insects, the individual instars show a lengthening of the wing bases and progressive development of the reproductive organs. The last larval instar changes directly into the imago (except for mayflies – see below).



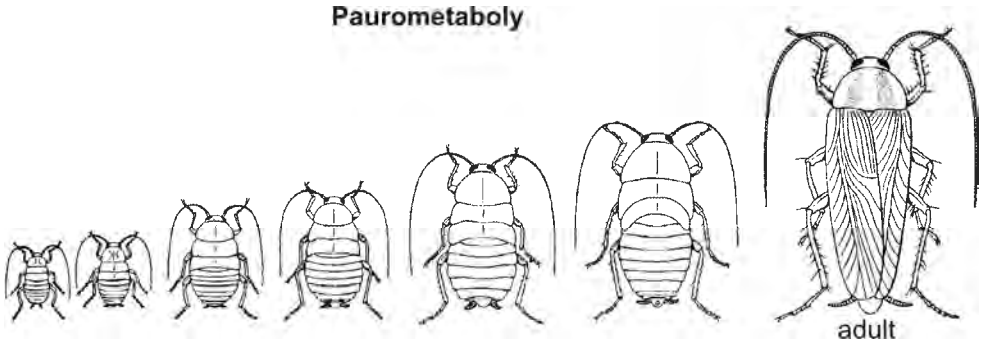
Variations of incomplete metamorphosis:

- **PALEOMETABOLY** is characterized by juvenile stages that are practically no different in appearance from adults (except for the undeveloped reproductive system and some minor inconspicuous features, such as chaetotaxy, number of antennal segments, segments of the posterior abdominal appendages). The situation is therefore similar to that in the Myriapoda subphylum.
  - **Epimetaboly** is development by simple growth. The larvae are morphologically virtually identical to the adults (they are primarily wingless), with the exception of the development of gonads and certain small conspicuous details in chaetotaxy and the formation of antennae and abdominal appendages. (Epimetaboly is typical for terrestrial species of the orders Zygentoma, Archeognatha, two-pronged bristletails [Diplura], springtails [Collembola], and coneheads [Protura].)
  - **Prometaboly** differs from epimetaboly primarily in that the imago moults once again shortly after hatching. The larvae live in the water and have developed tracheal gills (mayflies [Ephemeroptera]).

- **HETEROMETABOLY** is characterized by nymphs gradually growing wings and reproductive organs. This includes two variants:
  - **Archimetaboly** occurs in dragonflies (Odonata) and stoneflies (Plecoptera), i.e. in orders of which the larvae develop in water and have corresponding adaptations in the form of tracheal gills and, in the case of dragonflies, also specifically modified mouthparts.

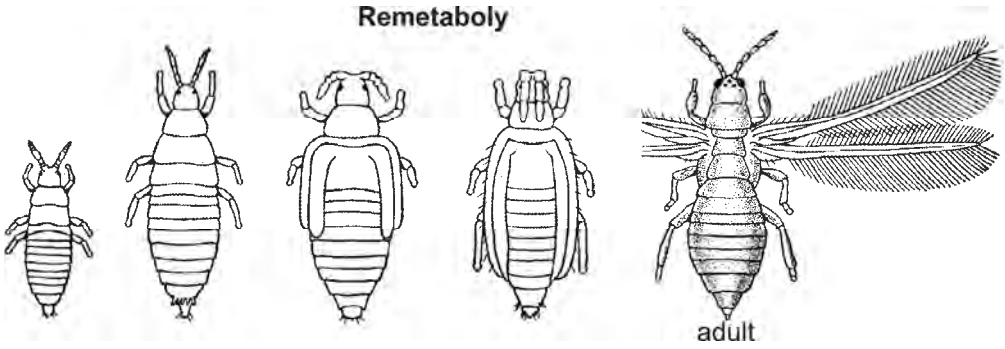


  - **Paurometaboly** occurs in an overwhelming proportion of terrestrial insect species with incomplete metamorphosis. This includes Embioptera (webspinners, which are not found in the Czech Republic), Orthoptera, Phasmatodea (phasmids, not found in the Czech Republic), Dermaptera (earwigs), Mantodea (mantises), Blattodea (cockroaches), Isoptera (termites, not found in the Czech Republic), Zoraptera (not found in the Czech Republic), Psocoptera (psocids), Phthiraptera (lice), and a majority of Hemiptera (true bugs, aphids, and cicadas).

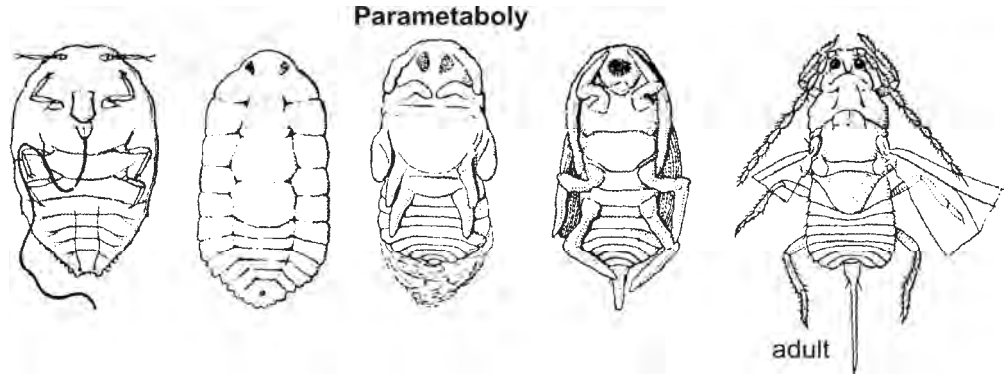


- **NEOMETABOLY** is characterized by development of wings and reproductive organs starting as late as in the later larval instars. Traces of these organs emerge up to the last two instars, or only in the very last instar. At the same time, these instars are immobile or have only limited mobility and usually do not intake food. Four modifications may be defined here:
  - **Homomeaboly** is characterized by wing bases forming as late as the last larval instar (in winged females of woolly conifer aphids [Adelgidae] and Phylloxeridae).

- **Remetaboly** is characterized by the first 2 larval instars having no wing bases and food intake, with the following 2–3 having no food intake but with wing bases (thrips [Thysanoptera]).



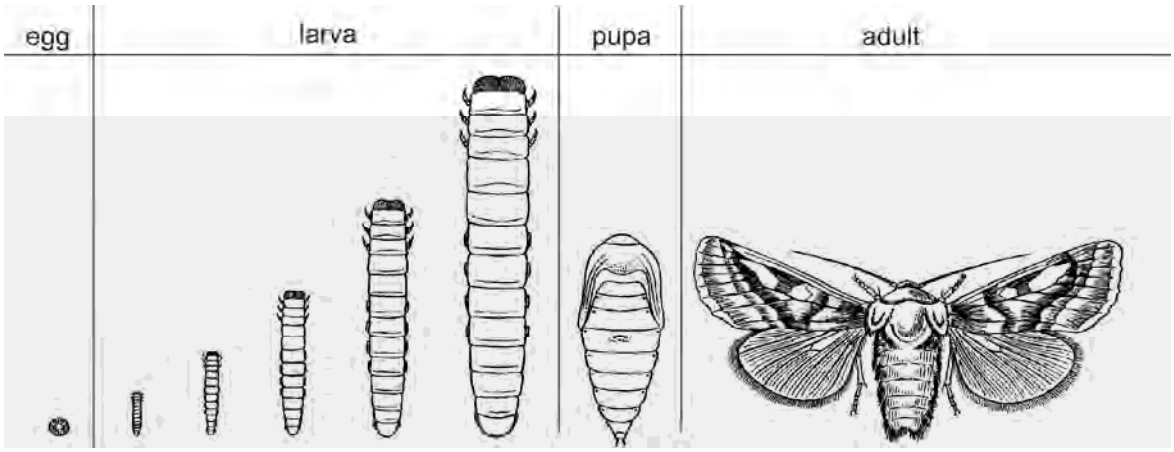
- **Parametaboly** is characterized by the first 2 (rarely 3) larval instars having no wing bases and food intake, and the next 2 with wing bases but no food intake (male scale insects [Coccoidea]).



- **Allometaboly** is characterized by 4 wingless instars, the first of which is mobile and the following 3 immobile. The last instar metamorphoses into a puparium (a sort of analogy to the pupa in Holometabola) (in whiteflies [Aleyrodoidea]).

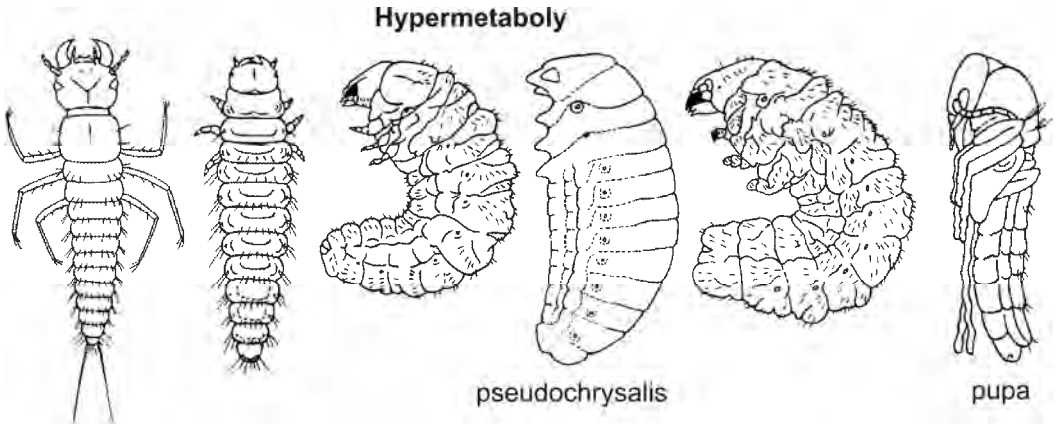
2. HOLOMETABOLY – COMPLETE METAMORPHOSIS

Larvae never have wing bases and are routinely unlike the adults. The proper transformation from the juvenile stage into an imago occurs by an extensive transformation during the pupal stage. This type of metamorphosis advances development of representatives of the orders Megaloptera, Raphidioptera (snakeflies), Neuroptera (net-winged insects), Coleoptera (beetles), Strepsiptera (twisted-wing parasites), Hymenoptera, Trichoptera (caddisflies), Lepidoptera (butterflies), Mecoptera (scorpionflies), Diptera (true flies), and Siphonaptera (fleas).



In the case of complete metamorphosis, too, there exist a number of more or less conspicuous variants that almost exclusively are tied to a parasitic lifestyle.

- **Polymetaboly** is characterized by larvae not of a single type during development but rather having significant morphological differences. It is found in part of the net-winged insects (mantidflies [Neuroptera: Mantispidae]), twisted-wing parasites (Strepsiptera), in certain beetles (some ground beetles [Carabidae – genera *Lebia* and *Brachinus*], some rove beetles [Staphylinidae: Aleocharini], some wedge-shaped beetles [Rhipiphoridae]), and in certain parasitic Hymenoptera and biologically similar groups of the order true flies (Diptera).
- **Hypermetaboly** is characterized, during larval development, by several morphologically distinct types of larvae, but the penultimate larval instar is immobile, does not intake food, and while pharate it is encased in the cuticle of the preceding instar. It forms a morphologically conspicuous formation somewhat resembling the pupa and called a pseudochrysalis (in blister beetles [Meloidae]).



- **Cryptometaboly** is an extremely rare extreme development in the exotic Diptera family Termitoxeniidae, where the entire development occurs within the eggshell from which only an adult larva exits and which also immediately pupates.

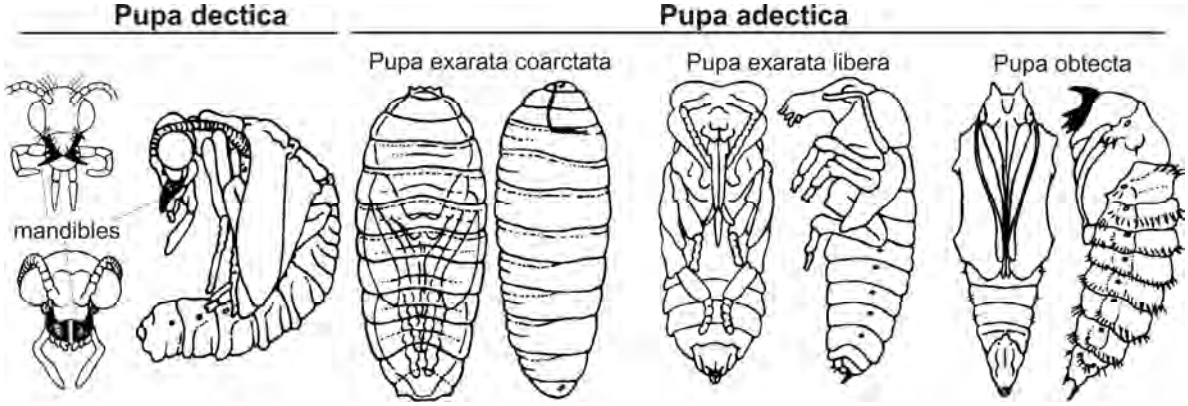
Pupa

The pupa is a unique developmental stage known only in insects with complete metamorphosis, where it is also the only developmental stage in which it is more or less possible to clearly distinguish the bases of the future imago's organs – compound eyes, wings, legs, antennae, and mouthparts, or at least some of these organs. The pupa's structure makes visible in particular the connection of the mandibles to the head, their sclerotization, and ability to move.

1. **PUPA DECTICA**
   The pupa dectica has mandibles capable of movement and more strongly sclerotized, and thus it is able to use these to bite through the cocoon and may even be used for movement. The bases of the legs and wings are free (not tightly fixed to the body) and the pharate imago can also use them, to a certain extent, for movement. Megaloptera, Raphidioptera (snakeflies), Neuroptera (net-winged insects), Mecoptera (scorpionflies), Trichoptera (caddisflies), and primitive representatives of Lepidoptera (Zeugloptera and Dacnonypha) have this type of pupa.

2. **PUPA ADECTICA**
   The pupa adectica has mandibular sheaths firmly fixed to the head, weakly sclerotized, and thus not functional. Body appendages are either fixed to the body or free. One can thus distinguish 2 variants of this type:

   - **Pupa exarata** has free body appendages and without more distinctive sclerotization.
     - **Pupa exarata libera** is usually situated inside a pupal chamber or cocoon (most beetles [Coleoptera], twisted-wing parasites [Strepsiptera], fleas [Siphonaptera], most Hymenoptera).
     - **Pupa exarata coarctata** represents a situation wherein the exarate pupa is enclosed in a firm case consisting of the skin of the last (3rd) larval instar, and the entire formation is called a **puparium**. It is typical in circular-seamed flies.
   - **Pupa obtecta** has body appendages firmly fixed to the body and rather strongly sclerotized. This type of pupa is characteristic for the overwhelming majority of butterflies (Lepidoptera), occurring also in long-horned and short-horned flies (Diptera) and certain groups of beetles (ladybird beetles [Coccinellidae], rove beetles [Staphylinidae], some leaf beetles [Chrysomelidae]).

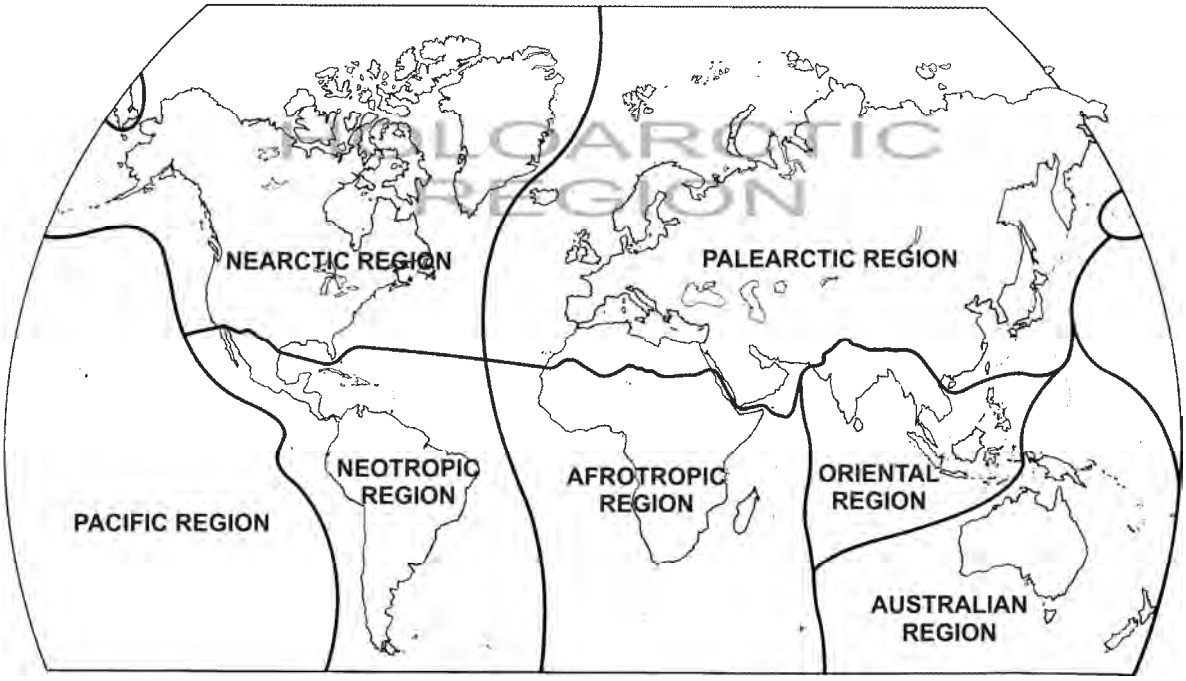


INTRODUCTION TO ZOOGEOGRAPHY

The following 7 zoogeographic regions are used to approximately define the ranges of the distribution of animal species: **Palearctic**, N**earctic, Afrotropic, Neotropical, Pacific, Australian, and Oriental.**

The Palearctic and Nearctic regions are collectively called the **Holarctic** region.

Species occurring in most zoogeographical regions (occurring worldwide) are known as species with **cosmopolitan distribution**.



SYSTEMATIC ENTOMOLOGY

System of Suborder Taxonomic Units and Suffixes of Taxa Names

Taxon	Example taxon	suffix
Superfamily:	**Curculionoidea**	**– oidea**
Family:	**Scolytidae**	**– idae**
Subfamily:	**Ipinae**	**– inae**
Tribe:	**Ipini**	**– ini**
Genus:	Ips	– no stable ending
Species:	typographus	– no stable ending

Introduction to Systematic Entomology

The immense variety of the species within the arthropod phylum is associated with the origins of the Tracheata subphylum. This group is fully adapted to life on dry land and also populated fresh waters.

Within this subphylum, two development trends can be rather distinctly noted. The more original subphylum, also called **Myriapoda**, has more or less homonymous body segmentation, where even posterior body segments are equipped with segmented limbs and even the mandibles have maintained segmentation. The classes Chilopoda (centipedes), Diplopoda (millipedes), Pauropoda (pauropods), and Symphyla (garden centipedes) belong here.

The more derivative subphylum is alternatively called **Hexapoda**, with the body rather clearly divided into three parts (head, thorax, and abdomen), of which only the three thoracic segments bear segmented legs and the mandibles are not segmented. Wings are also developed in most members of this developmental subphylum.

Transitional forms in which the limbs on the abdominal segments are very strongly reduced and wings are never developed give rise to a certain difficulty in this scheme.

These groups were formerly classified into the subclass Apterygota within the class Insecta (insects), i.e. coneheads (Protura), two-pronged bristletails (Diplura) and springtails (Collembola), and to a certain degree also Thysanura. Their common characteristic is primarily the presence of rudimentary limbs on the abdominal segments and the positioning of the mouthparts deep inside the head capsule. Abdominal limbs, however, are strongly reduced and the entire group is probably much closer to insects proper than to the Myriapoda subphylum. The presence of the remnants of abdominal limbs, however, can also be noted in Thysanura. Here, however, the mandibles are already situated outside the head, thus in the usual position for insects (even if it is still somewhat atypical in one order, the jumping bristletails [Archeognatha]).

Individual orders were thus recently created for the classification of Tracheata, such that the current system is as follows:

Subphylum: **TRACHEATA**

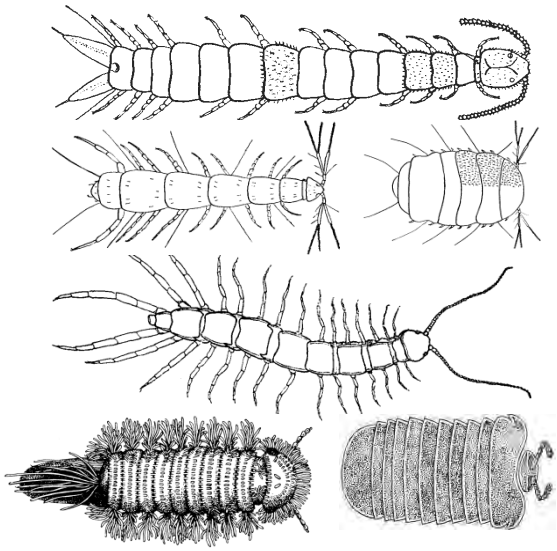
Superclass: **MYRIAPODA**

Class: **Symphyla** – garden centipedes

Class: **Pauropoda** – pauropods

Class: **Chilopoda** – centipedes

Class: **Diplopoda** – millipedes



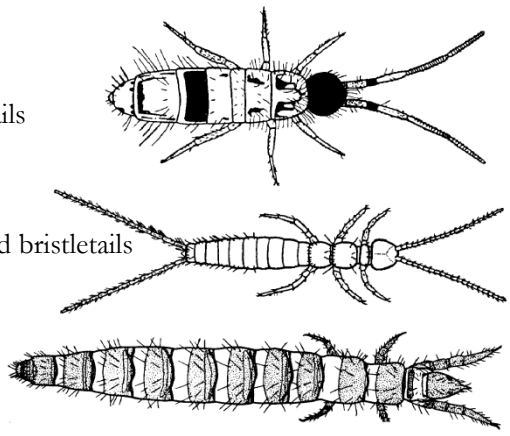
Superclass: **HEXAPODA**

Class: **Entognatha**

Order: **Collembola** – springtails

Order: **Diplura** – two-pronged bristletails

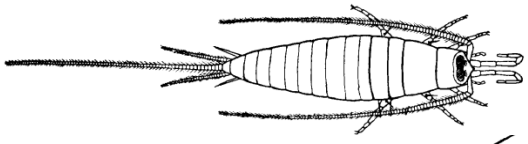
Order: **Protura** – coneheads



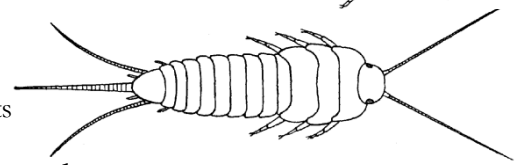
Class: **Insecta** – Insects

Subclass: **Thysanura** – silverfish and firebrats

Order: **Archeognatha** – jumping bristletails

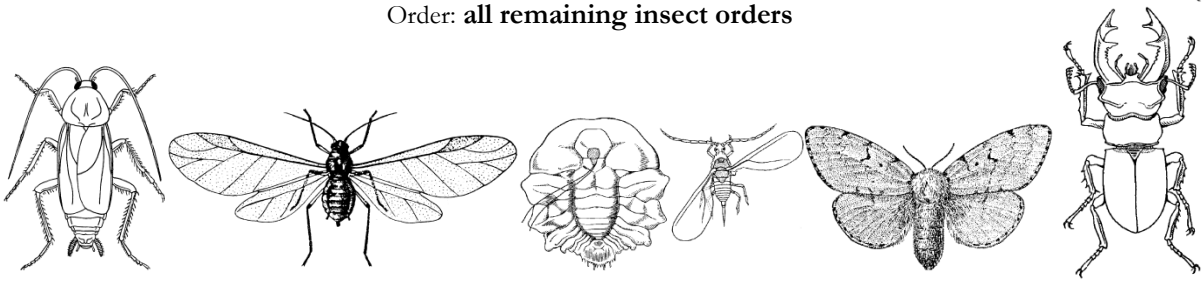


Order: **Zygentoma**

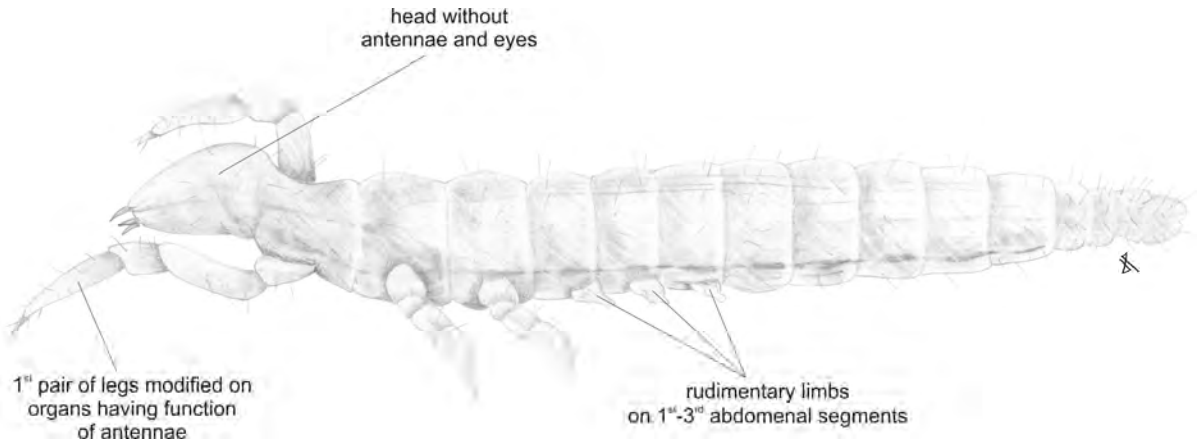


Subclass: **Pterygota** – winged insects

Order: **all remaining insect orders**



Order: **PROTURA** (coneheads)		
derivation of the order's name protos (Greek) = first, oura (Latin) = tail	number of known species in the world about 500	number of known species in the Czech Republic 22
Metamorphosis: **hemimetaboly: epimetaboly**		



Systematics

Protura are divided into three suborders, only two of which are found in Central Europe:

- Suborder: **Eosentomata** – tracheal system developed, and
- Suborder: **Acerentomata** – tracheal system not developed.

General characteristics and body description

Small, 0.5–2.5 mm long organisms with an elongated, more or less evenly segmented and only very slightly sclerotized body without pigmentation.

Head is egg-shaped, with the piercing-sucking mouthpart positioned deep inside the head (thus the same as in Collembola and Diplura). Antennae and eyes are absent.

The function of antennae is assumed by the 1st pair of legs, so the animals use only the two pairs of hind legs for their slow and lumbering movement.

Abdomen has 12 segments. The first three segments carry 1 pair of rudimentary limbs each, of which the first pair is always well-developed and two-segmented, and the remaining pairs can be strongly

reduced. All carry eversible terminal pads, perhaps serving to absorb moisture or playing a certain role during respiration. On the sides of the 8th segment, a protective gland opens, the sticky secretion of which can be squirted at an attacker while at the same time the abdomen is bent over the head. The reproductive organs open on the 11th segment, with paired openings in males and a single opening in females.

Tracheal system (with spiracles opening on the 2nd and 3rd thoracic segment) is relatively well-developed only in one of the 3 families (approximately 1/4) of known species. The remaining species breathe through the body surface.

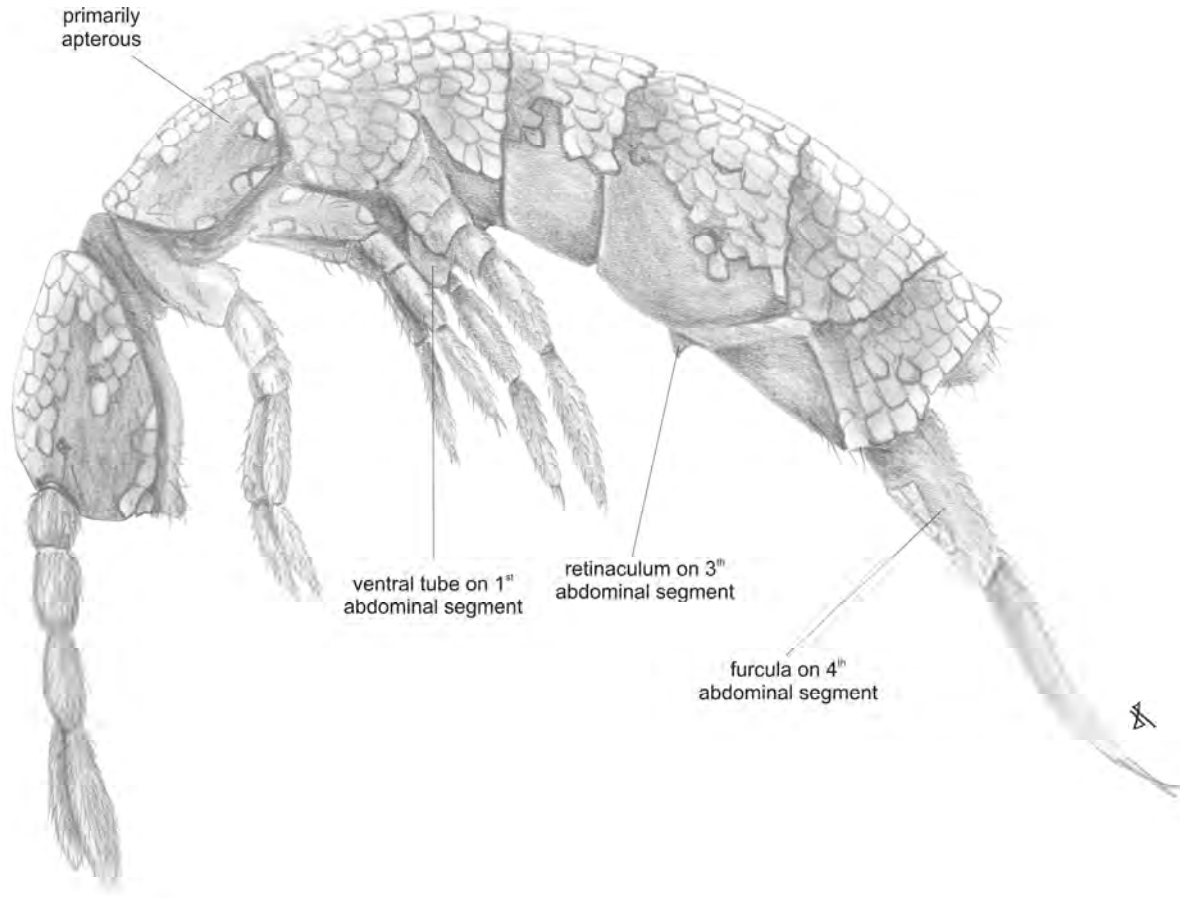
Eggs are laid in the spring (ovipary), hatching into nymphs with only 9 abdominal segments. The remaining segments are only added during the course of postembryonic development (anamery). Development therefore resembles the similar situation in Myriapoda.

Development takes place in 4 instars. The first instar (a prenymph) has, in addition to a 9-segmented abdomen, also incompletely developed mouthparts. In the second instar, the number of abdominal segments remains at 9, although mouthparts already have their normal shape. The third instar has a 10-segmented abdomen and the fourth instar (called maturus junior in males and pre-imago in females) already reaches the full number of 12 abdominal segments, but it does not yet have fully developed reproductive organs and also differs from the imago by chaetotaxy. It is unknown whether the imago moults as in springtails, two-pronged bristletails, silverfish, and firebrats.

Ecology

In central European conditions, they usually overwinter as nymphs. The life span does not exceed 1 year. The species of this order live furtively in the topmost surface layers of soil, primarily forest litter, in decomposing stumps, moss and the like. To date, very little is known about their nutrition. Some species suck fungal mycelia, while in others a predatory lifestyle is presumed.

Order: **COLLEMBOLA** (springtails)		
derivation of the order's name kolla (Greek) = glue, embolon (Latin) = prong	number of known species in the world about 7,000	number of known species in the Czech Republic 340
Metamorphosis: **hemimetaboly: epimetaboly**		



Systematics

Springtails are systematically divided into three suborders:

- Suborder: **Poduromorpha** – relatively thickset and oval body.
- Suborder: **Entomobryomorpha** – thin, elongated body. Most species have long antennae, well-developed furcula, and a (mostly) hairy body.
- Suborder: **Symphypleona** – spherical body shape with merged thoracic and 4 basal abdominal segments.

General characteristics and body description

Primarily wingless (apterous) forms. The existence of the Collembola order dates back already from the Devonian. They are mostly very small animals, averaging 1–2 mm (the largest 7 mm, the smallest

0.2 mm). Body sclerotization is weak, and the surface usually carries very distinctive hairs. A number of genera have also developed scales, colouring them in metallic shine. Coloration varies from monochromatic light grey to very colourful. Coloration in the same species or individual depends on light intensity, so darkness may cause even total loss of coloration, while on the other hand strong light may cause intense coloration. Reflexive bleeding is an interesting phenomenon whereby, in response to certain threatening stimuli, body contraction causes haemolymph to be expelled from the body surface or certain limited areas (so-called pseudocelli) simultaneously. It is probably a defensive reaction against an enemy.

Head is ortho- to prognathous, with chewing and, only rarely, piercing-sucking mouthparts positioned deep inside the cranium (entophagy). Muscular antennae, four-segmented, secondarily six-segmented. The eyes consist only of a small group of ommatidia (at most 8). Ocelli are also frequently developed, either as a frontal ocellus or parietal ocelli. Sometimes, however, compound eyes and ocelli are absent, although the animal nevertheless reacts to light.

Thorax has well-separated individual segments, or segments more or less merging amongst themselves and with the abdominal segments (depending on suborder membership). Of the legs, it is characteristic for the tibia and tarsus to fuse into a so-called **tibiotarsus** with a single terminal movable segment equipped with a claw and a pollex on the opposite side. Leg morphology is a very important determining feature for this group. Certain species are highly luminescent.

Abdomen has only 7 segments, while the 1st, 3rd, and 4th segments carry transformed limbs with entirely special functions. The 1st segment carries the so-called **ventral tube**, the 3rd the **retinaculum**, and the 4th a jumping bristle (**furcula**). While this is best developed in species living freely on the surface of plants, it can be strongly reduced in species living in soil. In a calm state, the furcula is folded forward and held by the retinaculum. By releasing the furcula in the retinaculum, the animal is then thrust forward in a high arc; at the same time, the furcula again folds forward in flight. While the locomotive function of these two organs is clear, the function of the conspicuous ventral tube is only speculated (change of the centre of gravity during the jump, holding on to the substrate, breathing, and perhaps also other functions). Reproductive organs are located on the 5th abdominal segment in the form of a transverse slit in females and longitudinal one in males. These are very useful for identification purposes – and often the only characteristic discerning individuals of the two sexes, as sexual dimorphism is either absent or is mostly only very weakly developed.

Due to their inconspicuous size, **body surface breathing** is sufficient for most species, which is also enabled by its weak sclerotization. Only **a portion of the species has a simple tracheal system**, opening outwardly via two spiracles between the head and thorax. Due to the properties of the cuticle, cilia and the scaly cover, these animals are water-repellent; thus, even in flooded and water-saturated soil they are "enclosed" by a thin layer of air, and the consumed oxygen is continuously replenished from water by diffusion.

Malpighian tubules are absent, uric acid alternatively accumulates in the midgut and the animal gets rid of it during moulting. Alternatively, it is stored in crystalline form in the fat body.

Ecology

Most species live in hiding. They are normally encountered in the topmost layer of soil, leaf litter, moss pads, beneath dead bark, and in similar places. One litre of soil to a depth of as much as 1 cm contains 500–1,000 individuals; however, even much larger values (up to 4,500 individuals) are not exceptional. Their quantity rapidly decreases with depth, so at 15 cm their number in 1 litre of soil ranges

only around a few dozen individuals. Due to their quantity, one must presume that they play a very important role in decomposing organic matter in the surface layer of soil, therefore contributing to the formation of humus. Many species (e.g. Sminthuridae) nevertheless occur only on plants, and a few species are permanent inhabitants of anthills. Their at times mass occurrence on snow or on the edges of glaciers is nevertheless conspicuous. It is assumed that in such cases they have been expelled from their usual areas by melting water.

They generally demand high air humidity, such that in a room temperature climate most species die due to loss of water within a few hours.

Most species feed on dead plant or even animal matter. Certain species also consume fine plant tissues, pollen, fungi, algae, lichens, and even bacteria and other unicellular organisms. Species living on glaciers subsist on windblown pollen and plant remains. They are mostly strongly polyphagous.

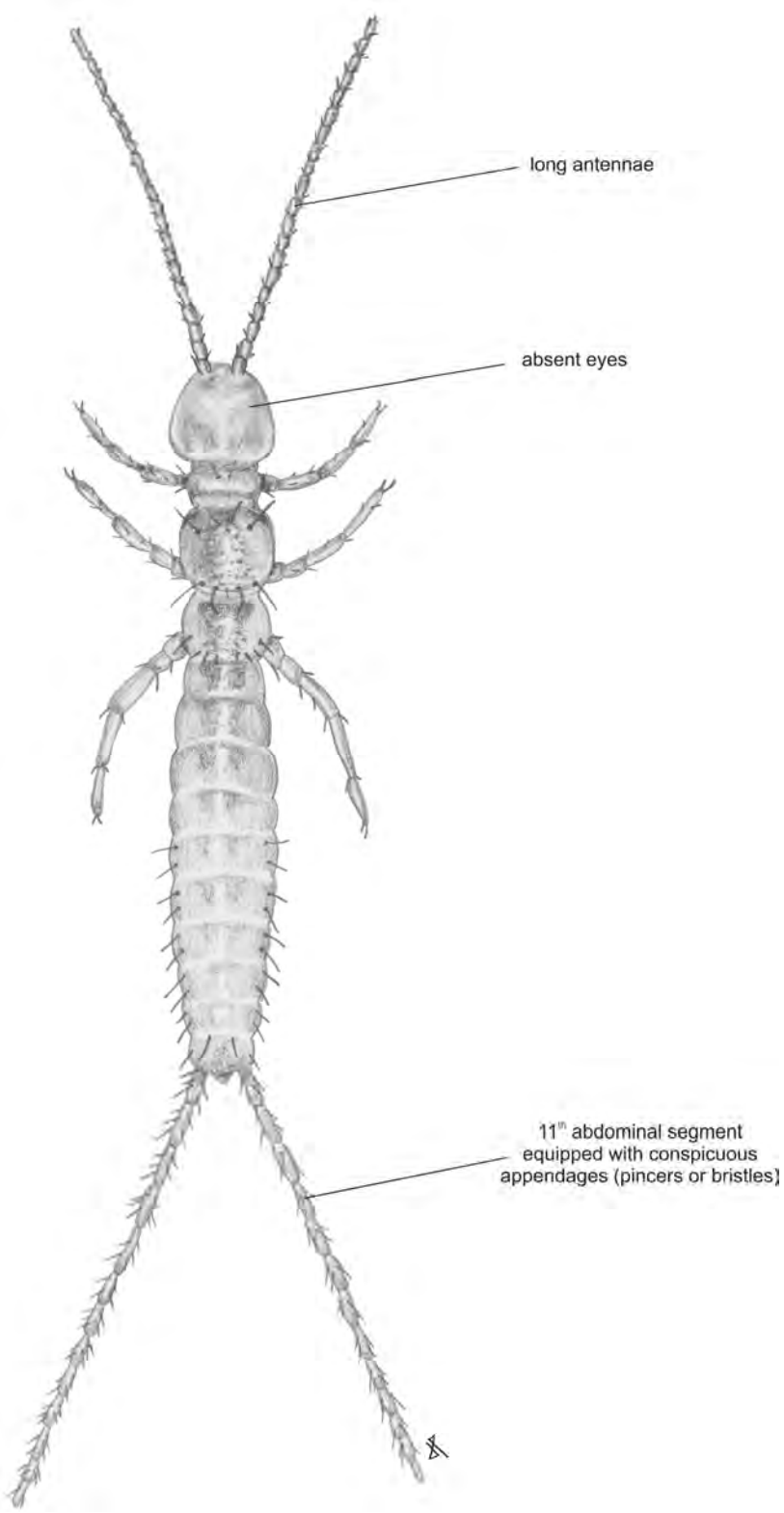
The animals normally move by crawling, and when disturbed by a directed impulse they flee by jumping. The first jump is in the opposite direction of the impulse, and it is followed by a number of others that are entirely directionally uncoordinated. In species living on the surface of water, the furcula is extended.

The male deposits up to 300 spermatophores, which the female then actively accepts. In most species, depositing spermatophores is not tied to the presence of a female. Eggs are generally spherical, deposited in bundles or individually (ovipary; ovovivipary is caused only rarely, and usually by adverse conditions). Parthenogenesis is also known in some species.

Embryonic development takes on average 10–15 days. After hatching from the egg, the larva moults regularly in periods of several days. The individual larval instars are very similar to adults and differ, apart from small details, primarily by smaller size. The individuals reach sexual maturity usually after 2–3 weeks. In that period, the as yet absent antennal segments grow, the sexual opening appears, and the imago gains the final coloration. The imago also moults in adulthood, when the number of moultings can be very high (in certain species up to 50) and can even regenerate lost body parts.

Most species of the Poduromorpha suborder can be found throughout the year, while almost all species of Symphypleona (ca 1/4 of all species) and most species of Entomobryomorpha living on plants overwinter in the egg stage. They usually live for 1 year at most. Enemies of the springtails include especially Acari (e.g. Gamasidae), but a number of other organisms also feed on them, such as spiders, beetles, true bugs, and others.

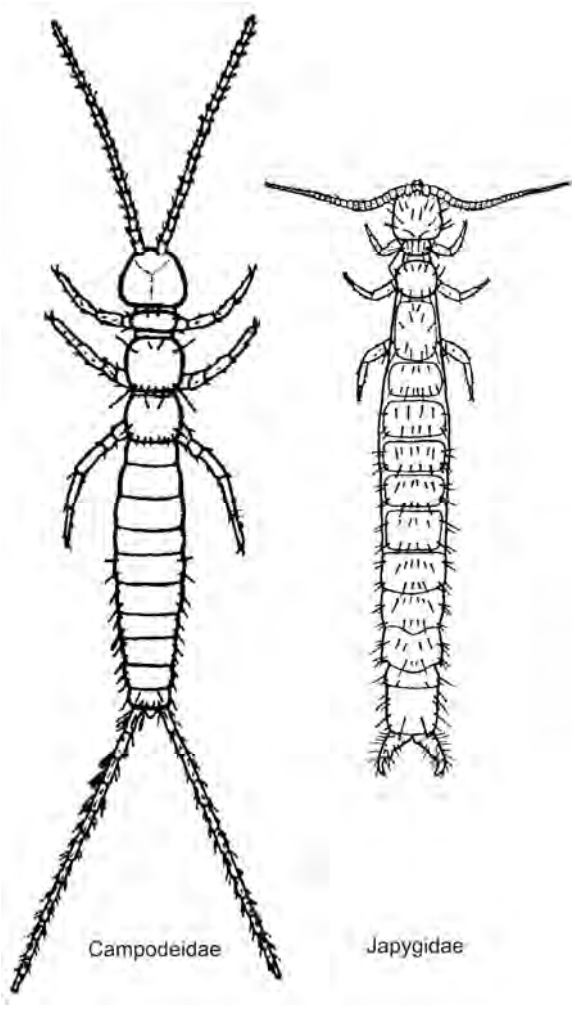
Order: **DIPLURA** (two-pronged bristletails)		
derivation of the order's name diploos (Greek) = two, oura (Latin) = tail	number of known species in the world 800	number of known species in the Czech Republic 10
Metamorphosis: **hemimetaboly: epimetaboly**		



Systematics

They are represented by two families in the Czech Republic:

- Family: **Japygidae** (japygids) – with an abdomen ending in unsegmented pincers, and
- Family: **Campodeidae** – with an abdomen bearing long segmented bristles on the 10th and final segment.



General characteristics and body description

Generally small, slim, almost evenly segmented, weakly sclerotized, usually whitish or yellowish coloured bodies sized 2–5 mm.

Head is spherical to elongated, with long and beady antennae, eyes absent. The chewing mouthpart is in the resting position (similarly as in Collembola and Diplura), retracted deep in the cranium.

Thorax carries 3 pairs of walking legs; the tarsus consists of one segment with 2 claws.

Abdomen has 10 segments; remains of limbs are evident on the 1st–7th (or 2nd–7th). Among the movable appendages (styli), there are small eversible pads similar to the ending of springtails' ventral tube and probably with a similar function (support of breathing). A characteristic feature of the group is always the presence of very conspicuous appendages of the 11th abdominal segment (cerci). On the edge of the 8th segment on the ventral side in both sexes there is a papilla with an unpaired opening of the reproductive organs.

Tracheal system is developed, opening to the outside via 11 pairs (Japygidae) or 3 pairs (Campodeidae) of spiracles. Both tracheal branches are already interconnected.

Imagos are relatively long-living. Adult Campodeidae usually live for over a year, japygids (Japygidae) up to 3 years. During their lives, they reproduce several times. In Campodeidae, reproduction lacks an obvious periodicity and they reproduce from March to October. In central European japygids, it seems to be that reproduction is only connected with spring months. Fertilization is indirect and repeated several times during life in relation to reproduction.

Spermatophores are usually deposited in the presence of females and they actively accept them into their reproductive organs, similarly to Collembola. Spermatophores are fixed to the soil by short stalks. Eggs are deposited in groups into the soil (in Campodeidae by 2–10, in japygids by 10–30 eggs). Females of certain japygids care for their eggs and protect them from moulds and predators, and for a certain period also stay with the youngest larval instars.

Embryonic development depends on temperature and ranges from 3 to 4 weeks. During postembryonic development, the larvae go through a number of instars (8–11 in Campodeidae, somewhat

fewer in japygids). Juvenile stages strongly resemble the adults, differing in chaetotaxy, formation of antennae and cerci, and their undeveloped reproductive organs. The first two instars in japygids do not even ingest food and have incompletely developed mouthparts.

Adults also moult many times during the course of their lives.

Ecology

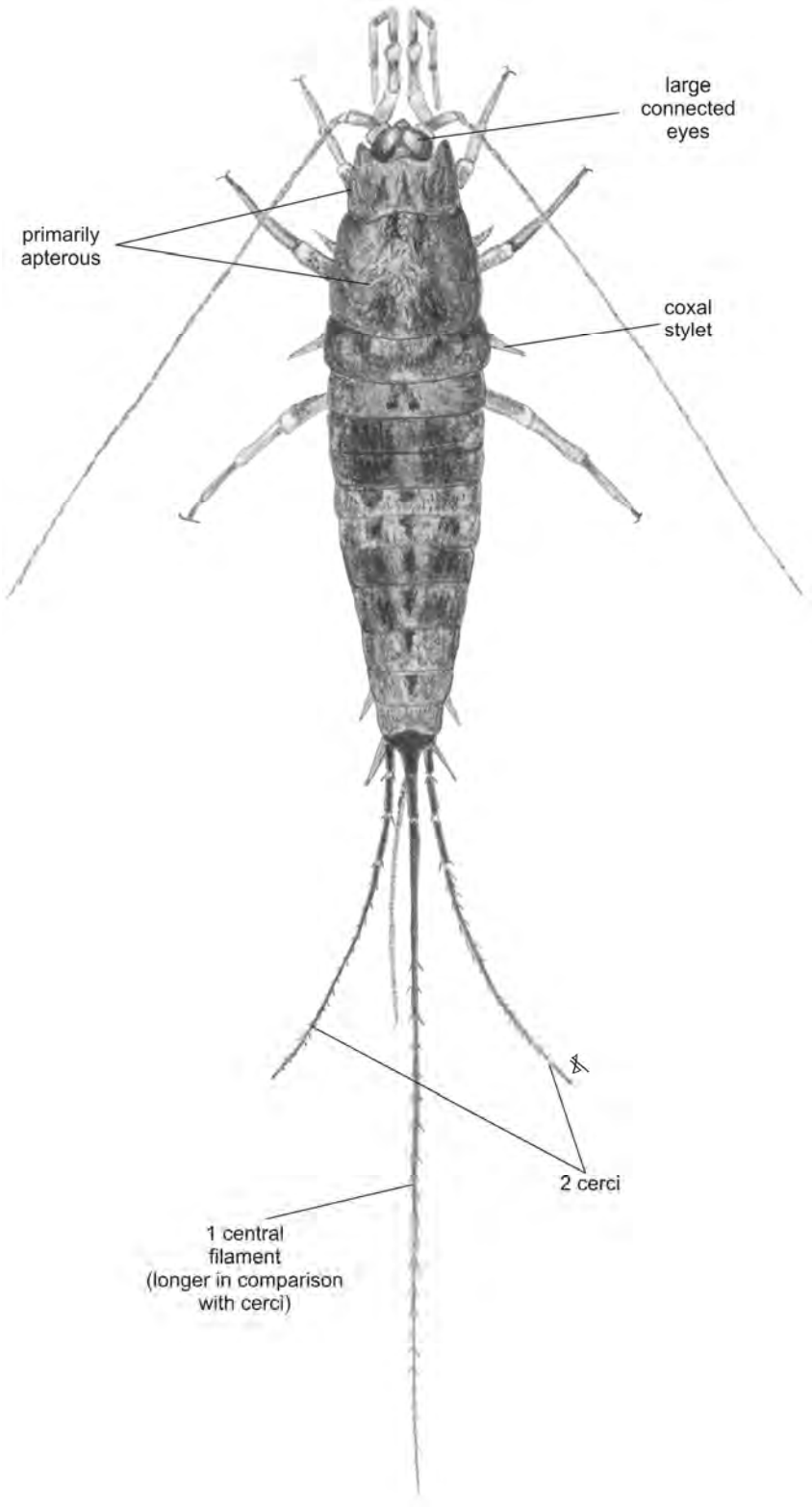
Two-pronged bristletails lead a hidden life in the uppermost layers of soil, under leaves, rocks, in moss, and the like. Only japygids (Japygidae) penetrate somewhat deeper.

Japygids (Japygidae) are predatory. They hunt small soil arthropods (even springtails and Campodeidae) and use pincers for holding their prey. They are among expressly thermophilic species (in Bohemia, only in the wider Prague vicinity).

Campodeidae are omnivores, feeding predominantly on plant detritus, perhaps even mycelium. Campodeidae are very tolerant to cold, even appearing high in the mountains and penetrating in the north up to colder areas (Finland and Norway).

Just as with springtails and coneheads (Protura), sufficient humidity is a condition for the existence of two-pronged bristletails.

Order: **ARCHAEOGNATHA** (jumping bristletails)		
derivation of the order's name arkhios (Greek) = ancient, gnathos (Latin) = mandible	number of known species in the world 350	number of known species in the Czech Republic 8
Metamorphosis: **hemimetaboly: epimetaboly**		



Systematics

This is in sequence the first order of insects and, along with the order Zygentoma, it represents the subclass Thysanura. Formerly, the two orders were combined as a single order, Thysanura, falling under the subclass Apterygota.

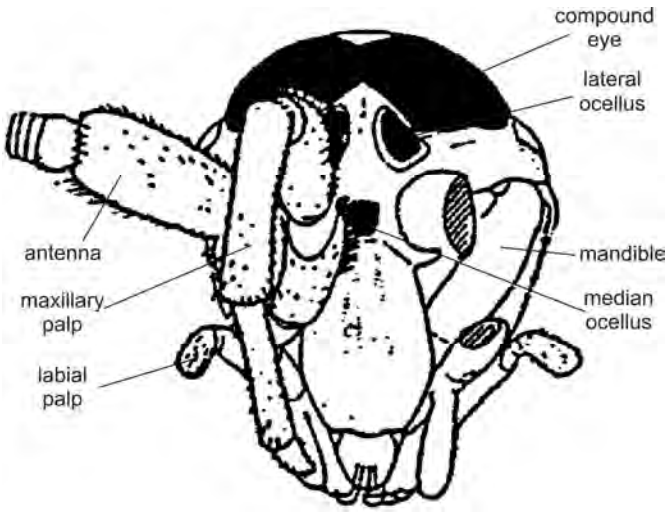
In contrast to those of springtails (Collembola), coneheads (Protura) and two-pronged bristletails (Diplura), mouthparts are ectognathous, close to the typical formation of the mouthparts of the Pterygota subclass, and therefore the classification of this order into the insect class is justified.

In the Czech Republic, there exists only the family **Machilidae**.

General characteristics and body description

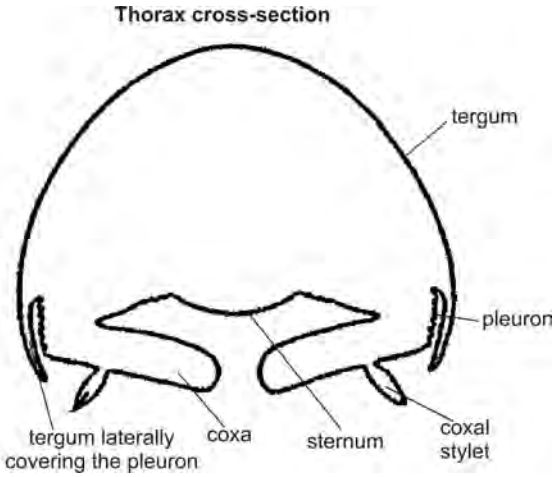
A primarily apterous species reaching up to 15 mm. The body is weakly sclerotized, covered by numerous pigmented scales, strongly arched on the dorsal side, regularly narrowing towards the rear, and terminating in conspicuous long bristles (cerci) and a terminal filament (epiproct).

Head is hypognathous to orthognathous, with ectognathous chewing mouthparts. Many-segmented antennae, setaceous; mandibles with a single joint articulation (one condyle); large compound eyes touching the forehead (most usable diagnostic feature), three developed ocelli; 7-segmented palpus maxillaris (partially used for locomotion).



Thorax markedly arched; terga laterally overlap the pleura. Wings primarily undeveloped (primary aptery). Gressorial legs, cylindrical coxae, 2nd and 3rd coxae often with a coxal stylus (=epipodite), tarsi with 3 (2) segments, 2 claws.

Abdomen 11-segmented, with 2 threadlike cerci and 1 terminal filament longer than the cerci (serving, apart from other things, for jumping [4–5 cm high and up to 10 cm distant]) on the end. Tergites extended in paranotal projections; 1 or 2 pairs of eversible vesicles on the 1st–7th segment; segments 2–9 ventrally with styli. Females with a slim ovipositor.



Food

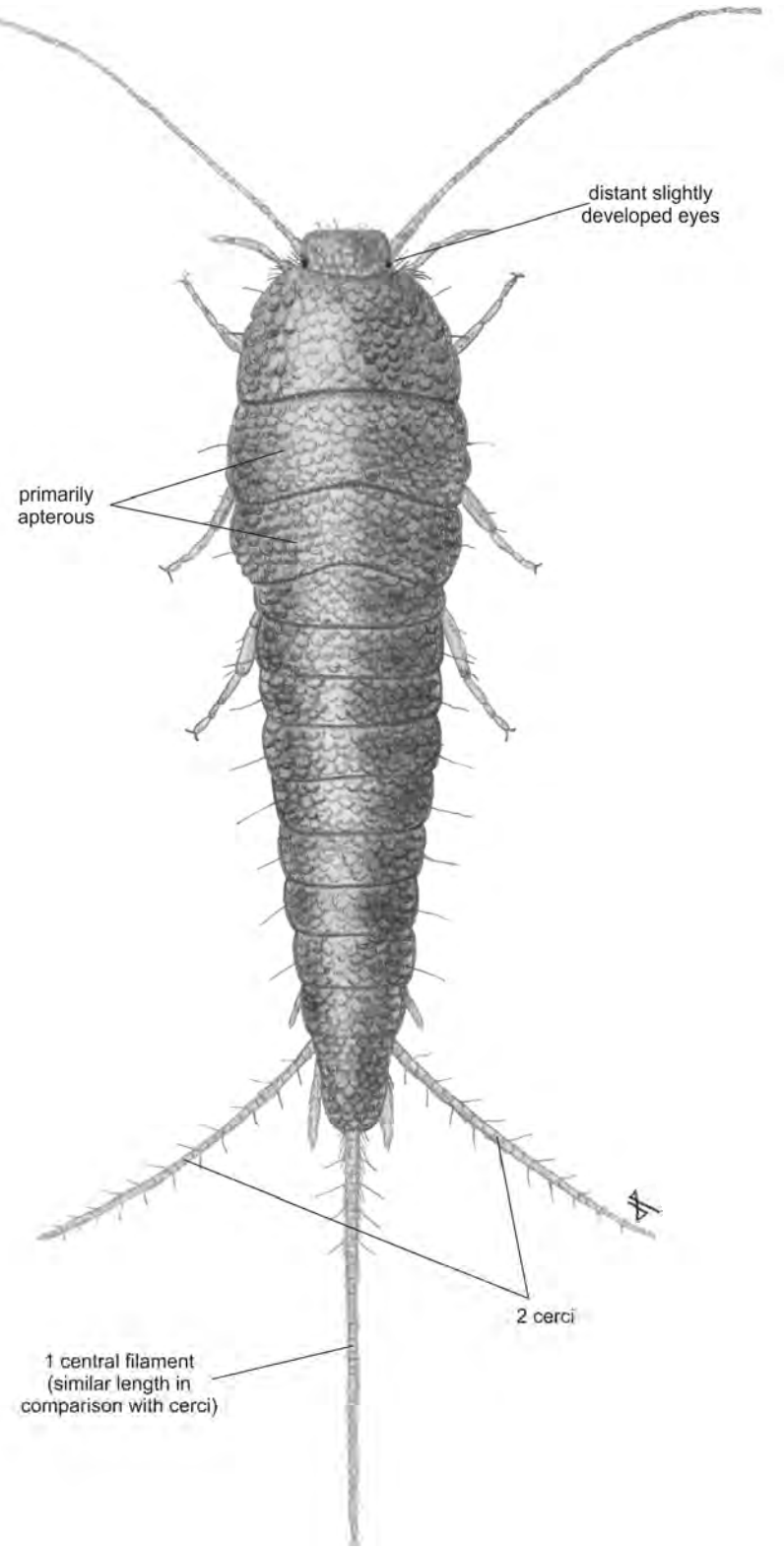
Jumping bristletails feed on algae and lichens.

Ecology

They prefer rocky sites, rocks, debris, tree trunks, moss, etc. The environment in which they live need not be so humid as for Collembola, Diplura, and Protura, but it must never go completely dry. Machilidae are not as demanding in regard to heat as the order Zygentoma (see below), and one can encounter them at heights of up to around 3,000 m a.s.l.

Fertilization is indirect. Males place their sexual products in the presence of females in liquid form and females actively accept them.

Order: **ZYGENTOMA**		
derivation of the order's name etymology of the name unknown	number of known species in the world 360	number of known species in the Czech Republic 3
Metamorphosis: **hemimetaboly: epimetaboly**		



Systematics

This is in sequence the second order of insects and, along with the order Archaeognatha, it represents the subclass Thysanura. Formerly, the two orders were combined into a single order, Thysanura, falling under the subclass Apterygota.

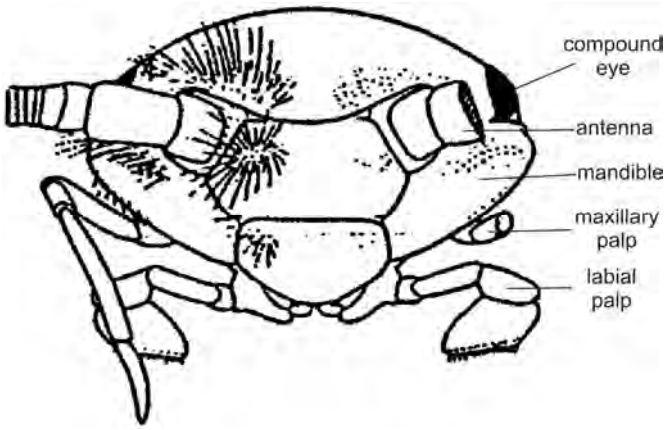
In contrast to those of springtails (Collembola), coneheads (Protura) and two-pronged bristletails (Diplura), their mouthparts are ectognathous (the same as in Archaeognatha).

In the Czech Republic, there exist only the 2 families: **Lepismatidae** and **Nicoletiidae**.

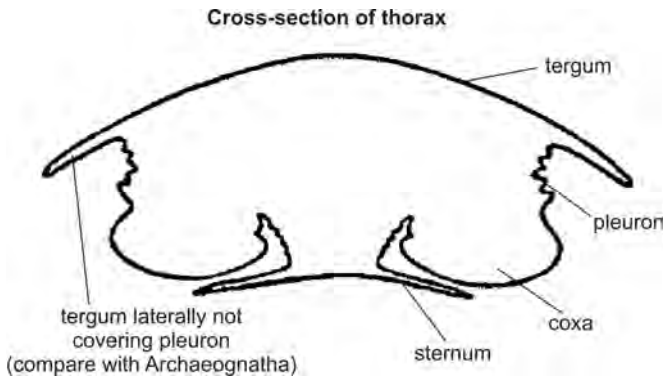
General characteristics and body description

Primarily apterous species with a weakly-sclerotized body, bare or with scales. Overall, the species are non-pigmented to pigmented, slightly arching from the top, regularly tapering towards the rear, and terminating with conspicuous long cerci and a terminal filament (epiproct).

Head is hypognathous to orthognathous, rarely prognathous, with ectognathous chewing mouthparts. Many-segmented antennae, setaceous; mandibles already with 2 joint articulations (condyles) (i.e. the same as in the remaining insect orders); compound eyes either reduced and separated from one another or undeveloped, ocelli not developed (except for one family); palpus maxillaris with 5 segments.



Thorax weakly arched to flattened; terga do not cover the pleura, while the lateral lobes may not even be developed. Gressorial legs, flattened coxae without styli, mostly 2-segmented tarsi, 3 claws.



Abdomen has 11 segments, terminating with 2 threadlike cerci and 1 terminal filament of approximately the same length as the cerci (in Archaeognatha the terminal filament is far longer than the cerci). Tergites are extended in paranotal projections; styli on abdominal segments reduced in various degrees, mostly present on the 2nd–9th segment, 7th–9th segment, or even absent. Only 1 pair of vesicles preserved, or completely absent (e.g. Lepismatidae). Females have a slim ovipositor.

Food

As omnivores, Zygentoma intake food of plant and animal origin (also as pests in storage rooms, households, museum collections, and libraries).

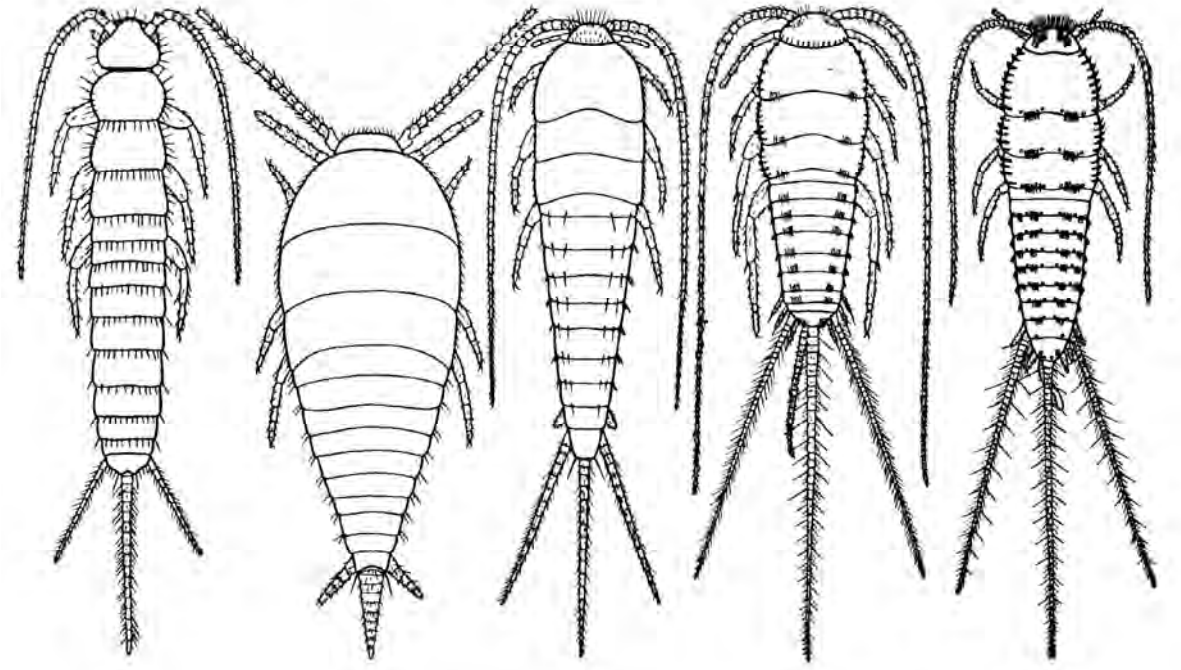
Ecology

Zygentoma are thermophilic, some species are tied to human buildings – e.g. silverfish (*Lepisma saccharina*), *Acrotelsa collaris*, and firebrats (*Thermobia domestica*). Certain species are permanent guests (commensals) in anthills and termite mounds, and, as a result, extensively changed their form.

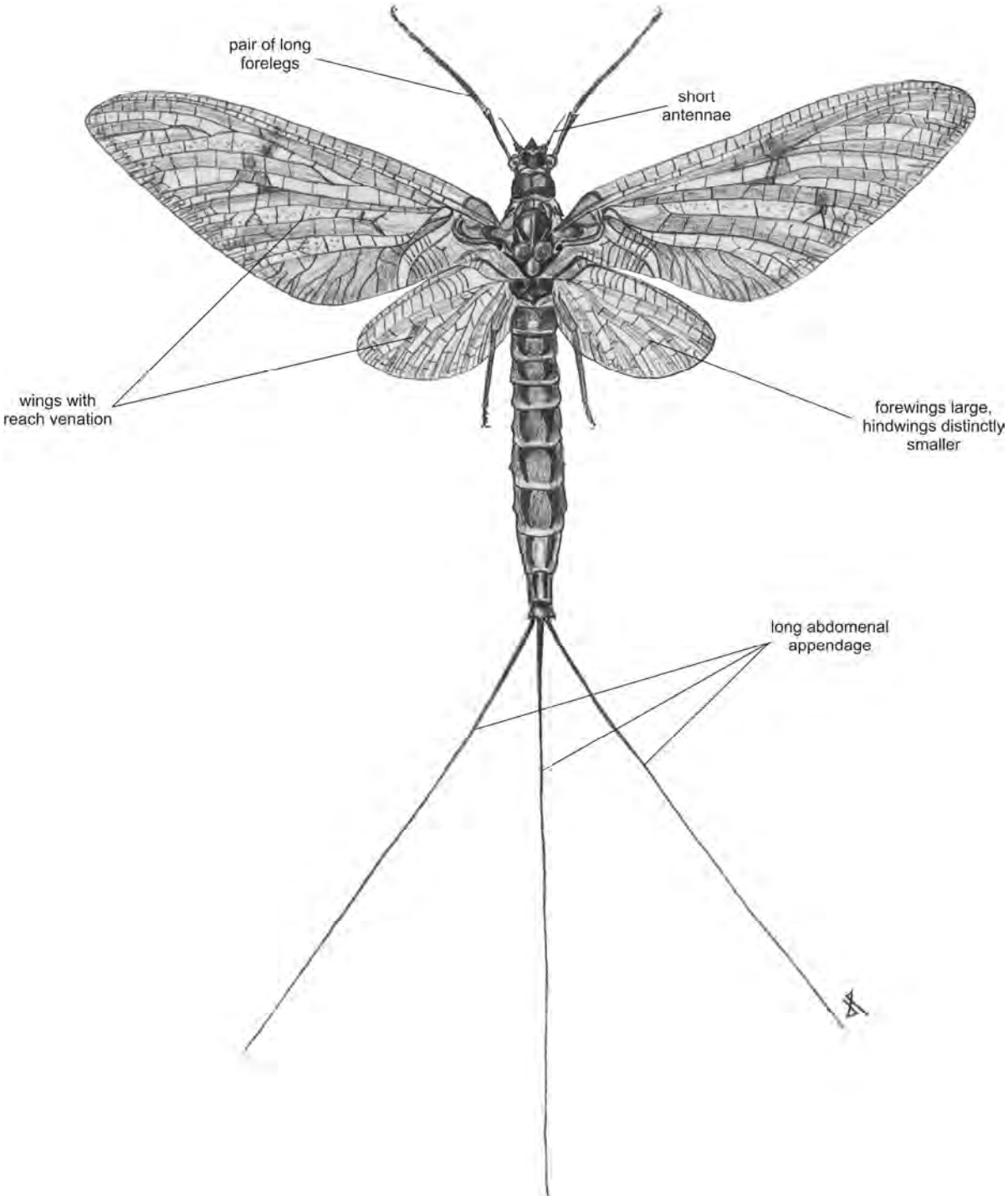
Imagos are relatively long-living; they can live for 2–3 years in nature, and synanthropic Zygentoma up to 4 years.

Fertilization is indirect. Males deposit their sexual products in the presence of females as spermatophores and the females then actively accept them.

Representatives of the Zygentoma order



Order: **EPHEMEROPTERA** (mayflies)		
derivation of the order's name ephemeros (Greek) = lasting one day, pteron (Latin) = wing	number of known species in the world 2,500	number of known species in the Czech Republic 95
Metamorphosis: **hemimetaboly: prometaboly**		



Systematics

The present-day fauna including ca 2,500 species is the remains of a rich fauna living approximately 200 million years ago (Permian–Triassic). Systematics is based on features on the ventral nerve cord, tracheal system, digestive system, gonads, and Malpighian tubules. They are systematically divided into 2 suborders:

- Suborder: **Schistonota** – larvae more "heterogeneous", and
- Suborder: **Pannota** – larvae more "homogenous".

General characteristics and body description of the adult

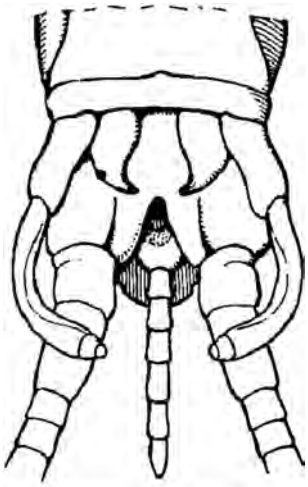
Inconspicuously coloured yellowish to grey–brown species with lightly sclerotized bodies. Body size (without terminal appendages) ranges from 3 to 40 mm.

Head is relatively small, with vestigial to entirely reduced mouthparts (adults do not ingest food). The strongly arched compound eyes are conspicuously large, sometimes divided into two sections that may be coloured differently; ocelli are always developed. Antennae are minute, short, and consisting of two larger basal segments (scape and pedicle) and the flagellum.

Thorax has, of all thoracic segments, the most strongly-developed mesothorax, bearing a pair of large triangular transparent wings that are without hairs and usually also with very dense venation. Hind wings are always much smaller and may be even entirely absent (*Caenis*, *Cloeon*). In resting position, the wings are erected perpendicularly above the body and folded by the dorsal side against one another (mayflies of the genus *Caenis* are the exception, as they hold their wings horizontally). Narrow prothorax, mesothorax firmly attached to the metathorax.

Legs have 3–5-segmented tarsi; in case the number is less than 5, the basal segments are only hinted at and immovably attached to the tibia. The terminal segment is fitted with 2 claws. Forelegs, especially of males, are markedly elongated and carried as if sticking forward.

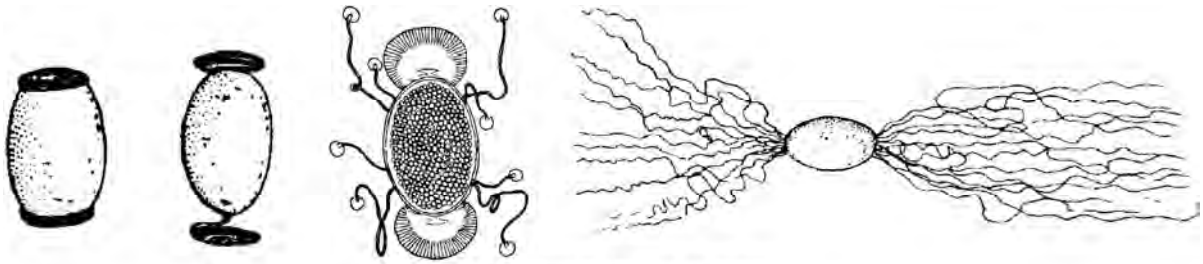
Abdomen is slim, cylindrical, consisting of 10 distinct segments. The end of the abdomen is equipped with three long, terminal, thread-like appendages important for flight. In connection with the stunting of the mouthparts, the digestive tract also has a different function. It is filled with air, thereby decreasing the specific weight of the animal, but also helping to push out eggs. Male reproductive organs are located on the 9th segment; female ones between the 7th and 8th sternites. In males, segmented gonopods are located on the 9th sternite, which, along with the penis, comprise the most important taxonomic features.



male genitalia

Egg

Eggs are small (0.15–0.40 mm), and in all species they are equipped with attachment mechanisms of various types (from a sticky secretion to various appendages, spiral-shaped threads, and the like).



eggs with various types of adhesive structures

Larva

The nymph that hatches from the egg (larvule) lacks respiratory organs and breaths through the body surface. Antennae are also only hinted at; the terminal filament is frequently absent. At this time, its size does not reach even 1 mm.

Head carries large compound eyes, 3 ocelli, and short filiform antennae. Mouthparts are very well developed, chewing, with strongly sclerotized mandibles.

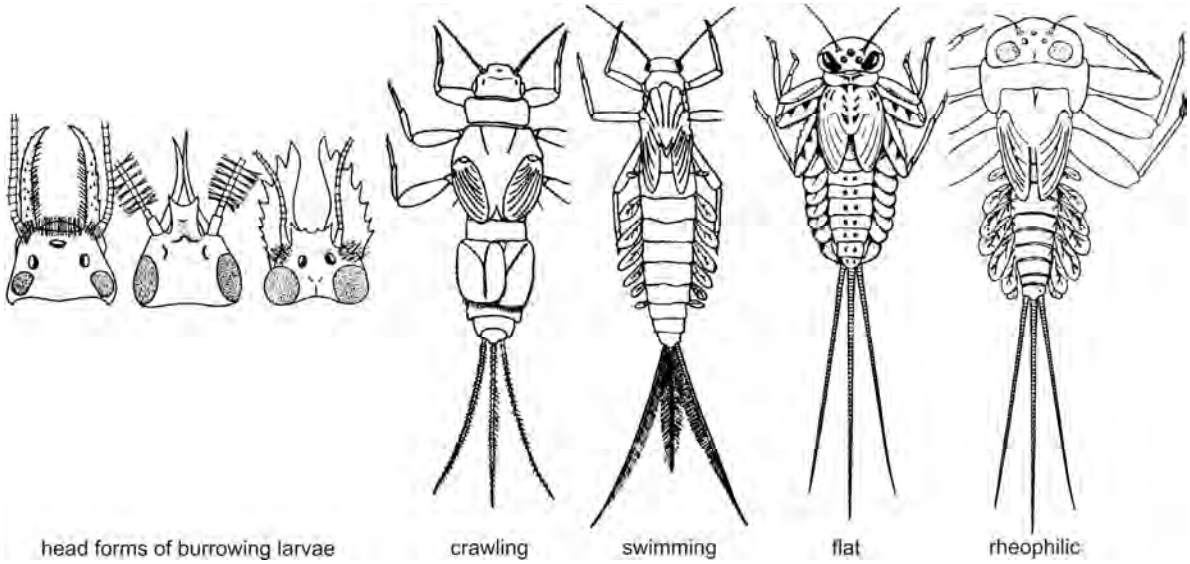
In further development, all appendages grow, tracheal gills develop, and the bases of wing sheaths emerge. After several moultings the larvae reach sizes around 2–3 mm, in principle do not change shape, and changes in size are accompanied by growth of the wing sheathes.

Legs are well-developed; tarsi have one segment with one claw. The characteristic leg shape is to a certain extent adapted by the conditions.

Abdomen is 10-segmented and equipped on the end with 3 long bristles that are often strongly ciliate. The first 7 segments each bear 1 pair of leaf-shaped tracheal gills, which also serve in part for locomotion. Gills are movable and, especially in still water with low oxygen content, their movement aids in better supplying oxygen. Swimming ability then depends especially on the terminal bristles and degree of their ciliation.

Larvae's body shape is significantly adapted to the conditions of the aquatic environment, especially to the speed of flowing water. One can thus quite distinctly differentiate 5 basic types of larvae:

- **Burrowing** larvae live in still and slowly flowing water. Using their strong forelegs and specifically formed long mandibles, they dig tunnels in the banks and on the bottom. Tracheal gills are located rather dorsally and their continuous movement ensures movement of water in the channels.
- **Crawling** larvae are typical for still, slowly flowing, and calm parts of mountain streams. They have longer gressorial legs and sparsely ciliated terminal bristles, and are thus also poor swimmers. They move slowly along the bottom, often covered by mud and detritus.
- **Swimming** larvae most frequently live in gently flowing waters with rich vegetation, where they wait for their prey or feed on coatings of algae. They frequently have protruding leaf-shaped gills, and terminal bristles are strongly ciliated. These two organs supply them with great mobility.
- **Flat** larvae live in fast-flowing waters, have a visibly flattened body, a large, wide head, frequently leaf-shaped extended limbs, and wide leaf-shaped tracheal gills. These adaptations enable them to use water pressure to increase their adhesion to the earth. They have crab-like movement, constantly pressing their body area to the earth.
- **Rheophilic** larvae live in swiftly flowing waters. They are similar to flat larvae, although the body is flatter and the head is overall helmet-shaped.



The number of larval instars is quite large and is not entirely stable within a given species. The average number of instars ranges around 12, and the highest established number exceeds 40.

Ecology

During hatching, one may encounter mass swarms for a number of species. Imagos most frequently fly in the evening before sunset, although a number of species swarm in full sunlight. Nuptial dances (swarms) are attended mostly or, at least in the initial phase, only by males, while the females remain on vegetation for the majority of the time and only join the swarm later. Males take off practically vertically upwards, flight is fluttery, and the body is positioned vertically. After reaching the necessary height, they change their body position to horizontal and with outstretched wings and terminal bristles they descend to the ground. Fertilization occurs either during the flight or on vegetation. Parthenogenesis is also known in certain species.

The females lay eggs almost immediately after fertilization, and in the simplest case by dropping them directly on the surface of the water (especially species living in still or only lightly flowing waters). In other cases, they will dip the end of the abdomen below the surface when laying. Less frequently (in species developing in rapidly flowing water), the female dives below the surface and sticks the eggs to stones, moss, leaves, and other objects.

In addition to the most common characteristic ovipary, ovovivipary and larvipary (species of the genus *Cloeon*) also may be encountered, though less frequently. Embryonic development lasts for 1–3 weeks in most mayflies. In a number of species (species swarming in the summer), egg diapause occurs. Diapausing eggs are very resistant to adverse environments and tolerate even drying out.

Larvae (nymphs) hatch from the eggs and are mainly herbivorous. Certain species are sensitive to changes in water purity and may thus serve well also as indicators thereof.

Adult nymphs frequently rise to the surface en masse and crawl onto rocks, plants, and branches. In the case of species living in still waters, they only rise to the surface where they spread their bristles and gills and remain lying on the surface. Soon thereafter, especially in evening hours, the skin on the nymph's head and thorax ruptures, and within several seconds the animal is not only free, but also able to fly away.

This hatched so-called subimago already bears all the characteristics of the imago, slightly differing in appearance only in coloration, atypical ciliation, and milk-coloured wings. In males, moreover, the external reproductive organs are absent. In most species, the subimago very shortly moults into a proper imago. The interval of this last moulting depends on the species and ranges from 2 minutes to several days. This type of postembryonic hemimetabolic development with the presence of a subimago is unique and only occurs in mayflies, and is therefore called prometaboly.

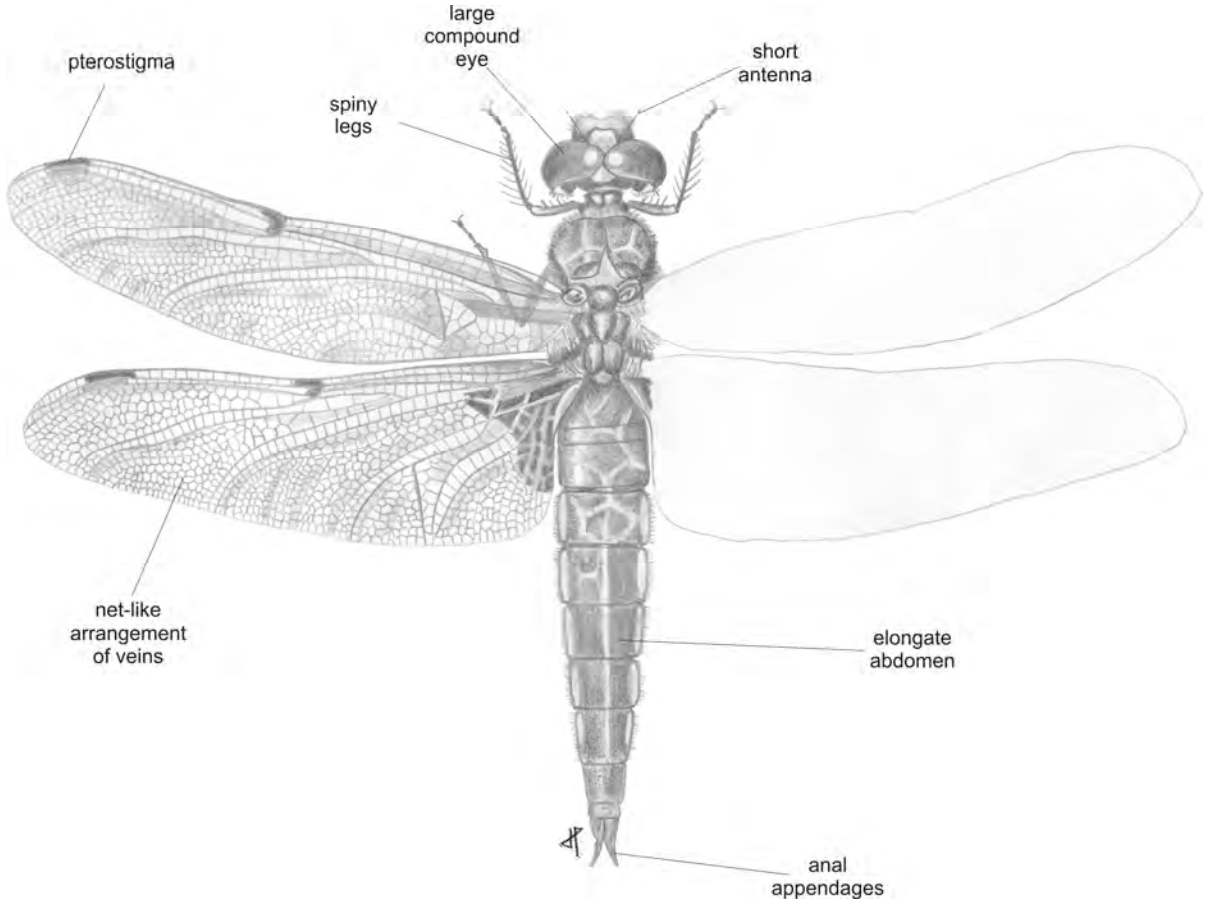
The lifespan of the imago is always short, ranging from several hours to between one to several days (exceptionally 10 to 14 days – the longest living mayfly of the genus *Cloeon* found in the Czech Republic). While males die shortly after copulation, females die shortly after laying eggs.

The development of most mayflies takes 1 year. In certain species, however, 2 generations per year are possible (usually in early spring and late summer). In contrast, certain large species have 2-year generations.

Food

Adults do not ingest food. Larvae of most species of this order are herbivorous and feed on both living (coverings of algae, diatoms) and dead material. At least certain species, especially burrowing forms, are evidently partially predatory (carnivorous) or omnivorous. In species living in flowing waters, a filtration apparatus may be developed on the mouthparts or legs, enabling the capture of food from the flowing water.

Order: **ODONATA** (odonates)		
derivation of the order's name odous (Greek) = tooth	number of known species in the world 5,300	number of known species in the Czech Republic 75
Metamorphosis: **hemimetaboly: prometaboly**		

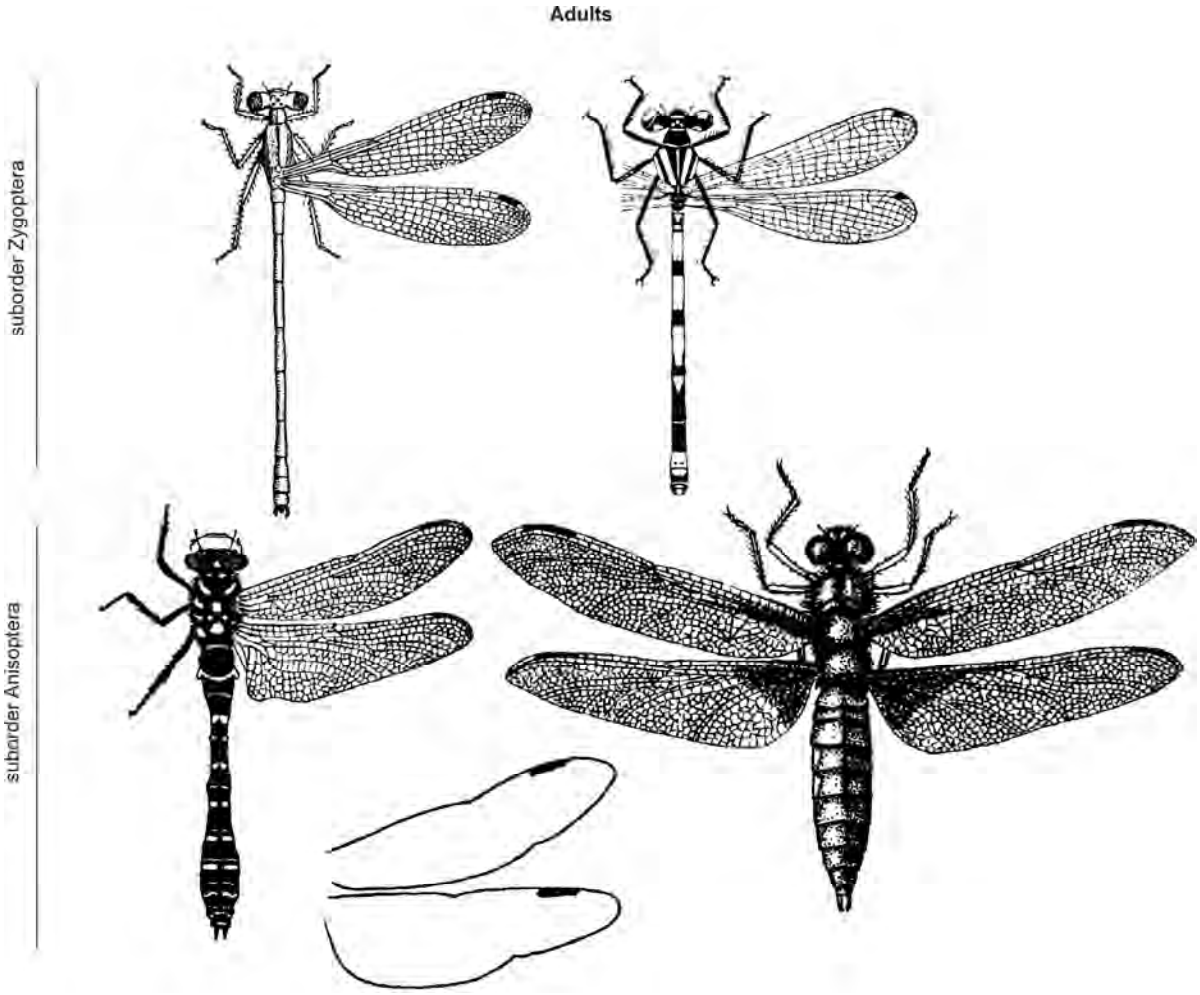


Systematics

An ancient insect group divided into 3 suborders, only 2 of which occur in the Czech Republic:

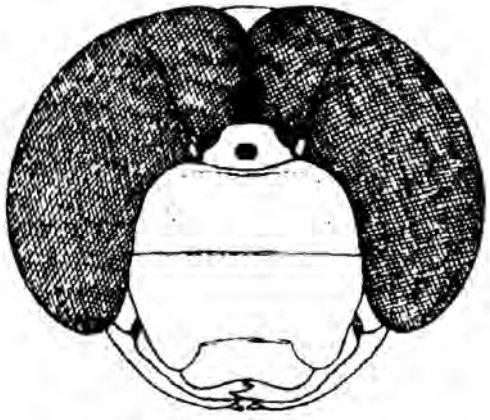
- Suborder: **Zygoptera** (damselflies) – thin species with a very slim abdomen, slim wings at the base, folded together at rest over the abdomen (e.g. Coenagrionidae) or askew towards the rear (e.g. Lestidae). Eyes angle to the sides and are widely separated. Flight is slow, rather fluttery.
- Suborder: **Anisozygoptera** – today, only 3 recent species living in Asia (in Japan *Epiophlebia superstes*, in Nepal *Epiophlebia laidlawi*, and in China *Epiophlebia sinensis*).
- Suborder: **Anisoptera** (**dragonflies**) – more robustly built species, the abdomen is never markedly thin. Hind wings extended at the base, spread horizontally when resting. Eyes (with the exception of Gomphidae and the exotic Petaluridae) touch at the top. Mostly excellent fliers.

The most recent approach distinguishes only 2 monophyletic groups: Zygoptera and Epiprocta (Anisoptera + Anisozygoptera).



General characteristics and body description of the adult

Slim, frequently also colourful and metallic-coloured forms of size ranging from 1.8 to 13 cm in body length, spanning up to 14 cm. Imagos and larvae are carnivorous and hunt their prey, consisting of various insects, in flight and often also consume it in flight. Males protect their territory from members of the same and other species.


Head of the anisoptera order
(large eyes joined at the vertex)

Head is orthognathous, wider than the thorax, connected to the thorax with a thin membranous neck, so it is extremely movable in all directions. Compound eyes are always large; in the suborder Anisoptera they occupy the largest part of the head and often touch on

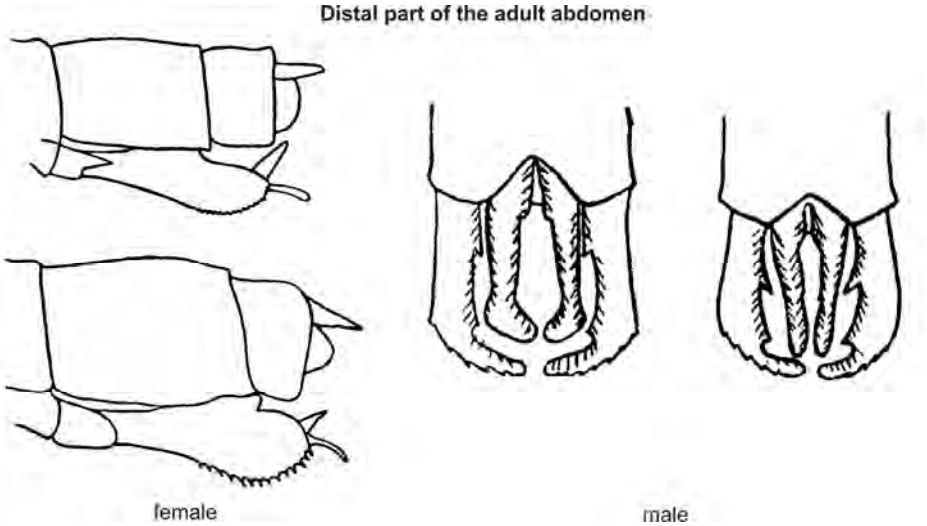
the top of the head (hawkers [Aeshnidae]). The top half of the eye frequently consists of larger, and often also differently coloured, facets. In the suborder Zygoptera, the eyes are large and arched but positioned on the sides of the head. They consist of a remarkably large number of individual eyes (facets), so the sight organs of odonates are among the best of all the insects (important for sharpness of vision). Three ocelli are always developed. Antennae short, setaceous (flagellum max. 5 segments), apparently playing an entirely secondary role. Chewing mouthparts with robust mandibles (maxilla are also equipped with teeth).

Thorax consists of small prothorax, movable against the following segment; meso- and metathorax fused and robust.

Legs are slim and gressorial, although they lost the ability to walk almost completely. In many cases, they are not even able to support the animal, so a number of odonates essentially hang from vertical objects. Tarsi are 3-segmented; the last segment carries 2 claws. The main purpose of the legs (especially forelegs) is capturing flying prey. The legs are therefore shifted significantly forward and equipped with prickles and spines, which is helped by the oblique position of the sternal part of the thoracic segments. The body of the imago assumes a vertical position when hunting.

Wings are always developed in 2 pairs. They are usually transparent, although sometimes with spots or brightly coloured, with rich and relatively primitive venation. Although smooth transitions in the formation of wings exist among all suborders, two basic types are nevertheless apparent. In Anisoptera the hind wings are markedly wider than the forewings, while in Zygoptera the two pairs of wings are approximately identical, relatively narrow at the base, and extend distally. During flight, the individual pairs of wings either operate simultaneously (in the suborder Anisoptera – excellent fliers), or alternately (Zygoptera – inferior flight ability, rather fluttery).

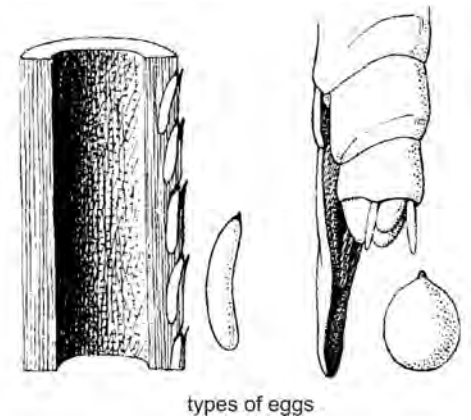
Abdomen is long, cylindrical, 10-segmented. The dorsal parts are strongly developed, and the smaller ventral sclerites often sunken. On the upper side of the 10th segment, both sexes have a pair of unsegmented appendages. In male Zygoptera, there is also a pair of lower anal appendages (under the anal opening), and in male Anisoptera, moreover, a non-paired ventral anal appendage (above the anal opening). These abdominal appendages especially serve the male for holding the head (in Anisoptera) or thorax (in Zygoptera) of the female during copulation. A gland with a sticky secretion located in the 10th segment also supports a firm grip.



The female reproductive organ opens between the 8th and 9th segments and, in species that deposit eggs into plant tissue, it is equipped with an ovipositor composed of three pairs of gonapophyses. The male gonopore opens on the 9th segment, but the copulation organs are not developed here. A complex copulation apparatus is found on the sterna (lower side) of the 2nd and 3rd abdominal segment. Here, a penis and a seminal receptacle are formed for temporary storage of sperm, and 1–2 pairs of hooks for grasping the female's ovipositor during copulation.

Egg

Eggs are very diverse (long oval to almost spherical), depending on whether they are deposited into the substrate (generally a smaller number of larger eggs without sculpture is laid) or only laid in the water (eggs frequently with sculpture, round, darkly coloured, and equipped with an attachment apparatus in the form of an adhesive, appendages, etc.).

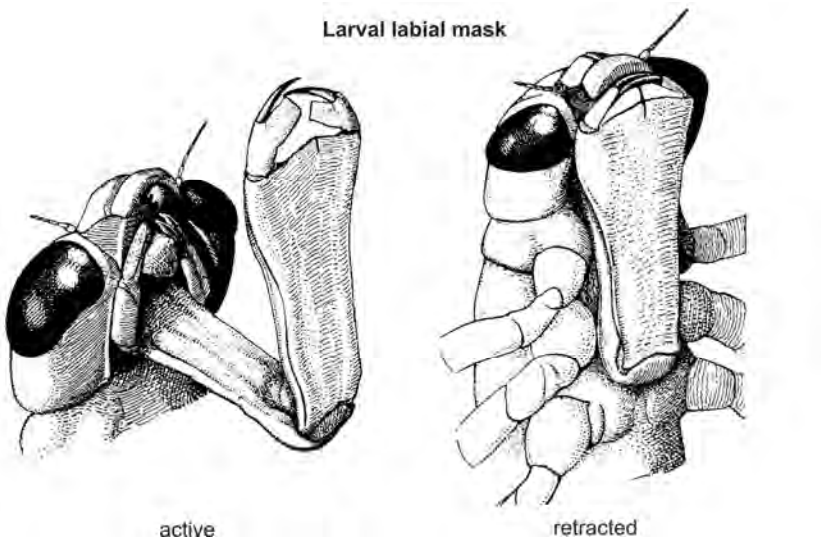


types of eggs

Larva

Nymphs are in principle aquatic and essentially similar to adults. Older instars already have wing sheaths; however, the body is shorter and more robust.

Head is prognathous, with large mandibles. The labium is transformed into a so-called labial mask for capturing prey. It consists of the submentum and mentum, with the mentum bearing paired lateral lobes fitted with pointy, elongated teeth on the external side (transformed labial palps). Both lobes move pincer-like against one another. The shape of the mask is characteristic for the species and genus.



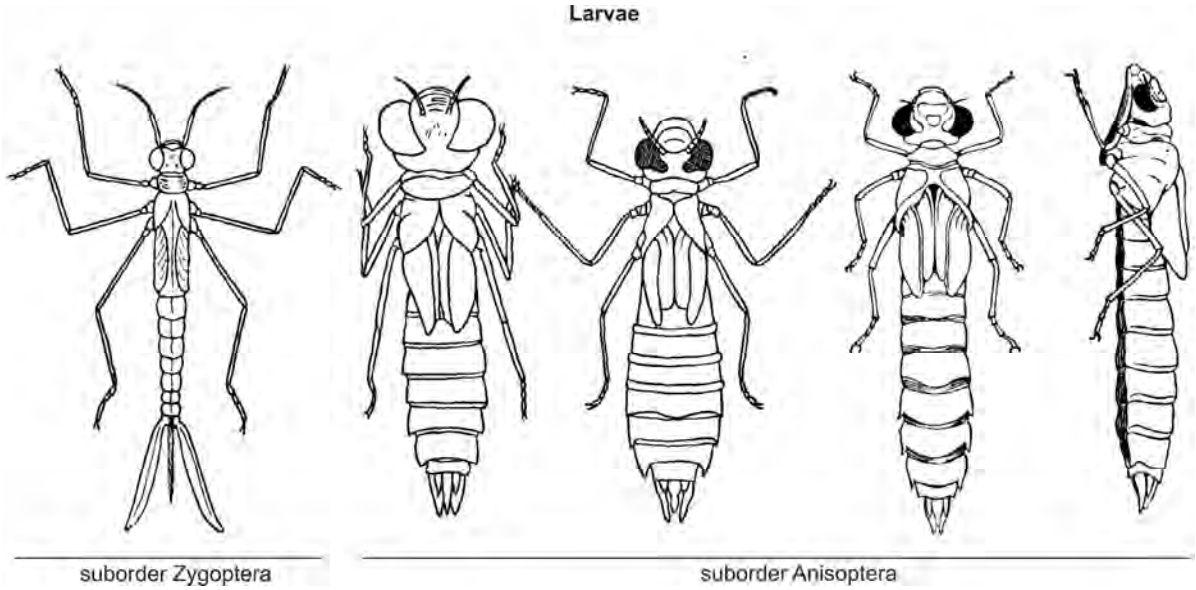
Legs are gressorial, modified for holding or burrowing.

Abdomen has 10 segments widely connected to the thorax.

- In Zygoptera, it is slim and terminates in three fine, generally leaf-shaped appendages that are tracheal gills. They serve as swimming organs and additionally also for respiration because the main respiratory organs in odonates are always rectal gills.
- In Anisoptera, the abdomen is significantly more robust and the end of the abdomen bears 5 pricle-like appendages forming a so-called anal pyramid.

The mighty musculature of the abdomen constantly sucks in and expels water out of the terminal part of the digestive tract, where 6 double rows of leaf-shaped rectal tracheal gills are located. The tracheal system of the larvae is therefore closed.

They go through 7–15 instars, and the number of instars depends on development conditions (especially water temperature and food) and, therefore, need not be constant even within the same species.

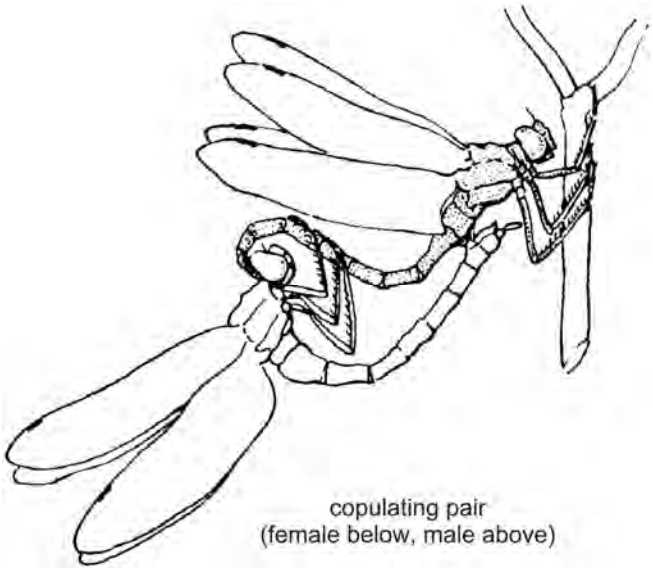


Ecology

Odonates can be encountered in practically all fresh water (including brackish water up to a certain salinity). Smaller lakes, ponds, and swamps with rich herbaceous vegetation are the richest. Some species move primarily along herbaceous vegetation (in particular, representatives of the families Coenagrionidae [narrow-winged damselflies] and Aeshnidae [hawkers], while other species prefer a muddy bottom where they dig out tunnels (e.g. skimmers [Libellulidae]).

Certain species also live in rapidly flowing cold waters, such as certain clubtail dragonflies (Gomphidae) and spiketails (Cordulegastridae).

It is possible to assess lifestyle according to the coloration of larvae, although it frequently changes during the course of life. Unicoloured dark larvae usually belong to the bottom fauna. Green (Green Hawker [*Aeshna viridis*]) and otherwise multi-coloured ones are denizens of plants, where they hunt for food.


copulating pair
(female below, male above)

Most species move only slowly using their legs; they achieve rapid movement by serpentine body movement and especially by sharply expelling water from their anus, which they also use for respiration.

If the oxygen content in the water drops significantly, larvae of the suborder Anisoptera rise to the surface, thrust out the end of the abdomen above the surface, and suck in air. In the tropics, the larvae of the odonates oftentimes even move on moist ground. Certain species existing in the Czech Republic can also survive long-term involuntary stay in the open air (e.g. broad-bodied chaser [*Libellula depressa*]).

The aforementioned species also develops in small puddles that frequently dry out during the year, and it is able to stay for up to 50 days on dry land, where it goes into a kind of dryness-induced torpor.

Several days before metamorphosis they cease ingesting food, the imago develops under the skin, and the nymph emerges from the water. Imagos usually hatch in the morning hours. The skin splits open lengthwise on the dorsal side from the head to the wings, and the imago crawls out. A total of about 4 hours pass before the imago, still incompletely coloured, is able to fly for the first time.

Sexual maturity occurs, depending on the species, after 3–28 days from hatching. The males then attempt to impregnate any female that comes within their reach. The start of the reproductive act occurs in the air. The copulation itself occurs in the air or after landing, when the male grasps the female's prothorax (Zygoptera) or head (Anisoptera) with its legs. Depending on the species, the sperm is transferred (by bending the abdomen) into an auxiliary copulation apparatus either before or after grasping the female. In this phase, the two connected individuals usually land and the copulation itself follows when the female bends the abdomen forward towards the male's reproductive organ and the actual sperm transfer occurs. In certain species, the entire reproductive act is performed in the air, as for example in the species common to the Czech Republic from the genus *Libellula*. After copulation, in the majority of species the pairs disconnect, although in a whole number of different species the two sexes fly together (in tandem) until the laying of the eggs.

Eggs are laid immediately after fertilization into either live or dead plant tissues (endophytic species, as are hawkers from the family Aeshnidae and damselflies of the family Coenagrionidae). In other cases, the eggs are laid on plants in the mud and sand (and then descend below the surface, surrounded by a silvery layer of air) or are simply dropped into water, sometimes in strings and other formations. Certain species also lay eggs outside of water, into the moist ground of the banks (exophytic species).

Nymphs hatch after 2–6 weeks from eggs laid in early summer, while eggs laid in late summer do not diapause until the next spring and the egg stage then lasts for 6–8 months.

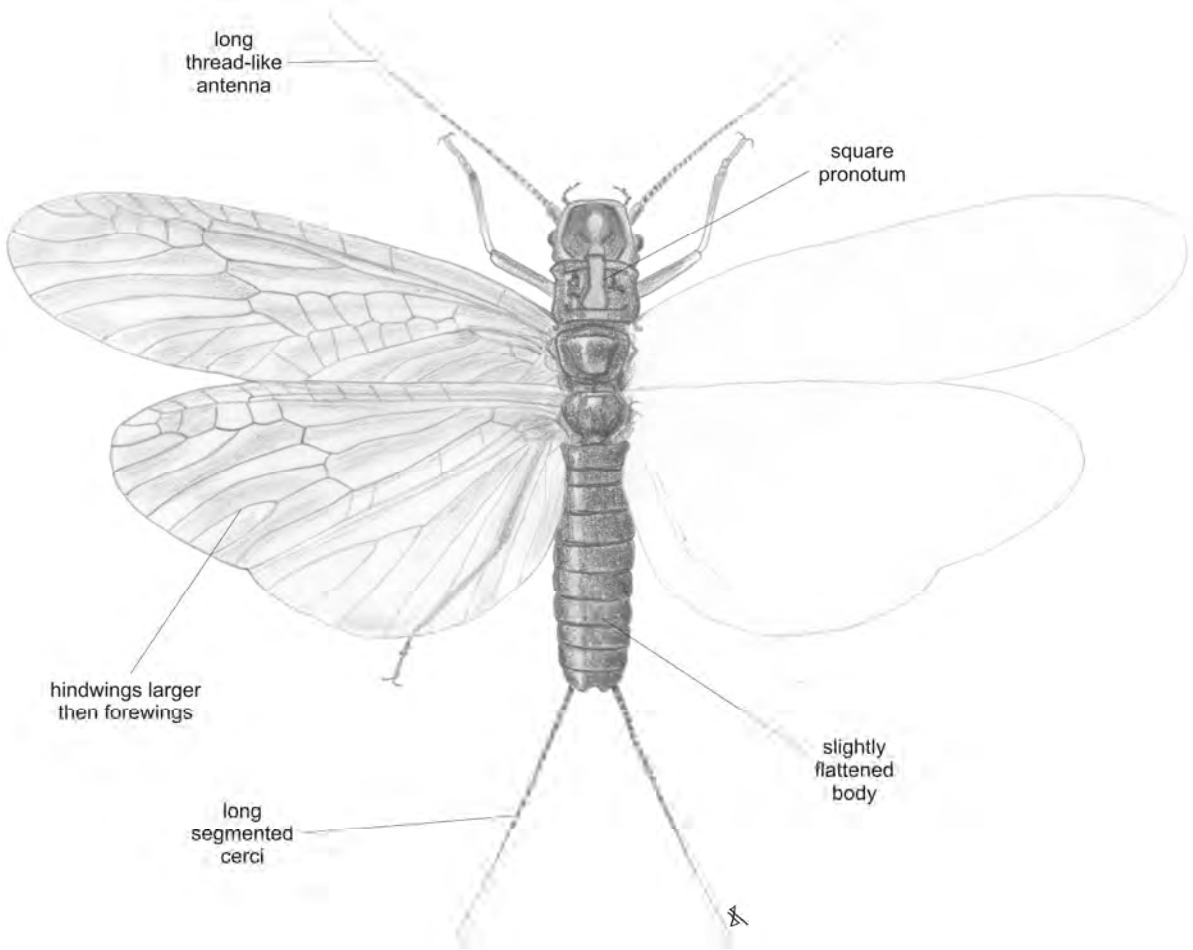
Total development time varies considerably and depends on geographic position as well as climatic conditions. The period of development ranges between 1–4 years.

The majority of species in the Czech Republic's geographical latitude overwinter as larvae, certain species as eggs, and relatively rarely as adults (*Sympecma*).

Food

Adults are predators and hunt various insects in flight. Larvae of odonates are likewise exclusive predators, but in comparison to adults they are altogether hardly mobile, and therefore frequently wait without movement for hours until the prey approaches and they can then seize it in a flash by flinging out the labial mask. They are very voracious and, as soon as they grow a little, attack anything living they are able to seize (from worms, annelids, and arthropods up to small fish).

Order: **PLECOPTERA** (stoneflies)		
derivation of the order's name plekein (Greek) = to braid, pteron (Latin) = wing	number of known species in the world 2,000	number of known species in the Czech Republic 105
Metamorphosis: **hemimetaboly: archimetaboly**		



Systematics

One of the oldest insect groups, dating as early as from the Permian. Most current cladistic classifications divide the stoneflies into 2 suborders, only 1 of which occurs in the Czech Republic:

- Suborder: **Arctoperlaria** (stoneflies of the Northern Hemisphere) – males tap on the substrate with the ends of their abdomens, attracting females. The end of the abdomen is also formed specifically for creating sound (with a tapping lobe, or so-called hammer).
- Suborder: **Antarctoperlaria** (stoneflies of the Southern Hemisphere) – a sternal muscle compressing the fore trochanters is present, while, on the other hand, no tergal compressor is present.

Older division was based on the morphology of mandibles and maxillary palps and also divided the stoneflies into 2 suborders – Setipalpia and Filipalpia. This division, however, includes a number of paraphyletic groups.

General characteristics and body description of the adult

Medium-sized species with inconspicuous, predominantly brown or grey coloration. They always stay near water, where they develop. Females are often possible to identify only down to genera. Males have many more diagnostic characteristics and may thus be identified down to the species. Stoneflies are widespread throughout the entire world, but their focal point and largest number of species occurs in the temperate zone. In contrast, only a few species live in the tropics.

Head is usually prognathous, flattened, and triangular shaped. Chewing mouthparts (in certain species fully functional, in others vestigial). Relatively large eyes, ocelli developed, usually 3 (exceptionally only 2). Long, filiform antennae consisting of 50–100 segments.

Thorax – all segments are approximately similarly well-developed. The prothorax is therefore large.

Legs are gressorial, slim, relatively long, with 3-segmented tarsi. Praetarsus with 2 claws and a central large prehensile pad, facilitating easy movement on very smooth and steep surfaces.

Wings are developed in 2 pairs. The forewings are large, elongated, and oval; the hind wings are smaller, triangular, with a strongly developed anal lobe. At rest, the wings are folded over the abdomen, always extending beyond its end. In certain species (only the genus *Leuctra*), the wings also sheathe its sides. Certain species are brachypterous (more often males); aptery is an exception.

Flight capabilities are relatively weak. Movement of both pairs of wings is independent (which is a relatively primitive feature in insects), and flight is therefore fluttery and clumsy. When threatened they do not try to escape by flight, but simply fall down or try to swiftly escape on foot.

Abdomen is long and has 11 segments, the first segment being very small and barely noticeable. The end of the abdomen bears 2 segmented cerces of various lengths (sometimes only 1–2 segments). For the first time, external copulation organs in males are encountered, with the eversible part bearing various chitinous formations.

Egg

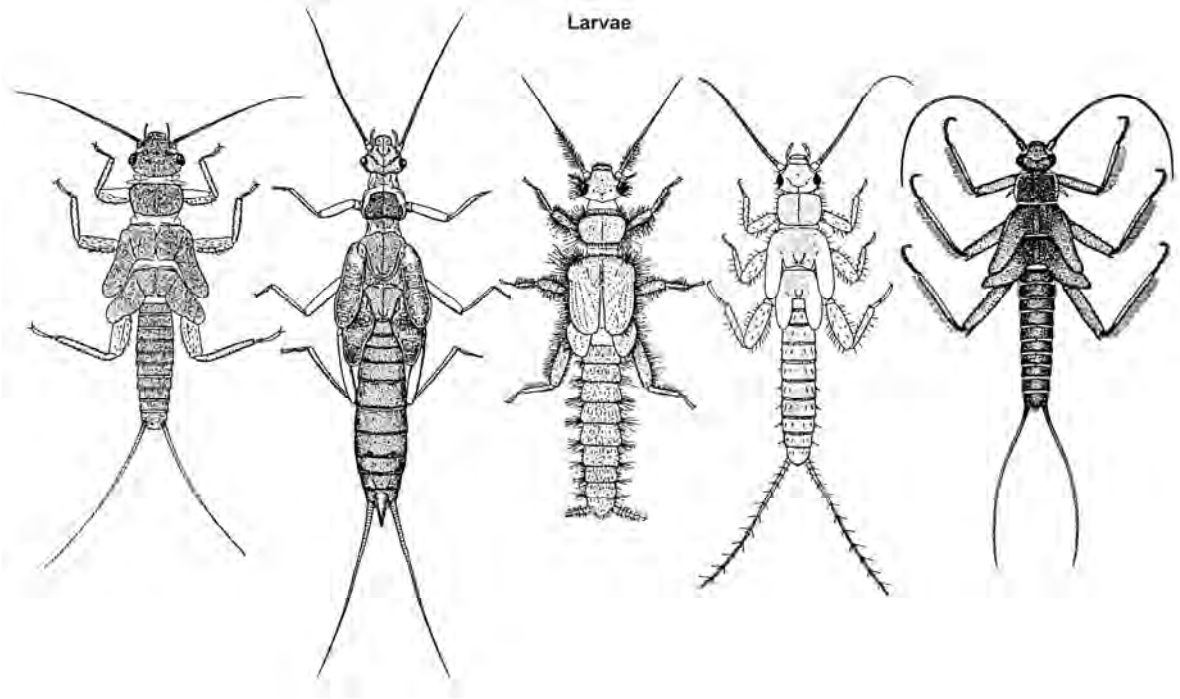
Eggs are small, oval to spherical, with various appendages used for sticking to surfaces.

Larva

Head is prognathous, antennae long and filiform, eyes not well-developed (due to way of life, eyes play a secondary role; in the larvae of Perlidae, prey is recognized only from a distance of around 3–4 cm).

Legs are gressorial, very well-developed. In species digging in mud, they bear various extensions of the tibiae, prickles, and hairs.

Abdomen bears two conspicuous, long, segmented bristles on the end.

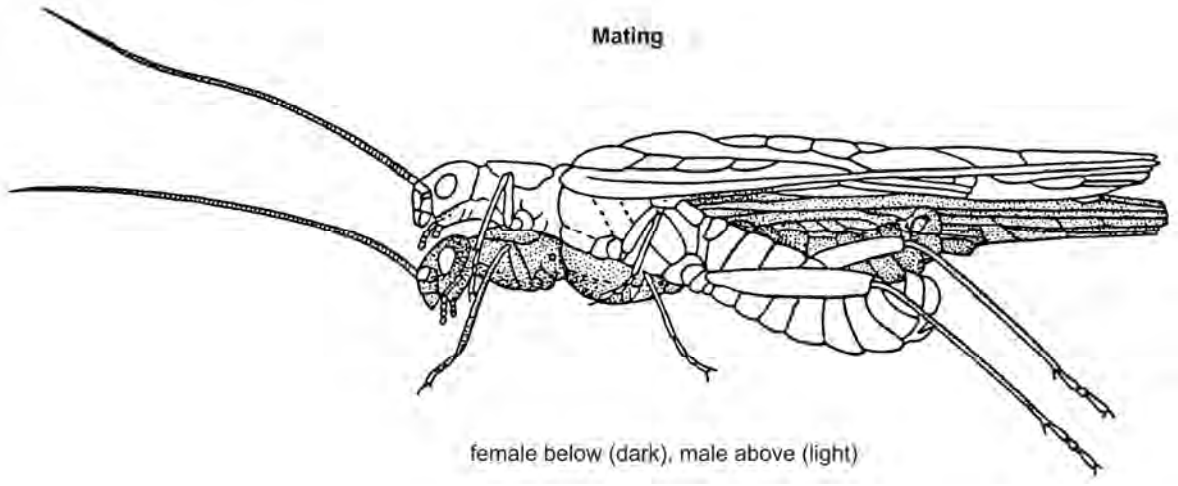


Larvae breathe through tracheal gills that are found beside the abdominal segments, as well as on other less-sclerotized places, such as the neck, thoracic segments (most frequently), and leg bases. The gills are feathery, leaf-shaped appendages, and, in contrast to mayflies, they are immobile.

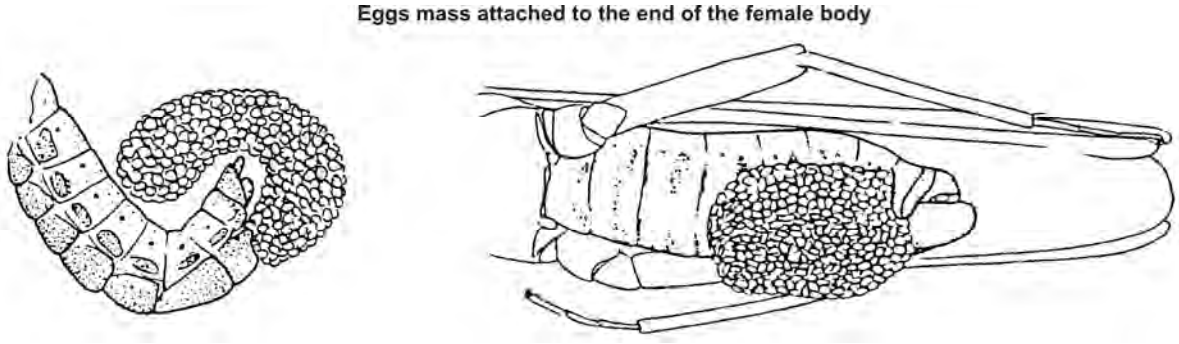
Ecology

Imagos are encountered on stony, muddy, and sandy banks of usually rapidly flowing streams.

Reproduction occurs throughout the entire year. A number of species belonging to the primitive Capniidae (winter stoneflies) and Taeniopterygidae sometimes reproduce as early as February (January), when banks are still covered with snow. Most species, however, reproduce in the spring and summer, and a smaller portion in late autumn and the beginning of winter.



Copulation occurs on plants or on the ground, very exceptionally in flight (e.g. *Chloroperla*). Several hours to days after copulation, the female begins to lay eggs that are joined by secretions from glands into a sort of bundle that remains for variously long periods (several hours to days) attached to the female's reproductive opening, containing ca 100–400 eggs (total number of eggs may reach up to 1,000). When dipping the abdomen into water, the connecting adhesive rapidly dissolves and the eggs are released. At other times the female flies just above the water, releasing the eggs in a similar fashion. Eggs are equipped with either an adhesive coating or various appendages so that they stick to objects in the water. Males usually die after 1–2 weeks, females in ca 3–4 weeks.



Embryonic development usually lasts for 4–6 weeks.

Larval development usually takes at least 1 year, sometimes even several years (e.g. 2 years in species of the genus *Perlodes*, and in the genus *Perla* even 3 years); only exceptionally do 2 generations per year develop (certain Nemouridae). The temperature at which larval development stops is very low (close to zero), and thus, in streams that do not freeze, larvae develop even through the winter. Nymphs moult many times in the course of development (20–30 times) and their wing sheaths gradually grow. Metamorphosis is incomplete (archimetaboly).

They develop in the water and are among the bottom fauna (living under stones, in gravel, or under decaying organic remains). The vast majority of species of this order are among the fauna of rapidly flowing water. They are most frequent in mountain streams of the trout zone, where they also comprise an important part of fish nourishment. Muddy bottoms of slow flowing water with dense vegetation are only inhabited by a few adaptable species. Demand for oxygen content in water is, however, usually high. The periodic movement of larvae, which approach and retreat from the surface, facilitates improved access to oxygen. Some species may additionally breathe through the gut. They occur at altitudes up to around 5,000 m.

They usually have sharply defined demands regarding environment; ubiquists are minimal (e.g. *Nemoura cinerea*). The species composition of stoneflies changes considerably in accordance with changes during the year (speed of flow, water temperature, oxygen content, as well as pollution of various origins); therefore, they also serve as indicators of water quality.

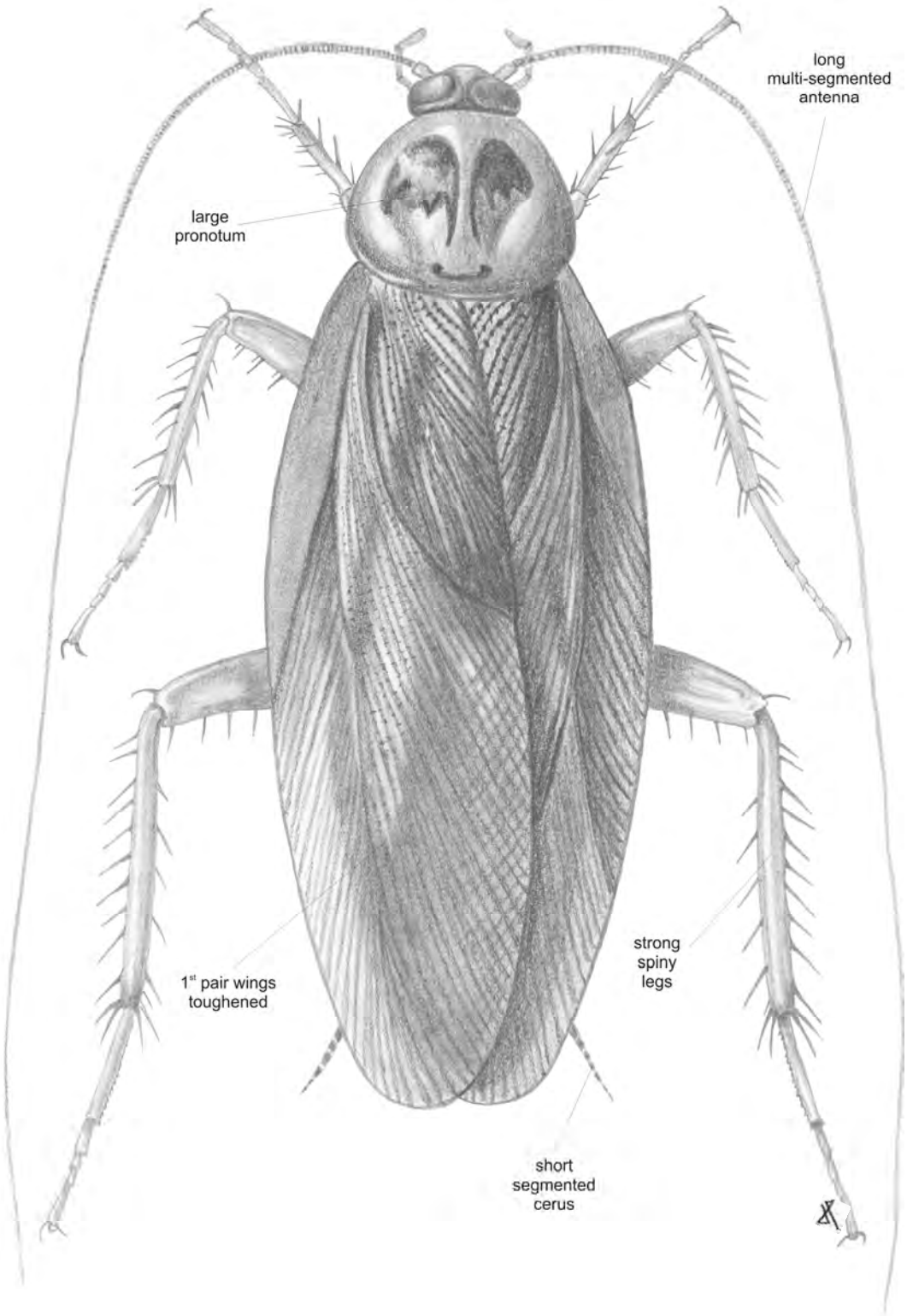
The imago hatches from the last instar of the nymph that leaves the water and climbs onto rocks, plants, bridge pillars, etc. Hatching usually occurs at night. They exhibit nocturnal activity or are active at sunrise. They remain hidden during the day.

Food

Imagos of species with functional mandibles (most smaller species) feed on algae coatings and lichens on stones and branches. Species with non-functional mandibles (predominantly larger species) do not ingest food at all.

Larvae of most species feed on animals (corresponding large head and mouthparts with pointy, toothed mandibles and dagger-like maxillary gums). The smaller proportion is herbivorous and also consumes plant detritus (here, mandibles are equipped with masticatory surfaces).

Order: **BLATTODEA** (cockroaches)		
derivation of the order's name blatta (Latin) = cockroach	number of known species in the world 4,500	number of known species in the Czech Republic 11
Metamorphosis: **hemimetaboly: paurometaboly**		



Systematics

Cockroaches (Blattodea) along with mantids (Mantodea) and termites (Isoptera) form the so-called Dictyoptera complex of monophyletic origin.

It is a very ancient group, one of the oldest representatives of winged insects. Fossil representatives are dated as far back as the Upper Carboniferous. Cockroaches are divided into 4 suborders.

Warm and humid tropical sites comprise the centre of distribution. The number of species drops rapidly in drier tropical areas, and the fauna of the temperate zone is utterly poor in free-living species. Nevertheless, certain species living beyond the polar circle in high mountains and deserts are known.

General characteristics and body description of the adult

All species of cockroaches have a significantly dorsoventrally flattened body with an overall oval outline. Their size ranges from 3 mm (genus *Nocticola*) to 12 cm (genus *Blaberus*). The body is smooth; only in desert species is it more densely hairy. Predominantly unicoloured, brown to black (only certain tropical representatives are colourful).

Head is mostly hypognathous, with chewing mouthparts. Olfactory and gustatory organs are especially developed on the palps of both pairs, which are in constant contact with the ground surface and constantly moving. Eyes are relatively large, kidney-shaped, adapted for night vision, and only exceptionally reduced or absent. In certain species the ocelli are developed, but more commonly there are only 2 pale ocelli-like spots in their stead. Antennae are long, with many segments, usually the same length as the body or even longer.

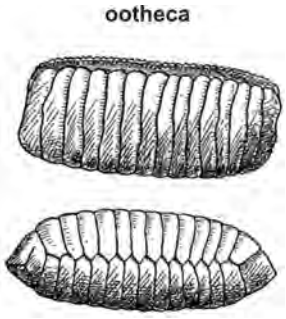
Thorax has maintained, to a certain degree, mutual motility of the individual segments. The prothorax is visible as a conspicuous scutum, while the meso- and metathorax are usually larger (in wingless forms, the two segments are of approximately identical size; in winged forms, the metathorax is always larger than the mesothorax).

Legs are long and gressorial. Massive and very long coxae, tibiae strongly prickled, tarsi with 5 segments, and final segment bearing two claws (in the genera *Mononychoblatta* and *Nymphytria* the claws are absent). They move very quickly and nimbly, jumping frequently and well.

Wings are folded over the body when resting. The first pair is tough and leathery (so-called tegmina) and in a resting state they partially overlap, protecting the second pair. The second pair is larger, for the most part significantly more membranous, and are used for actual flight. Cockroaches, however, fly only rarely. They only use the wings to prolong their jump and to ensure a soft landing. The two pairs move independently of each other. Winglessness is frequent, especially in females.

Abdomen is connected to the thorax by a wide base and consists of 10 visible tergites; the 11th tergite (epiproct) is embedded in the 10th tergum (supra-anal plate). The first sternal segment is small or absent; the 7th sternite in females and the 9th in males is prolonged and forms the subgenital plate. The final, 11th sternite is divided into paraprocts. Two segmented bristles grow out of this last abdominal segment. Males usually have 2 styli on the subgenital plate (9th sternite). The styli are usually not developed in adult females. Females have various types of glands developed on the abdomen (used for protection or in connection with reproductive behaviour). In males, so-called tergal glands are developed.

Egg

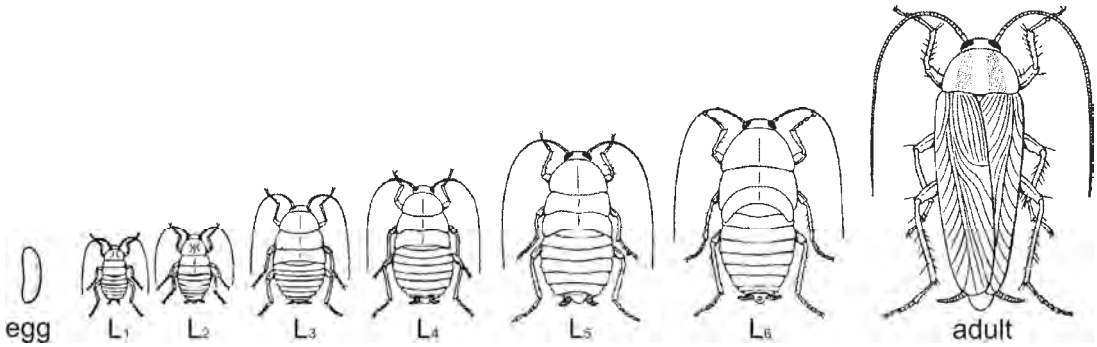


Most species are oviparous, but ovovivipary and vivipary is also known. Most eggs are white, deposited in oothecae containing 12–40 eggs. The ootheca is formed in the genital chamber of the female, as a product of accessory glands. The number of eggs and their shape are to a considerable extent characteristic for the species. The female carries the ootheca with her for a certain period, and it partially protrudes from the genital opening.

Larva

Larvae are generally very similar to adults, with the first instars similar to males (presence of styli). In later female instars, the styli disappear. Nymphs do not have tegmina or wings, and the bases of wings only occur in later instars.

The number of moults depends on the species, sex, and living conditions, and therefore need not be constant within the same species. It does relate to a certain extent to the size of the imago. In the German cockroach (*Blatella germanica*), 5 instars (males) or 5–6 instars (females) have been observed; in the oriental cockroach (*Blatta orientalis*), 7–9; and in the American cockroach (*Periplaneta americana*), 11 (males) and 12 (females). The duration of the larval stage depends on the species and temperature. For example, the German cockroach develops for 50–60 days, the Oriental cockroach for 280–500 days, and the American cockroach for 250–270 days.



Ecology

Cockroaches hide during the day under leaves, in moss and humus, and under rocks and loose bark and are active during the night. The species in the Czech Republic also behave like this (with the exception of males of the genus *Ectobius*, which are active during the day). Certain species live permanently on plants, others in wood or in caves, and some also exist as commensals of termite mounds, ant hills, and the nests of wasps and birds. Humans are directly affected by synanthropic species, which are often cosmopolitan.

Various levels of social behaviour can be observed in cockroaches. Certain species live solitarily (e.g. *Ectobius*), in families (e.g. *Cryptocercus*), or are even distinctly gregarious with various levels of social hierarchy (e.g. *Nauphoeta*) with flexible dominance (e.g. *Blaberus*) and male territoriality (e.g. *Gromphadorhina*).

Imagos live for a relatively long period (6 months to 1 year, *Periplaneta americana* up to 4 years). Copulation occurs ca 10–15 days after hatching. The female starts laying eggs 7–12 days after copulation (which is repeated in approximately weekly intervals). Synanthropic species exhibit no obvious periodicity in reproduction. Free-living species in the Czech Republic usually reproduce in autumn or early summer.

Food

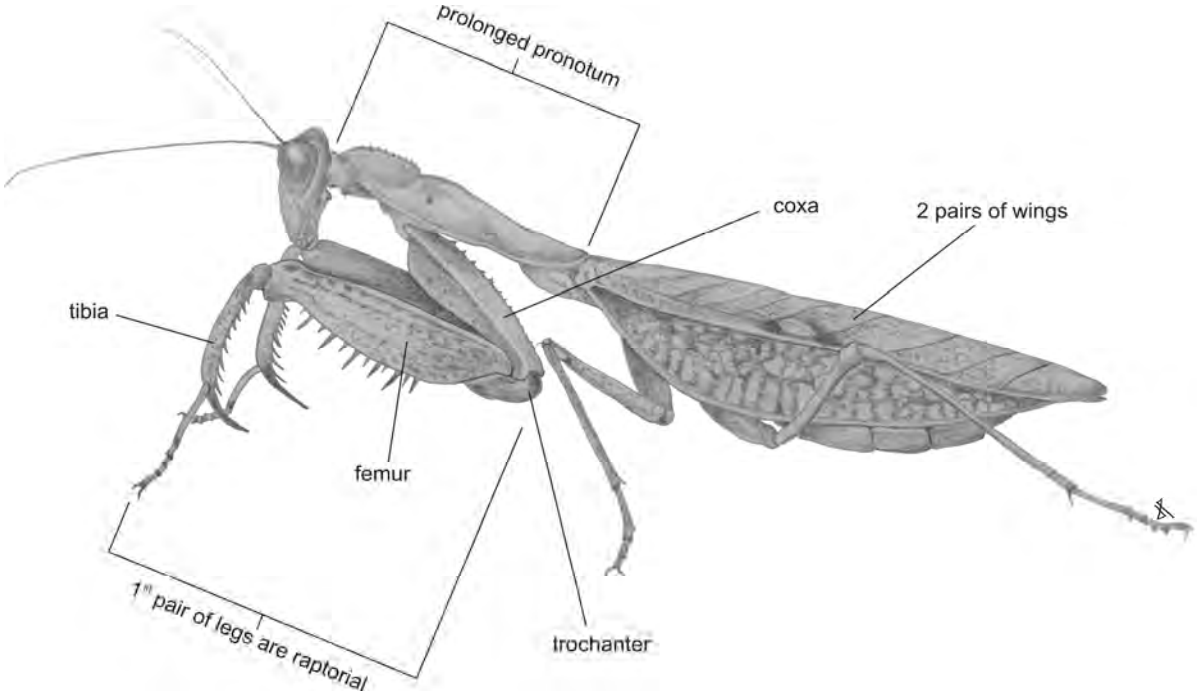
Imagos, like nymphs, are omnivores, or rather omnivorous scavengers and detritophages. They feed on algae, dead bodies of small invertebrates, fungi, and dead plant parts. Particularly in the tropics they have immense importance in the decomposition of organic matter.

Importance for humans

Free-living species in the Czech Republic do not cause damage, although in the tropics they can damage agricultural crops and decorative plants.

Synanthropic species are especially detrimental to food, but they also feed on paper and leather in archives and libraries. The most important synanthropic species are *Blatta orientalis*, *Periplaneta americana*, *P. australasiae*, *Blattella germanica*, and *Supella longipalpa*. In addition to direct damage, they also irritate with their presence. They frequently move in infectious environments, and thus can transmit viruses, bacteria, and even helminths. Certain species can also be significant causes of allergies (e.g. *Blattella germanica*).

Order: **MANTODEA** (mantids)		
derivation of the order's name mantis (Greek) = prophet	number of known species in the world 2,000	number of known species in the Czech Republic 1
Metamorphosis: **hemimetaboly: paurometaboly**		



Systematics

Mantids (Mantodea) along with cockroaches (Blattodea) and termites (Isoptera) form the so-called Dictyoptera complex of monophyletic origin.

The largest portion of known species lives in the tropics and subtropics; only a very small portion in the temperate zone. Systematically they are divided into 8 families. Only approximately 150 species live in the Palearctic ecozone and only one in the Czech Republic – *Mantis religiosa*.

General characteristics and body description of the adult

Body size of 1–16 cm, coloration usually in various shades of green or brown; in exotic species also colourful coloration and various body modifications, frequently in connection with mimetism and aggressive mimicry. The body is relatively very weakly sclerotized, with the exception of the head and thorax.

Head is orthognathous, relatively small, of a rounded triangular shape, and very agile. Eyes are pronouncedly arched with a large field of vision, with three developed ocelli. Antennae are setaceous,

many-segmented, and relatively long (although significantly shorter in comparison to cockroaches). Chewing mouthparts.

Thorax – prothorax is slim, very long, and movable against the mesothorax. The meso- and metathorax are normally developed.

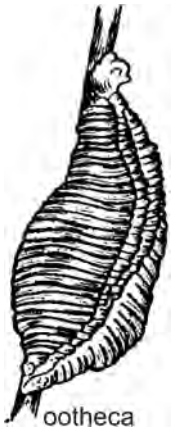
Legs – the front pair is raptorial, considerably shifted forward on the prothorax. Coxae are very long (at rest they are folded back along the prothorax), increasing the range of action of the entire leg. The actual raptorial apparatus consists of a spiked femur and an adjoining spiked tibia. The hind and middle legs are long and gressorial. The tarsi have 5 segments with 2 claws.

Movement is usually slow, essentially provided only by the two hind pairs. When running away, however, they are capable of moving very quickly.

Wings are developed in 2 pairs. The fore pair is more strongly sclerotized and entirely covers the membranous hind legs. Venation is very rich with many cross-veins. Flight ability is very limited, similarly to cockroaches, and they fly only flutteringly and over short distances.

Abdomen has 10 segments, widely attached to the thorax. The first segment is strongly reduced. At the end of the abdomen there are segmented cerci.

Egg


ootheca

The eggs have an elongated oval shape. They are laid into a parchment case (so-called ootheca). The ootheca is a secretion of the accessory glands of the reproductive organs. It is formed from a sheer secretion that rapidly solidifies in the open air. The shape of the ootheca is species-specific, usually oval to elongated, 2–6 cm in size. The shape is formed by collaboration of the ovipositor, movable valves, and bristles. The ootheca consists of chambers in which the individual eggs are deposited, of which there are 30–1,200 (30–200 in the species in the Czech Republic, *Mantis religiosa*). Oothecae are placed on vegetation or under stones.

Larva

Larvae are generally similar to adults, differing only in their small size, absence of wings, and shape of the abdomen, which is usually lifted upwards. Nymhs go through 5–9 instars.

Ecology

All species are thermophilic and active only during the day. They orient themselves (as do most free-living predators) predominantly by sight.

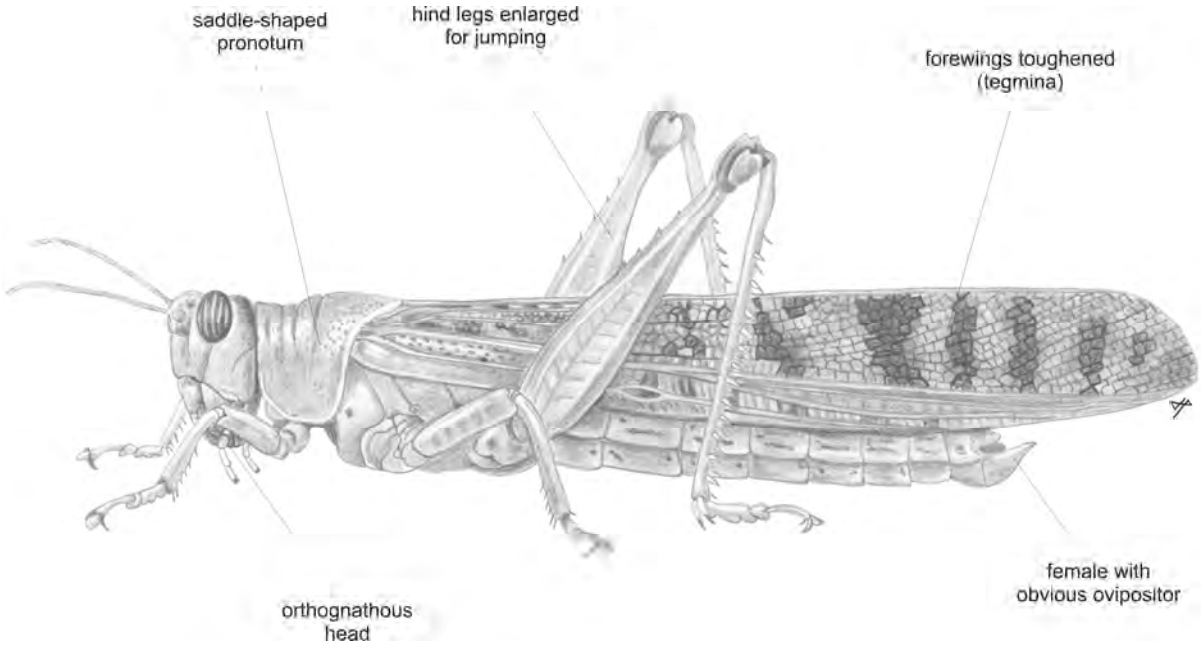
They frequently wait without moving for their prey for hours, with their forelegs folded on the thorax until their victim comes within their reach. They then capture it by fast movement of the forelegs. After capturing, the prey is moved to the mouth and consumed incredibly rapidly, while harder parts are discarded. A similar manner of hunting is known only in net-winged insects (Neuroptera [Mantispidae]), of which only the genus *Mantispa* occurs in the Czech Republic.

Food

All species, without exception, are predatory. They hunt insects, especially trueflies (Diptera), Hymenoptera, and Orthoptera, but also butterfly caterpillars. Young nymphs predominantly eat aphids.

Praying mantis (*Mantis religiosa*) is the only species of mantids living in the Czech Republic. It has an immense distribution (Europe, Asia, Africa, and also introduced into Australia and North America). It is found on warm grassy hillsides. Imagos emerge only at the height of summer.

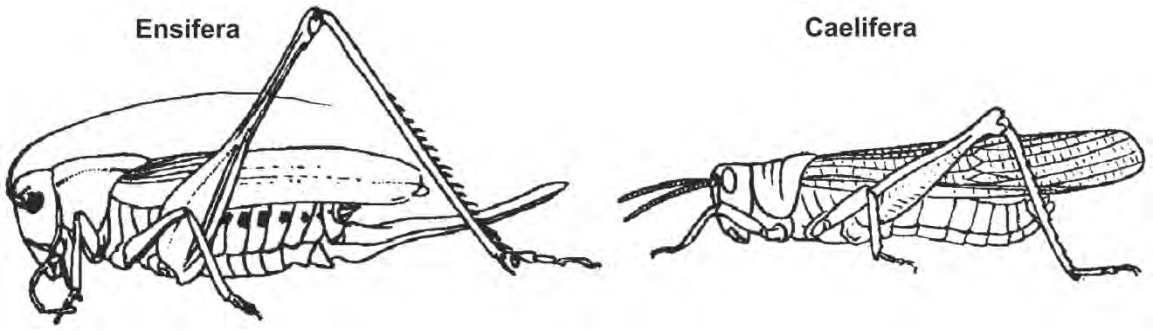
Order: **ORTHOPTERA**		
derivation of the order's name orthos (Greek) = straight, pteron (Latin) = wing	number of known species in the world 23,000	number of known species in the Czech Republic 92
Metamorphosis: **hemimetaboly: paurometaboly**		



Systematics

An ancient group of insects (findings dating from the end of the Carboniferous), it is systematically divided into 2 suborders:

- Suborder: **Ensifera** (crickets, katydids) – antennae longer than the body (if shorter, then the forelegs are fossorial, as in mole crickets), long ovipositor:
  - Superfamily: Grylloidea,
  - Superfamily: Gryllacridoidea, and
  - Superfamily: Tettigonoidea;
- Suborder: **Caelifera** (grasshoppers, locusts) – short antennae (usually shorter than the head and the scutum together), short ovipositor:
  - Superfamily: Tridactyloidae,
  - Superfamily: Tetrigoidea, and
  - Superfamily: Acridoidae.



All Orthoptera are generally thermophilic, although explicitly mountain species and species living beyond the polar circle are known.

General characteristics and body description of the adult

Species of the Czech Republic's fauna are usually mid-sized or large. The Czech Republic's (and Europe's) largest species, the predatory bush cricket (*Saga pedo*), reaches lengths of up to 75 mm. In general, size varies from very small species (1.8 mm *Myrmecophilus microscopicus* in the Seychelles) to large species (130 mm *Pseudophyllus titan* in India). The body is robust, cylindrical, slightly flattened from the sides, relatively strongly sclerotized, with the exception of weaker sclerotization of the abdomen.

Head is usually orthognathous, movable to all sides (although in a limited manner). The eyes are relatively small, rounded, and better developed in grasshoppers. Species living in darkness have strongly reduced eyes, as in myrmecophiles (e.g. the genus *Myrmecophilus*) and cave species (e.g. the genus *Troglophilus*). Originally three ocelli; in crickets (Ensifera) the central or lateral ocelli are often reduced. The antennae are very diversely formed, of various lengths (according to suborder), with segments numbering 7–200. In the suborder Ensifera, the number of segments is always larger than 30. In the suborder Caelifera (grasshoppers), the number of antennal segments is a maximum of 30. Chewing mouthparts. Mandibles are large, toothed with a basal part with variously developed chewing surfaces. Maxillary palps have 5 segments; labial palps have 3.

Thorax has 3 segments. The prothorax is at least partially mobile against the mesothorax. The mesothorax and the metathorax are grown together. The prothorax forms a conspicuous scutum (in Tetrigoidea, it extends backwards so it covers the entire abdomen).

Legs – hind legs are practically always saltatorial, with thickened femurs and elongated tibiae. The first two pairs are normal, gressorial, and in rare cases the fore pair is modified to fossorial (Gryllotalpidae, Tridactylidae) or adapted for hunting and bearing spikes (Ensifera of the subfamily Saginae). Grasshoppers (suborder Caelifera) and crickets of the superfamily Grylloidea (suborder Ensifera) have tarsi with three segments. Apart from the aforementioned Grylloidea, the remainder of Ensifera (Gryllacridoidea and Tettigonoidea) have 4-segmented tarsi. The last tarsal segment is fitted with two claws.

Wings are developed (2 pairs). The forewings (so-called tegmina) are opaque, parchment-like, and more strongly sclerotized. The hind wings are triangular, fine, and membranous with a large anal lobe, and in grasshoppers are frequently colourful. At rest, they are folded like a roof over the abdomen. In many species there is a strong trend for wing reduction, even up to total winglessness (especially in females). Wings, with altogether rare exceptions (e.g. migratory locust [*Locusta migratoria*]), are not used for

longer flight in most species. Most species use their wings for prolonging jumps. During flight, the forewings seem to play the largest role.

Abdomen is widely attached to the thorax and has 11 segments, although usually only 8 to 10 are visible. Bristles (styli) are developed. The ovipositor is developed, at various lengths, and is especially prominent in Ensifera, consisting from 4 to 6 gonapophyses (though strongly reduced or entirely absent in Gryllotalpidae). The ovipositor of grasshoppers is entirely different. Here, the gonapophyses are short, strongly sclerotized, and hooked (used for burrowing the abdomen into the ground).

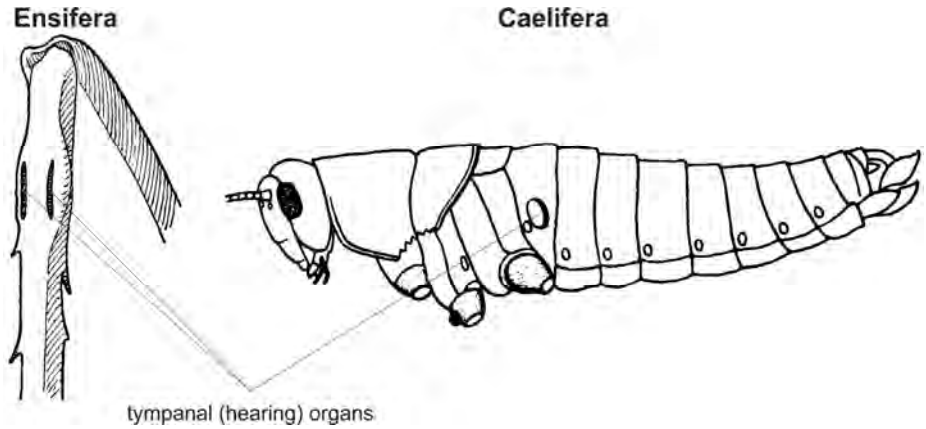
Sound organs – sound is produced mostly by males and serves for attracting the female. All sound organs are of the stridulating type. Sound originates:

- in Ensifera by rubbing the bases of forewings, and
- in Caelifera by rubbing a scraper on the hind legs against the forewings.

In apterous species, sounds can also be produced in coordination with other body parts according to a similar principle.

Auditory organs (so-called tympanal organs) are:

- in Ensifera at the base of the tibiae, and
- in Caelifera along the sides of the 1st abdominal segment. They connect to a tracheal sac with sensitive cells amplifying the sound.



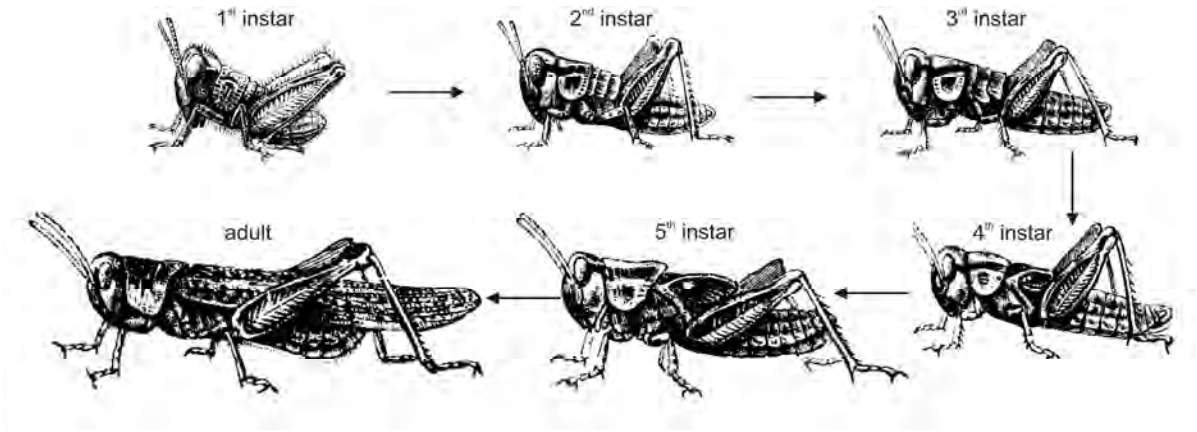
Egg

Eggs of Orthoptera are relatively large (in the genus *Saga* up to 13 mm, in the genus *Parepistaurus* they form up to ¼ of the female length), ovally elongated, cylindrical, or flattened from the sides. In Ensifera they are usually laid individually or in small groups into the ground or various plant parts. In Caelifera they are laid in groups and covered in a secretion that forms a species-specific capsule after hardening.

Larva

The number of instars in the suborder Ensifera varies greatly even within a single species. The usual number is 5–7 (in Grylloidea, up to 14). In Caelifera the number of larval instars is also varied,

although relatively stable among individual species (4–6). In certain groups (e.g. the genus *Tetrix*), males always go through 5 instars and females through 6.



Ecology

In regards to the suborder Ensifera, they are mostly thermophilic and hydrophilic species. Bush-crickets (Tettigonioidea) usually live on trees (crowns of high trees are inhabited, for example, by the Great Green Bush-Cricket [*Tettigonia viridissima*]), bushes, and taller herbaceous plants; certain species also move directly on the ground surface. Most Grylloidea inhabit the ground surface. Mole crickets (Gryllotalpidae) live in underground tunnels.

Caelifera (grasshoppers) mostly live in low vegetation, in grass, and on herbs. The exception is the genus *Xya* (Tridactyloidae), which spend part of life underground. Most species are thermophilic and xerophitic. Certain species, however, are also ripicolous and can swim well (the genus *Tetrix*), and others are able also to move on the water surface (the genus *Xya*) and when disturbed flee by jumping into water.

An interesting phenomenon among Orthoptera is a certain polymorphy of wings. For example, in brachypterous species of crickets, an increased proportion of macropterous individuals is recorded on the edges of habitats, on islands, and in high mountains. The increased proportion of macropterous individuals is not only caused by climatic extremes, but also by increased population densities. In Central Europe, this commonly occurs in the genera *Conocephalus*, *Platycleis*, and *Metrioptera*. The same phenomenon is recorded also in the suborder Caelifera (grasshopper).

In certain species of grasshoppers, one finds so-called phase polymorphism with 2 phases:

- solitary phase – nymphs of the species are in low population density;
- gregarious phase – high population densities, adults adapted for migration and colonizing new areas (for migratory locust [*Locusta migratoria*], ca 2,000 individuals per 1 ha).

Stridulatory displays have a crucial role in seeking the other sex. Most species in the Czech Republic have 1 generation per year. Mole crickets, which have 2-year development, are an exception. In contrast, certain introduced species can also have multiple generations in a year (e.g. the house cricket [*Acheta domestica*]). Most species overwinter in the egg stage. In Grylloidea, nymphs overwinter; in *Tetrix*, adults.

Food

Grasshoppers (Caelifera) are little-specialized herbivores. Certain species feed on soft plant tissue, others on the hard parts (blades and leaves of grasses). Species of the genus *Tetrix* feed on algae, mosses, and lichens. In grasshoppers, the chewing stomach is not developed and so food is processed as finely as possible by the mandibles (which also corresponds to their morphology).

Crickets (Ensifera) are mostly carnivorous. Their food consists of other Orthoptera, larvae of other insects, aphids, spiders, etc. A number of groups crossed over to plant food or combined diet. For example, Gryllidae and mole crickets constitute transitory omnivorous forms that, apart from plant food, like to eat earthworms and molluscs.

Important species

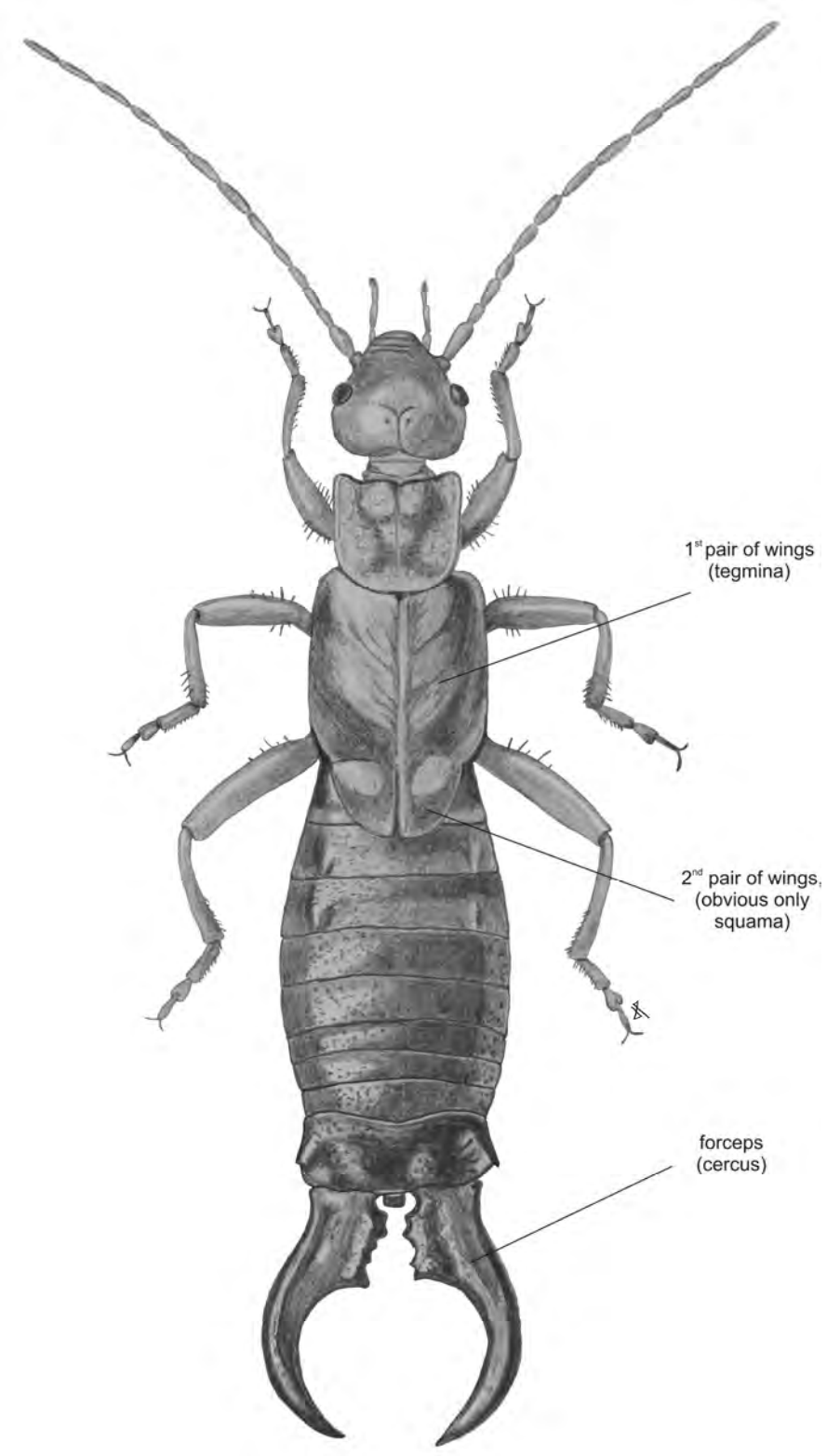
Ensifera (crickets)

- House cricket (*Acheta domestica*) – occasionally harmful in households in food.
- European mole cricket (*Gryllotalpa gryllotalpa*) – a more significant pest causing damage by biting through and tearing roots of seedlings and saplings of forest trees (and also agricultural crops) when digging underground tunnels.
- Wart-biter (*Decticus verrucivorus*) as well as other species can cause damage by chewing on bark, leaves, and needles when overpopulated.

Caelifera (grasshoppers)

- Migratory locust (*Locusta migratoria*) – migrating individuals consume grasses as well as wheat, maize, and leaves of trees and bushes. Negligible presence in the Czech Republic.
- *Calliptamus italicus* – recorded damage to pine stands in the Czech Republic.

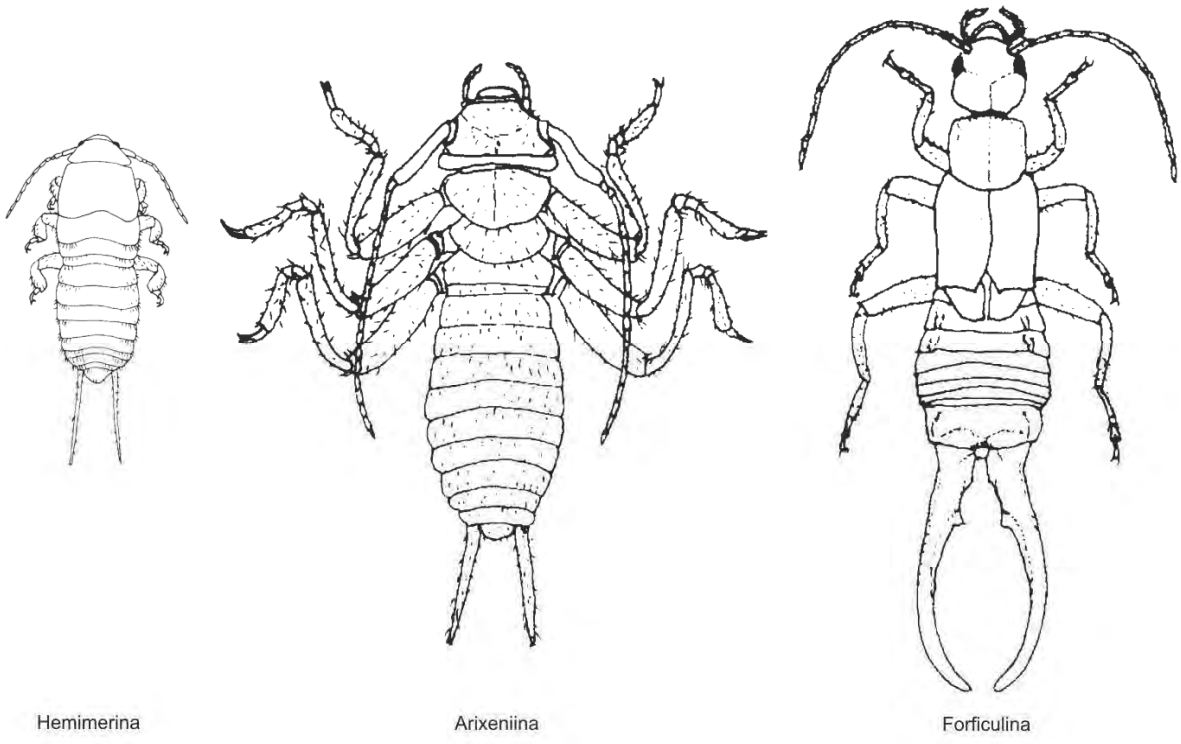
Order: **DERMAPTERA** (earwigs)		
derivation of the order's name dermatos (Greek) = skin, pteron (Latin) = wing	number of known species in the world 2,000	number of known species in the Czech Republic 7
Metamorphosis: **hemimetaboly: paurometaboly**		



Systematics

Earwigs (Dermaptera) form a small, clearly distinct order. The overwhelming majority of species live in the tropics. They are systematically divided into 3 suborders. Only representatives of a single suborder (Hemimerina) live in the Palearctic ecozone (thus also in the Czech Republic).

- Suborder: **Forficulina** (almost all earwigs),
- Suborder: **Hemimerina** (associated with African rodents – 9 species), and
- Suborder: **Arixeniina** (associated with Indonesian bats – 5 species)



General characteristics and body description of the adult

Thin, medium-sized species, with body size from 2.5 mm (*Eugerax poecilum*, Panama) to 70 mm (*Labidura herculeana*, Saint Helena). The body is flattened, the surface smooth with microsculpture that creates a gloss or matt finish, and a thick coat of fine hairs is also common. Coloration is usually monochromatic, yellowish to dark brown, at most with lighter spots. Their characteristic feature is the presence of pincer-shaped cerci.

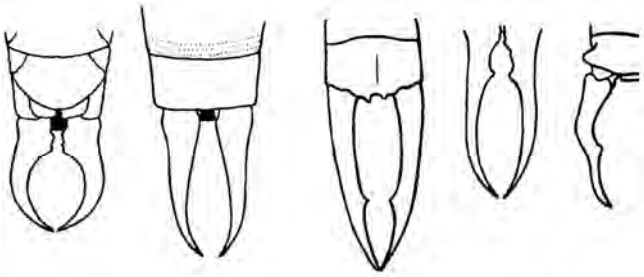
Head is heart-shaped, freely mobile, prognathous, and with chewing mouthparts. Compound eyes consist of ca 300 facets adapted for night vision, and in certain groups they are reduced (Arixeniina) or entirely absent (Hemimerina). Ocelli are not developed. Antennae are bead-like, consisting of 10–50 segments, and are very important for the nocturnal activity of these animals because earwigs orient themselves primarily by touch using the antennae.

Thorax – prothorax is large and mobile relative to the two following fused segments.

Legs – all pairs are gressorial (and are the main organs for agile and swift movement). Tarsi have 3 segments and the praetarsus is equipped with two claws.

Wings are developed in 2 pairs. Forewings are transformed into more strongly sclerotized tegmina that reach no further than to the middle of the abdomen. Hind wings are relatively large, membranous, and folded three times under the tegmina. When folded, the second pair is covered by the first pair so that only the squama is visible from the second pair. Flight is relatively rare in earwigs; only few species of earwigs fly (although their wings are well developed). Of species common to the Czech Republic, *Labia minor* fly relatively often. Assistance of the cerci is necessary when unfurling the wings. Reduction and absence of wings are quite common (so-called aptery).

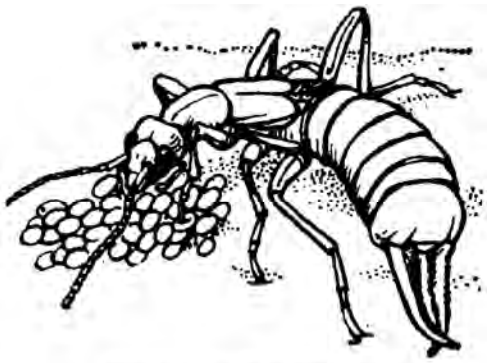
Abdomen has 11 segments, while the 11th segment forms the pygidium. In males, 10 tergites are visible, in females 8. The first abdominal sternum is usually absent. At the end of the abdomen (10th segment) there are 2 unsegmented, and in the suborder Forficulina strongly sclerotized, cerci curved inward. They are used for hunting, defence, and as auxiliary organs in unfurling and folding the wings. Sexual dimorphism in earwigs manifests itself through the shape of the cerci and pygidium. There are openings of the scent glands along the sides of the 3rd and 4th segments from which a substance smelling like carbolic acid can be sprayed and dispersed. It is presumably a mechanism to frighten away enemies.



morphology of cerci of various earwig species

Egg

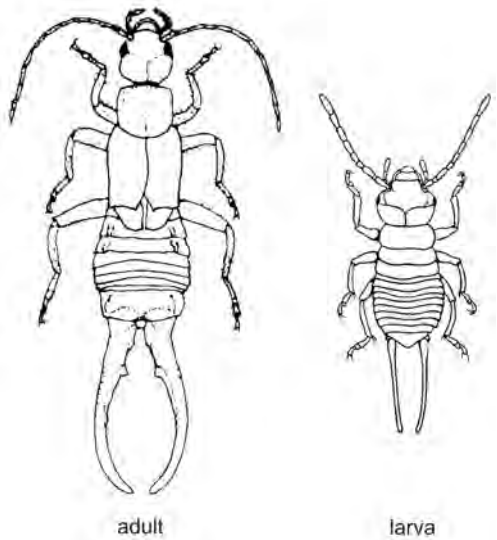
Eggs are relatively large (0.5–2.5 mm), usually lightly coloured with a wide oval shape. The number of eggs laid is small (ca 15–80) and varies in different species. Embryonic development takes 2–4 weeks in conditions common to the Czech Republic.



female caring for a clutch of eggs

Larva

Larvae are generally similar to adults, differing primarily by smaller size, lighter colour, absence of tegmina and membranous wings, lower number of antennal segments, and simple cerci. Nymphs go through 4–5 instars. Nymphal development is relatively long. In the most common European earwig (*Forficula auricularia*), it takes 5–6 months. Postembryonic development is paurometaboly.



adult larva

Ecology

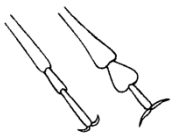
Most species are thermophilic, preferring humid habitats. Even species living in dry areas also seek wetter places. The vast majority of species are active at night and seek shade during the day (moister spots under bark, stones, organic remains, etc.).

In the temperate zone they have 1 generation per year. Eggs, larvae, and adults overwinter. In the case of the European earwig (*Forficula auricularia*), for example, adults overwinter with eggs. In species of the genus *Chelidurella*, imagos and larvae of the last two instars overwinter. Care for the young is observed in certain species (and expected in most or even all species of the suborder Forficulina). Females dig a chamber for the clutch of eggs (sometimes along with the male); after laying the eggs, only the female cares for the clutch. It cleans and moves the clutch, which prevents the development of moulds, and protects the eggs from predatory beetles and mites. Young nymphs remain with the female frequently up to the second instar. Females of the suborders Hemimerina and Arixeniina are viviparous, and care for larvae has not been observed.

Food

The food of imagos and larvae of the suborder Forficulina is identical. They are mostly omnivores, consuming animal and plant food, both living and dead.

List of all species living in the territory of the Czech Republic (7 species within the suborder Forficulina):



Family: **Labiduridae** (antennae consisting of more than 20 segments)

- *Labidura riparia* – very rare, on sandy surfaces in the vicinity of rivers and lakes

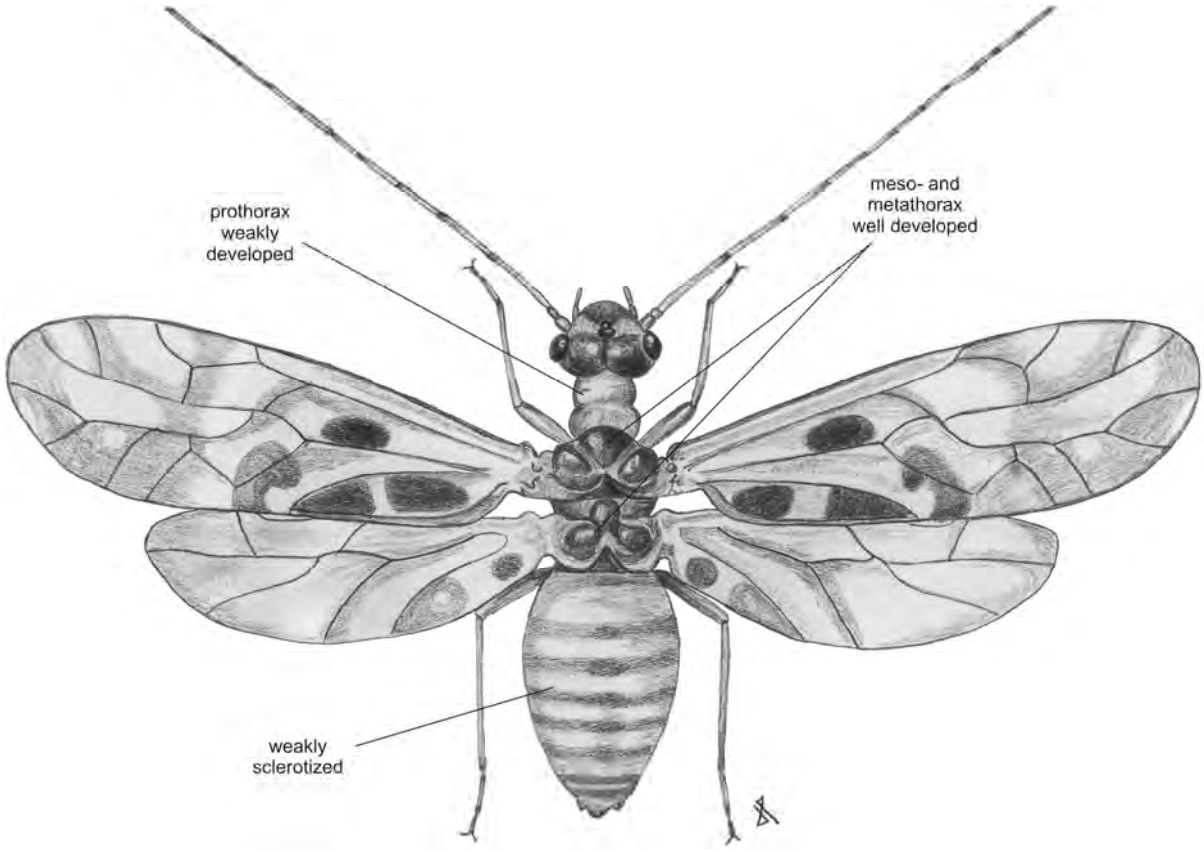
Family: **Forficulidae** (antennae with less than 16 segments; second tarsal segment extended and heart-shaped)

- *Chelidurella acanthopygia* – an abundant forest species living in litter and under tree bark
- *Chelidurella guentheri* – an abundant forest species living in litter and under tree bark
- *Anechura bipunctata* – a very rare species living on dry meadows on steppes and forest steppes
- *Apterygida media* – a hydrophilic species living on bushes and herbs in alluvial forests along watercourses
- *Forficula auricularia* – abundant in all types of biotopes

Family: **Spongiforidae** (antennae with less than 16 segments; second tarsal segment is cylindrical)

- *Labia minor* – a coprobiont abundant everywhere, seeking pastures and secondarily dung heaps and the like

Order: **PSOCOPTERA** (psocids)		
derivation of the order's name psokos (Greek) = gnaw, pteron (Latin) = wing	number of known species in the world 3,000	number of known species in the Czech Republic 70
Metamorphosis: **hemimetaboly: paurometaboly**		



Systematics

An order represented by approximately 2,250 species; of those, about 80 species live in Central Europe and 70 in the Czech Republic. The greatest abundance of species is in the tropics.

- Suborder: **Trogiomorpha** – tarsi with 3 segments, strongly reduced forewings, scaly, hind wings not developed, antennae having 22–50 segments
- Suborder: **Troctomorpha** – tarsi with 3 segments, antennae with 15 segments, minimally from the 5th segment secondarily disappearing, apterous
- Suborder: **Psocomorpha** – tarsi with 2–3 segments, antennae with 13 segments, without secondary disappearance, pigmented pterostigma

General characteristics and body description of the adult

Small insect, inconspicuously coloured, so it completely blends in with the background.

Head is large, considerably mobile, orthognathous, with a conspicuously large and arched clypeus. Chewing mouthparts have well-developed mandibles that are sharp on the end and with chewing surfaces in the basal part. Maxillary palps are very long with 4 segments. Apart from ingesting food,

mouthparts also serve as weaving organs (eggs are spun during laying, as is the surface on which the species lives; larvae are also protected with cocoons). Eyes are developed to various degrees. The same applies for ocelli, which are, however, always absent in apterous individuals. Antennae are of approximately the same length as the body and with 13–50 segments.

Thorax – prothorax is always by far the smallest. The mesothorax, especially in winged forms, is very strongly developed and often completely covers the small prothorax from above.

On the thorax, two pairs of wings are developed, of which the fore is folded over the abdomen like a roof in resting position, entirely covering the smaller hind wings. Both pairs are joined in flight, and therefore move simultaneously. In a large number of species, there is an apparent tendency towards reduction of wings, leading even to total winglessness. Although they can fly very well, they do so only very rarely (similarly to stoneflies or caddisflies), and when in danger they escape by running rapidly.

Legs are cursorial, long, and slim; tarsi have 2–3 segments with 2 claws. They move jerkily, with pauses, in all directions, with the same dexterity even to the sides and backwards. In certain groups, the hind legs have thickened femurs (saltatorial).

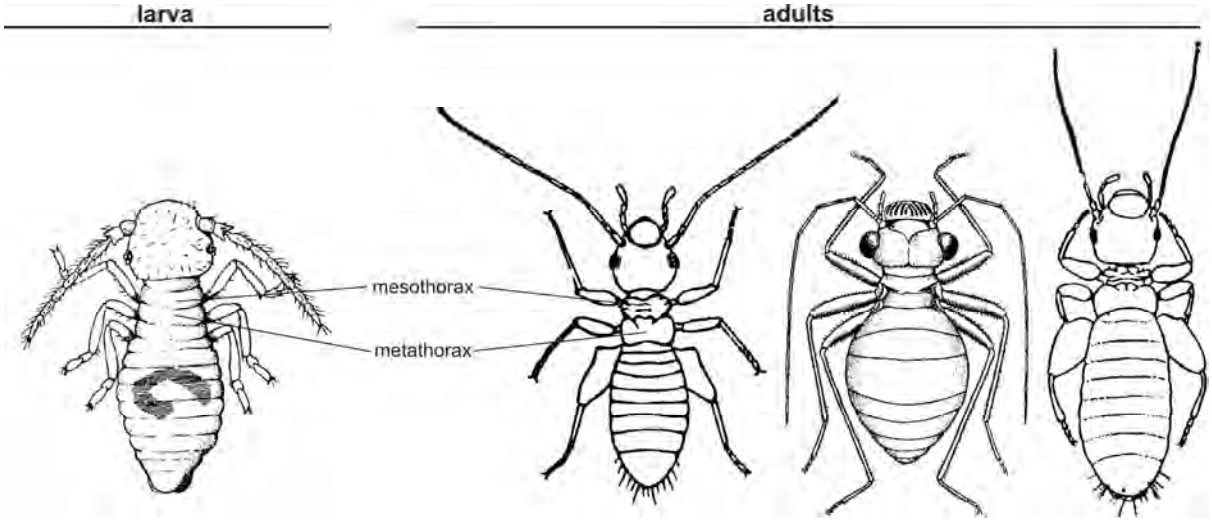
Abdomen is 10-segmented, sac-like, and weakly sclerotized with the exception of the parts around the genitals and the end of the abdomen.

Egg

Eggs are laid either individually or in groups on various surfaces, most frequently on bark and woody plant leaves. In a number of species, the clutch is covered further by a secretion mixed with the material of the surface, so they are very well masked, or even covered with a cocoon.

Larva

The larva is considerably similar to the adult, but it has only 2-segmented tarsi (the adults 2 or 3 segments) and in the youngest instars all thoracic segments are also the same size. Bases of antennae also emerge in the second instar. The number of instars is regularly 6 (in wingless forms, only 5).



Ecology

Reproduction is sexual, connected with epigamic phenomena (male wedding dance, circling around the female with semi-extended wings). The ratio of sexes is relatively balanced in most species. Parthenogenesis is also common, usually facultative; obligatory parthenogenesis is rather an exception. In case of geographical parthenogenesis, asexual reproduction usually occurs in the northern part of the species' area of distribution.

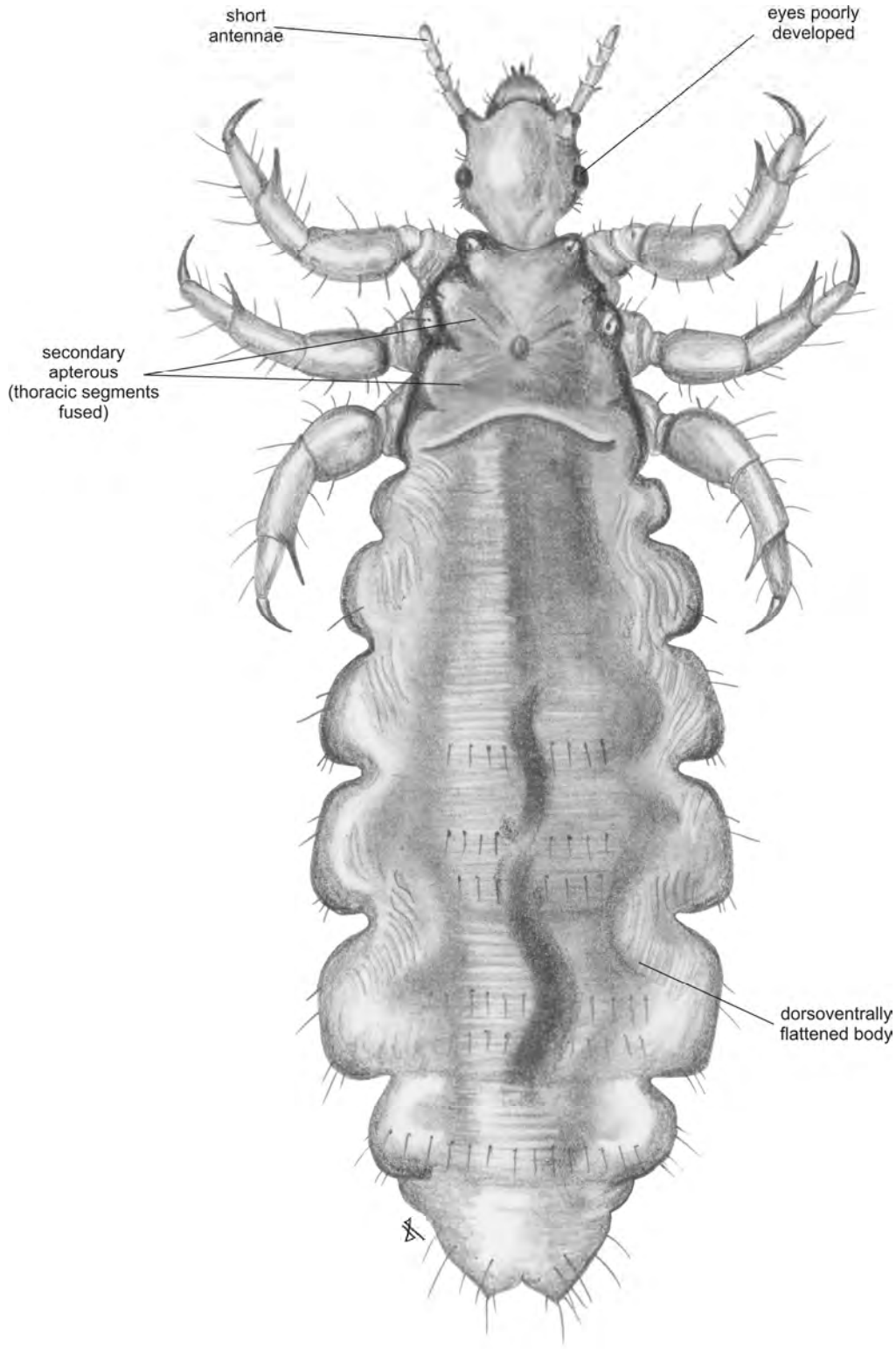
The number of generations depends on the species. They can have from one to several generations per year. Development can be relatively fast under optimal conditions (ca 1 month). The main period of occurrence of imagos is the end of summer (July to September). The lifespan of the adult is several months at the most. The eggs overwinter most frequently, nymphs more rarely, and imagos only exceptionally.

Psocids live mainly on trees and bushes, but also in litter, on surfaces of rocks, in the nests of mammals and birds, as well as in human buildings.

Food

Imagos and larvae feed especially on algae, lichens, moulds, as well as various organic detritus.

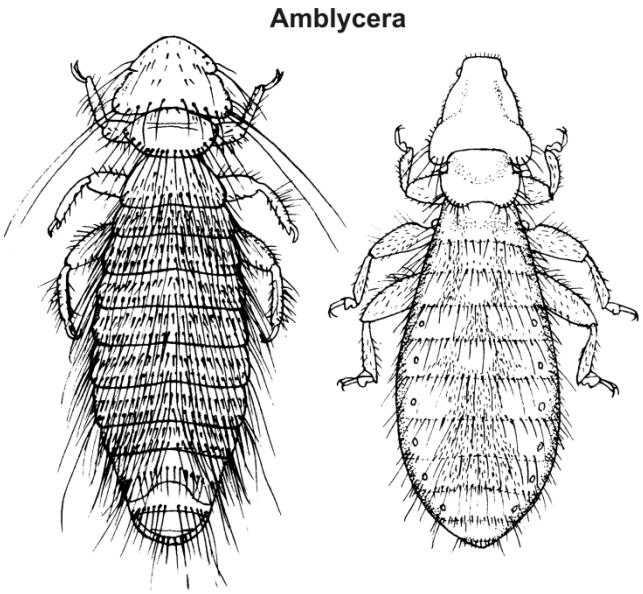
Order: **PHTHIRAPTERA** (lice)		
derivation of the order's name phthir (Greek) = lice, aptera (Latin) = wingless	number of known species in the world 5,000	number of known species in the Czech Republic 350
Metamorphosis: **hemimetaboly: paurometaboly**		

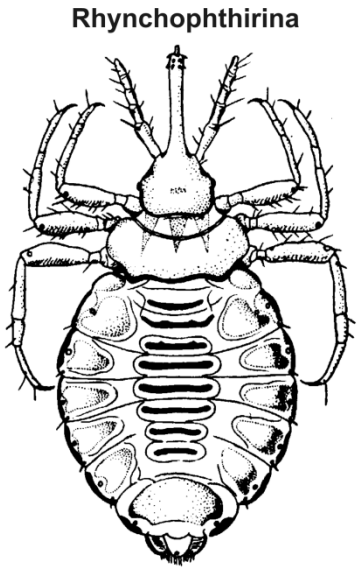


Systematics

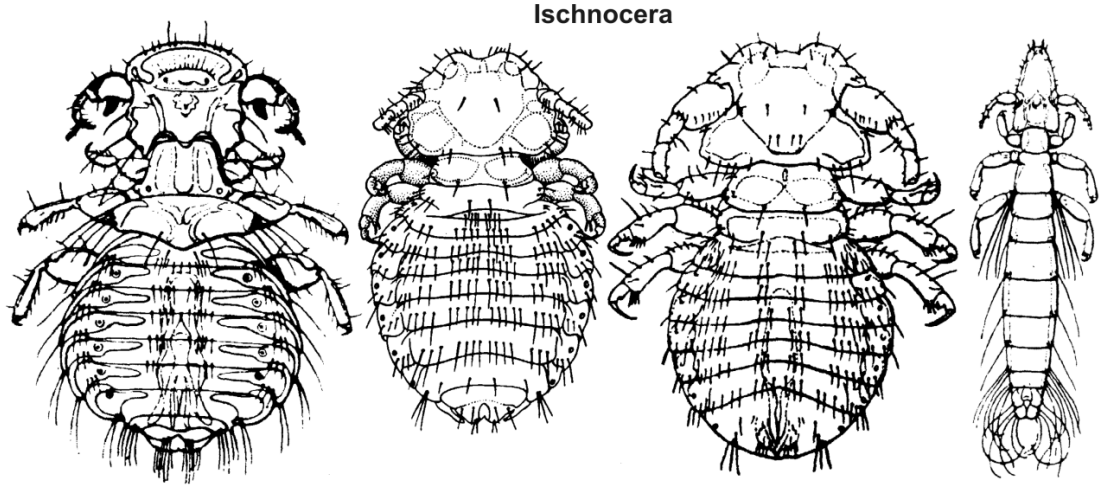
Lice (Phthiraptera) are systematically divided into 4 suborders, of which the suborder Rhynchophthirina is found only in Africa. The remaining 3 are found in the Czech Republic. The suborders Amblycera and Ischnocera were formerly united in a separate order, Mallophaga (chewing lice).

- Suborder: **Amblycera** – in comparison to Ischnocera: larger body; 4-segmented antennae with heterogeneous segments (3rd segment stalk-like), antennae hidden in fossae (fossa antennalis), and therefore in most cases do not extend over the edge of the head. Sexual dimorphism is not developed. Chewing mandibles (working horizontally), 4-segmented maxillary palp (rarely 2 segments). Meso- and metathorax are mostly separated, gressorial legs (apart from the family Gyropidae, where they are prehensile). Live on mammals and birds.
- Suborder: **Ischnocera** – in comparison to Amblycera: smaller body; antennae with 3 or 5 homonomous segments and well visible. Sexual dimorphism is very common (males use antennae for holding the female during copulation). Mandibles are tilted ventrally and the maxillary palp is reduced. The meso- and metathorax are merged and the seam between them is not pronounced. Legs are always prehensile. Live on mammals and birds.
- Suborder: **Rhynchophthirina** – development on both elephants and warthogs. Head is long, elongated, and snout-like.
- Suborder: **Anoplura** (sucking lice) – parasites of mammals. Head is elongated, relatively small, and narrower than the thorax, with piercing-sucking mouthparts. Eyes are not developed (or only 1 ommatidium). Antennae have 5 segments (rarely with 3 or 4). All thoracic segments are merged. Prehensile legs on which the tarsus has 1 segment with 1 claw that closes against the distal protrusion on the tibia. Live only on mammals.

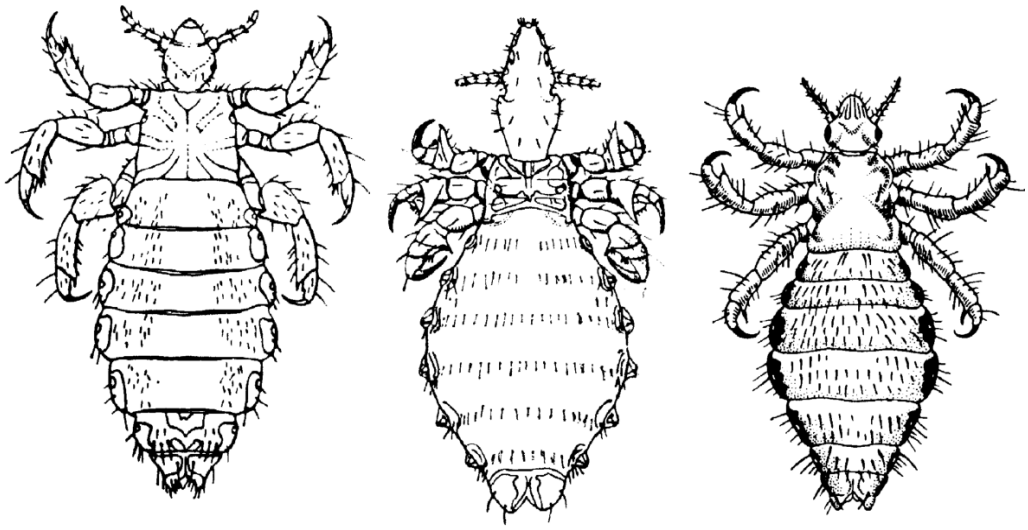




Ischnocera



Anoplura



General characteristics and body description of the adult

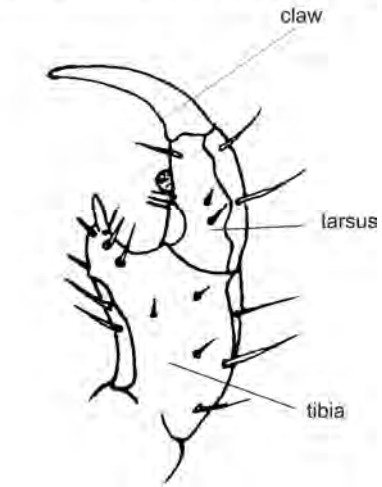
Secondarily wingless insect, flattened from the top. Permanently and obligatorily living on warm-blooded vertebrates, with a number of adaptations to life on the body of the host.

Head – mouthparts with a tendency to transform into piercing or piercing-sucking. The labial palp is reduced or even absent. The flagellum of the antenna has a maximum of 3 segments. Ocelli are absent; compound eyes have a maximum of 2 ommatidia or may be entirely reduced.

Thorax – free prothorax; the meso- and metathorax are partially merged (in Anoplura, all 3 thoracic segments are merged).

Legs are well-developed, strong, and gressorial or prehensile.

prehensile leg of the Anoplura suborder (sucking lice)



Wings are always absent.

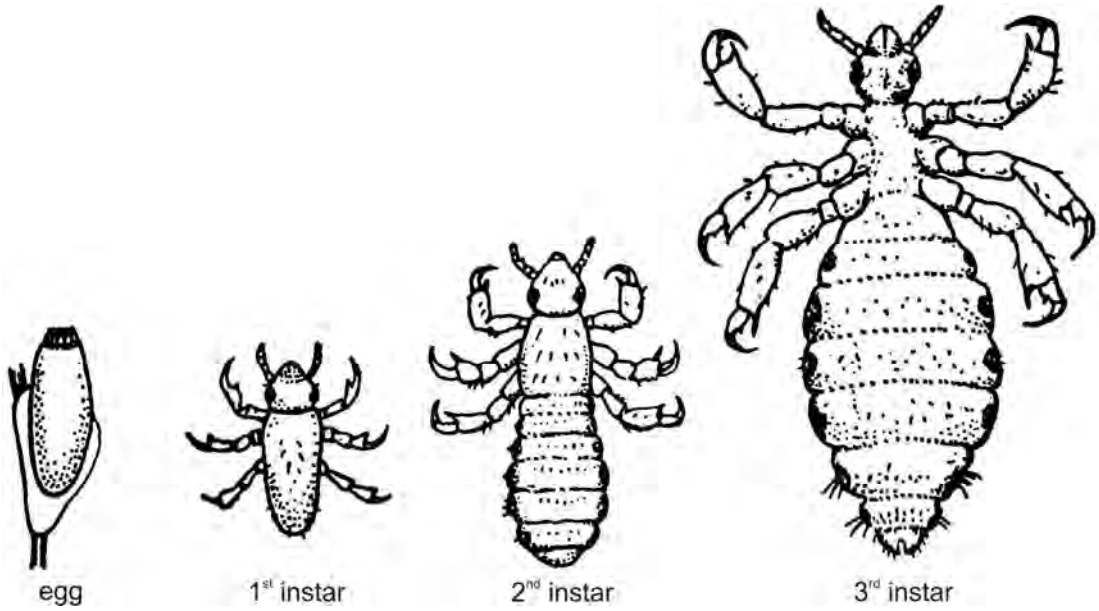
Abdomen has 8–10 segments; cerci not developed. Ovipositor is missing; males have complex external genitalia.

Eggs

Eggs are oval, relatively large, stuck to hair or feathers (so-called nits), frequently sculptured, and variously adapted in the upper lid section (so-called operculum).

Larva

Development is paurometabolous (i.e. larva similar to the adult) with 3 instars. The total length of the nymphal stage is very short, up to 3 weeks.



Food

Amblycera and Ischnocera have chewing mouthparts and live in the hair of mammals and plumage of birds. They feed on dead skin detritus and the main component of food is keratin and, when the skin is damaged, also coagulated blood. Anoplura have developed piercing-sucking mouthparts, which suck the host's blood.

Ecology

They live their entire lives on their hosts, where complete development occurs. Development, therefore, is not tied to seasons. Nevertheless, they reach the highest population density in the summer, and the lowest in the winter. Transfer to a new host occurs during individual contact, especially in the

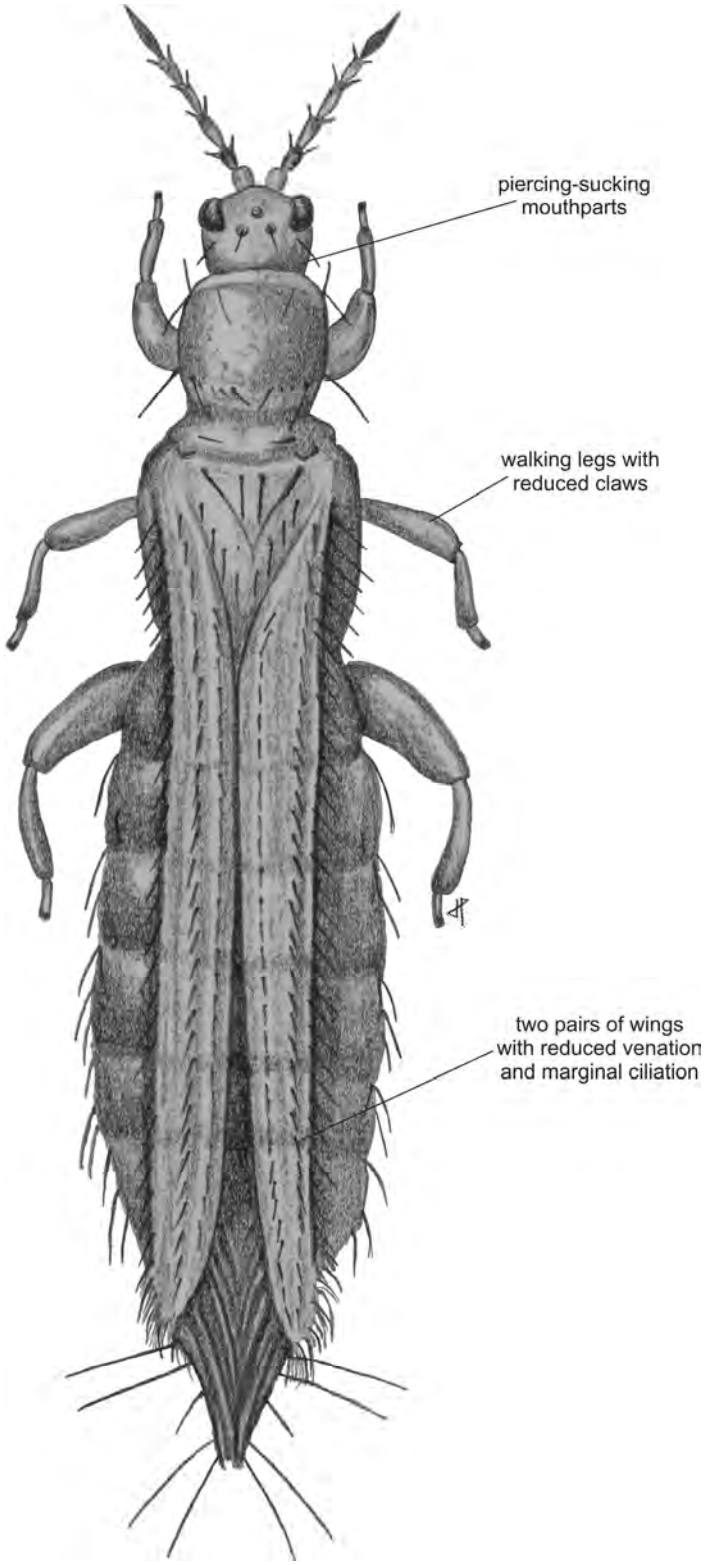
period when they care for the young. For Amblycera and Ischnocera, the connection to the host species is very strong.

The period of development of a single generation is short; in Amblycera and Ischnocera it is only slightly longer than a month. In the human louse *Pediculus humanus*, moreover, it can be even a mere 16 days under optimal conditions, but on average about 25.

Overview of certain species of sucking lice (Anoplura) important for humans

Species of lice	Place of parasitization
Crab louse (*Pthirus pubis*)	Parasite exclusively of humans. Usually parasitizes on the hairs of the genital and anal areas, rarely on eyebrows and eyelashes. Transfer occurs primarily through sexual intercourse.
Body louse (*Pediculus humanus*)	Lives in the folds of clothes and underwear, sucks on skin primarily covered by clothing.
Head louse (*Pediculus capitis*)	Lives almost exclusively in hair, exceptionally in eyebrows and facial hair. It causes eczema when overpopulated.

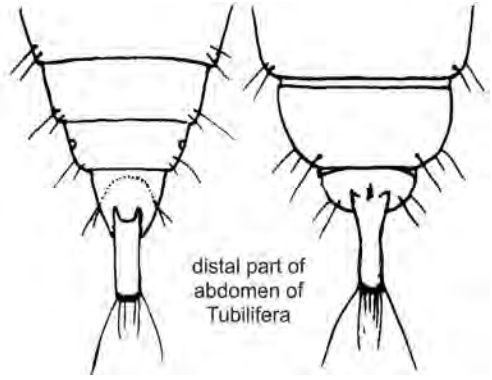
Order: **THYSANOPTERA** (thrips)		
derivation of the order's name thysanos (Greek) = fringe, pteron (Latin) = wing	number of known species in the world 4,500	number of known species in the Czech Republic 210
Metamorphosis: **hemimetaboly: remetaboly**		

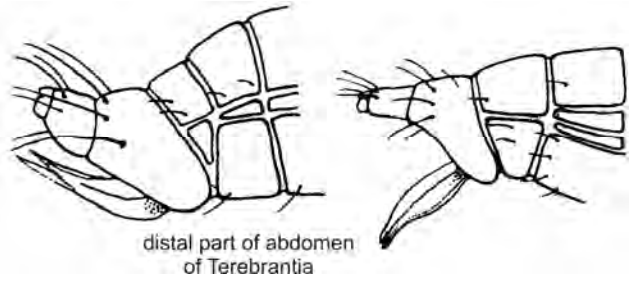


Systematics

Based on the morphology of the end of the female abdomen, thrips are divided into 2 suborders:

- Suborder: **Terebrantia** – female ovipositor is developed, eggs are laid into plants, venation of the forewings is richer;
- Suborder: **Tubulifera** – females without an ovipositor, eggs are laid on plants, wings have poorer venation.





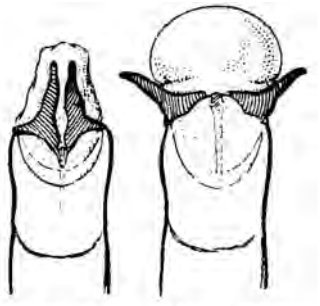
General characteristics and body description of the adult

Species are generally small, 1–2 mm (exceptionally 4–5 mm) long. The body is elongated, often dorsoventrally flattened, and weakly sclerotized. Males are smaller than females, usually also of lighter coloration, and they have slimmer abdomens rounded at the end (pointed in the female). Males are usually much less numerous than females (primarily due to frequent parthenogenetic reproduction).

Head is hypognathous or opisthognathous. Antennae have 6–9 segments, moniliform or filiform. Large compound eyes consist of a relatively small number of large facets. Three ocelli are developed in winged imagos. Mouthparts are piercing-sucking and asymmetrical, with 1 mandible and both maxillae transformed into spikes.

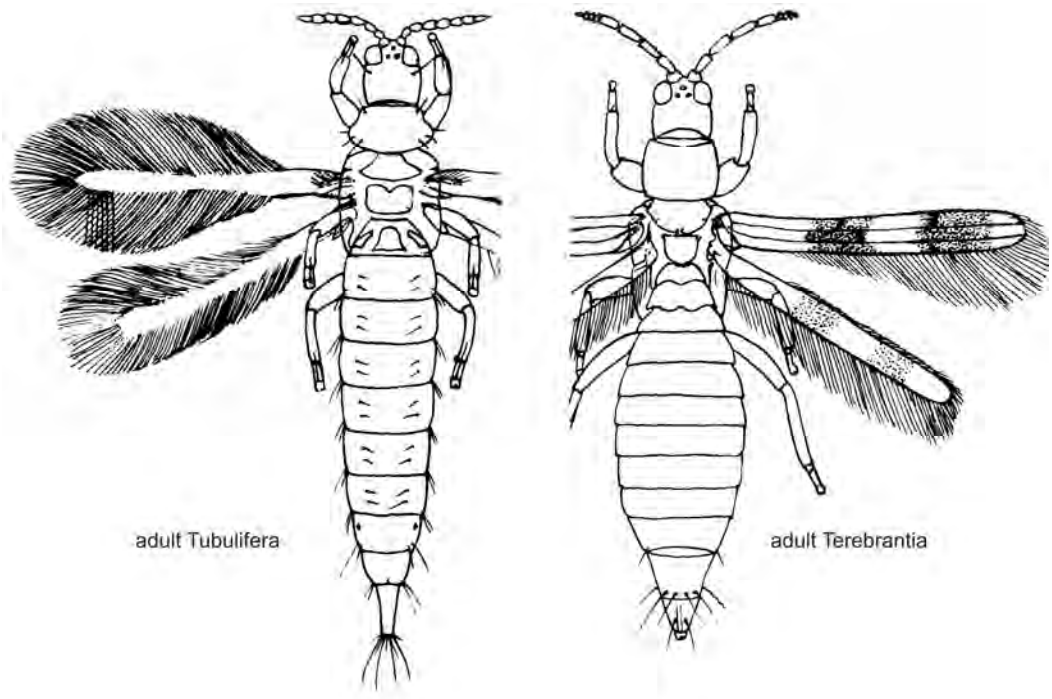
Thorax – prothorax is always conspicuously developed, whereas the mesothorax and metathorax are variously developed in apterous and winged species.

Legs are gressorial. Tarsi are short, with 1–2 segments. In the imago, claws are strongly reduced and there is a very conspicuous eversible pad between them (arolium). Certain species also jump well.


arolium on the last tarsal segment
(left contracted, right eversed state)

Wings are developed in 2 pairs. They are long and very thin with long marginal ciliation. At rest, they are folded along the abdomen. Venation is strongly reduced (max. 3 longitudinal veins). In certain species, the wings are strongly reduced (brachyptery) or entirely absent.

Abdomen has 10 segments. The last segment in the suborder Terebrantia is conical, terminating in an ovipositor; in the suborder Tubulifera, it is elongated into a long tube.

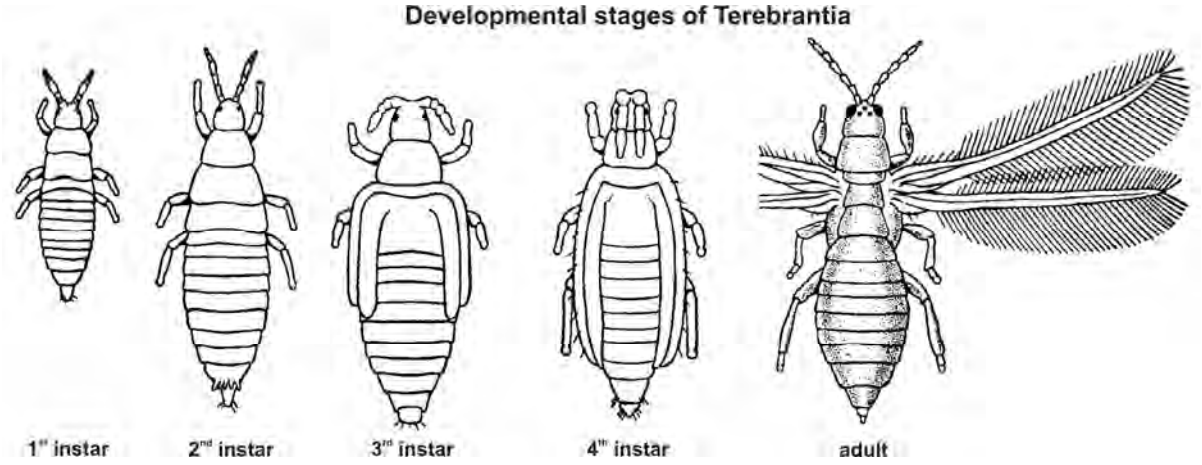


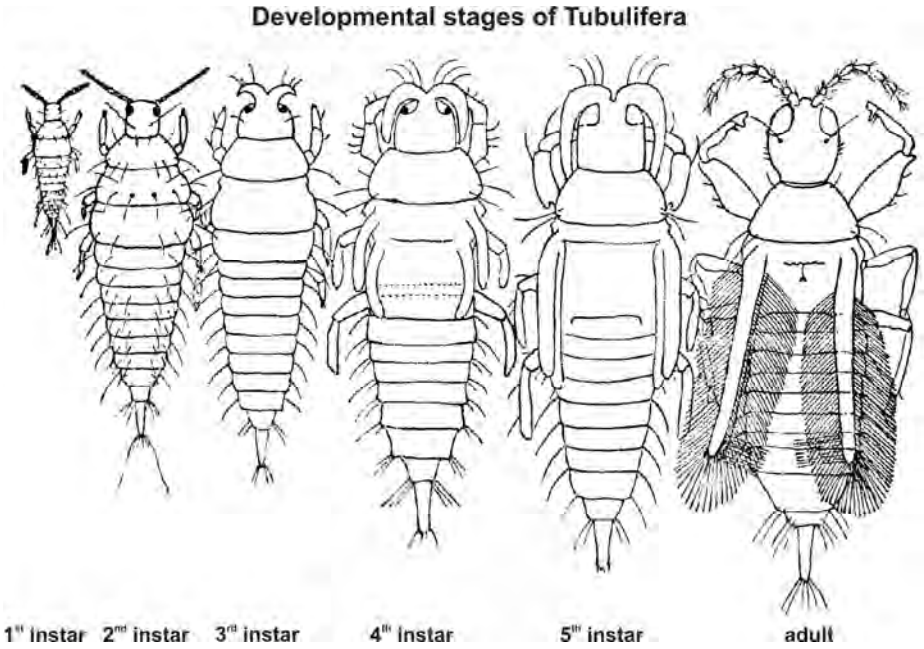
Egg

Many species reproduce parthenogenetically (arrhenotoky and thelytoky). In Tubulifera, eggs are deposited freely on plants; in Terebrantia, they are cut into the tissue by the ovipositor. Eggs are large in comparison with the size of the imago (0.3 mm) and oval (Tubulifera) or kidney-shaped (Terebrantia). Embryonic development lasts only around 1 week.

Larva

Larvae are very similar to the imago, but they are missing ocelli, eyes are reduced, wings are missing, they are lighter-coloured, and they have a smaller number of antennal segments. The first 2 stages are very active and they lack wings entirely (in Tubulifera, they are coloured more conspicuously than the imagos; in Terebrantia, they are lighter). Two to three resting stages then follow (3 in Tubulifera, 2 in Terebrantia), which are inactive and almost immobile (the first resting stage of Tubulifera still does not have the bases of wings while the other 2 already have them, just as in Terebrantia). An imago hatches from the last nymph. This type of incomplete metamorphosis is called remetaboly.





Ecology

Imagos and sometimes even nymphs overwinter. The number of generations depends on the species. It is strongly affected by weather; a warm dry spring has a very favourable impact on development (which causes strong gradation). A number of species have 1 generation per year, while other species have several generations. The imagos are very immune to cold. They spread by flight, and especially active swarming occurs in warm sultry weather.

Food

The overwhelming majority of species are phytophagous, sucking on almost all plant parts. They also suck on fungi, lichens, and pollen grains. Certain species, however, are predatory (hunting mites, aphids, whiteflies, butterfly eggs, and phytophagous Terebrantia).

Importance for humans

Phytophagous species cause very frequent and devastating damage in agriculture. Apart from direct damage, they also cause harm through the transmission of viral and bacterial diseases. They enable fungal infections to enter due to sucking.

Cereals are commonly damaged by *Frankliniella tenuicornis*, *Stenothrips graminum*, *Haplothrips aculeatus*, and *Haplothrips tritici*. Peas and beans, among others, are also often damaged by *Kakothrips robustus*. *Thrips linarius* are a significant pest on flax. Cucumbers, tomatoes, and peppers are often damaged by onion thrips (*Thrips tabaci*) and western flower thrips (*Frankliniella occidentalis*).

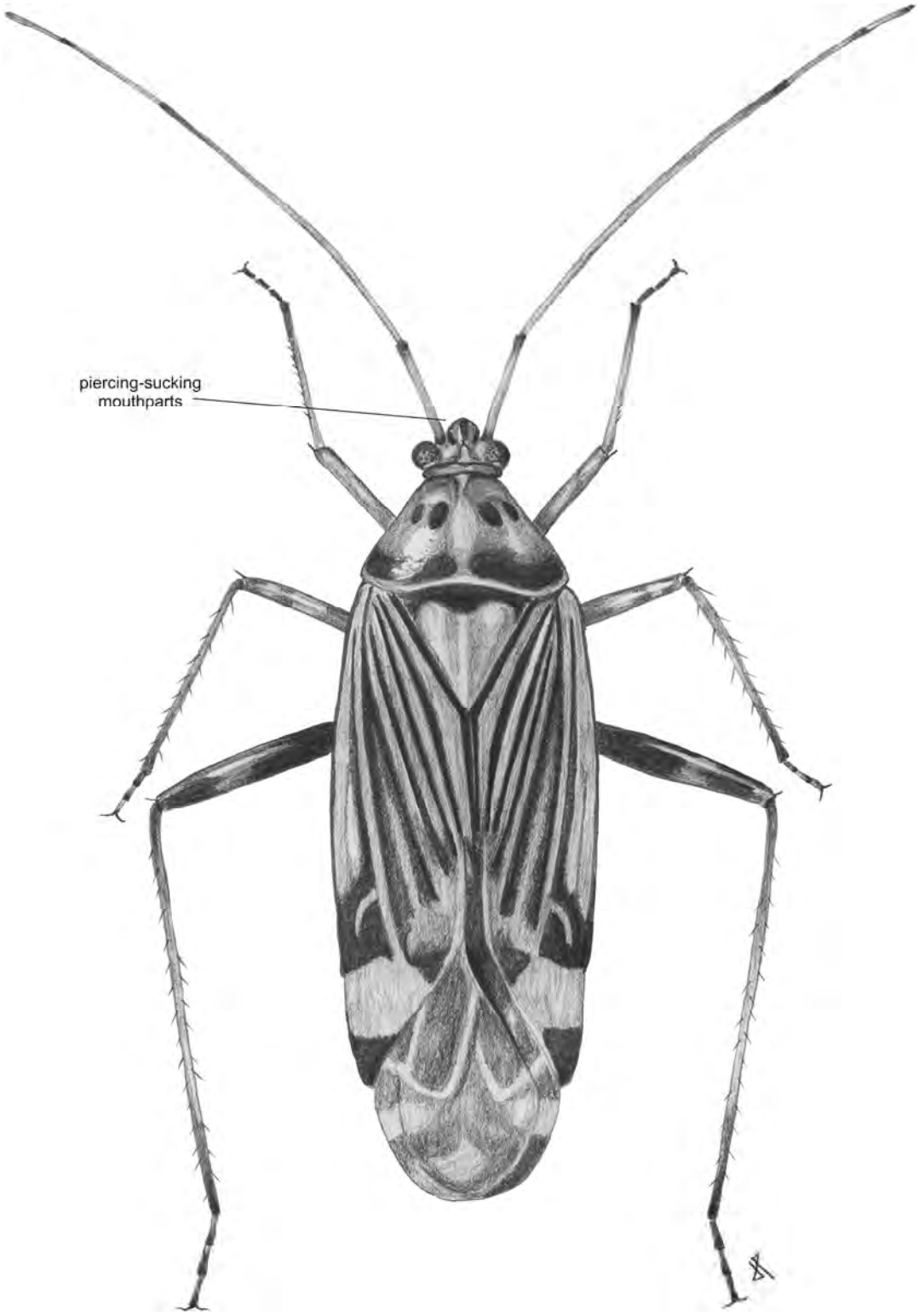
In forestry, only a single species can be considered a pest, *Taeniothrips laricivorus*.

Taeniothrips laricivorus is ca 1.2 mm long. The imago overwinters (below the scales of buds of other conifers, especially spruce) and in May it transits to a larch and deposits eggs on young needles of the terminal shoots (top parts). From May to approximately July (i.e. the imago's lifespan), it lays ca 40 eggs (eggs of 0.3 mm, thus relatively large). Embryonic development takes 2 weeks, and the same period also applies to the first 2 instars. These are followed by the 2 resting stages, when they remain under bark scales on the lower part of the trunk and do not ingest food. The entire development period of the first (spring) generation lasts approximately 2 months. The sex ratio is probably 2:3 in favour of females. The larvae and adults suck on the needles, which causes them to turn grey (and later black due to the development of fungi), warping, neoplasms, and loss of leaves. Sucking on young shoots leads to their death.

Another generation is established in July (the summer generation, which is not so concentrated on the peak of the tree), the development of which takes only 4 weeks. The imago overwinters (exclusively females of the summer generation).

It is the primary pest of young larches, attacking well-growing larches (only European ones) in the phase of their largest growth.

Order: **HEMIPTERA** (true bugs)		
derivation of the order's name hemi (Greek) = half, pteron (Latin) = wing	number of known species in the world 82,000	number of known species in the Czech Republic 2,300
Metamorphosis: **hemimetabloy: allometaboly** (in Aleyrodoidea [whiteflies]), **parametaboly** (in Coccoidea [scale insects]), **paurometaboly** (other groups)		



Systematics

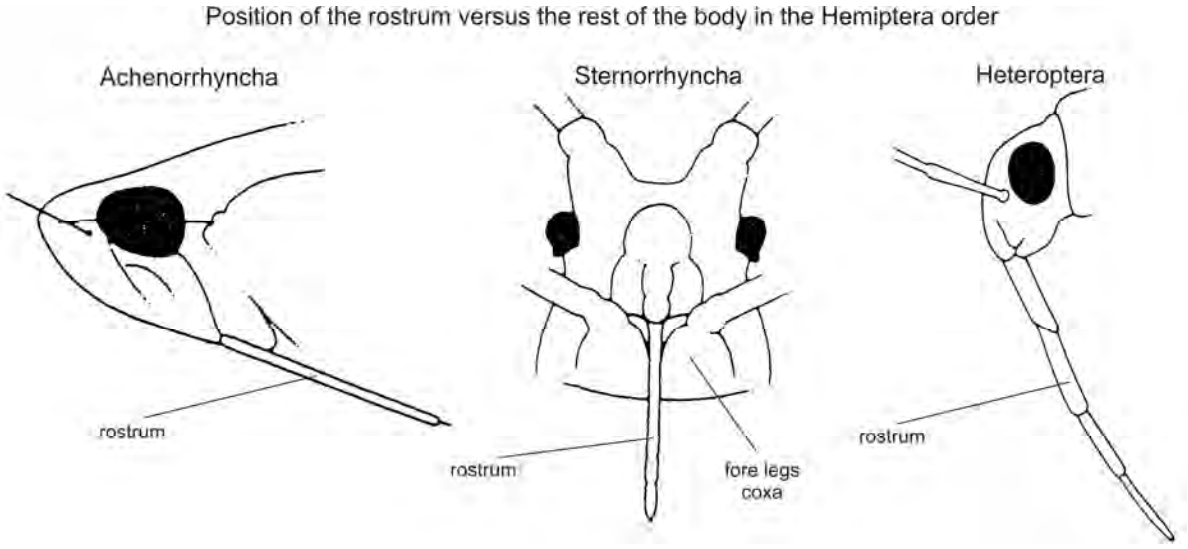
Hemiptera are systematically divided into 4 suborders, of which the suborder Coleorrhyncha is found only in the Southern Hemisphere. The following 3 are found in the Czech Republic. The suborders Auchenorrhyncha and Sternorrhyncha were previously classified as the independent order Homoptera.

- Suborder: **Auchenorrhyncha**
  - Infraorder: Fulgoromorpha (planthoppers)
  - Infraorder: Cicadomorpha
    - Superfamily: Cicadoidea (cicadas)
    - Superfamily: Cercopoidea (froghoppers)
    - Superfamily: Membracoidea
- Suborder: **Sternorrhyncha**
    - Superfamily: Psylloidea
    - Superfamily: Aleyrodoidea (whiteflies)
    - Superfamily: Aphidoidea (aphids)
    - Superfamily: Coccoidea (scale insects)
- Suborder: **Heteroptera** (typical bugs)
  - Infraorder: Cimicomorpha
  - Infraorder: Dipsocoromorpha
  - Infraorder: Enicocephalomorpha (tropical group)
  - Infraorder: Gerromorpha
  - Infraorder: Leptopodomorpha
  - Infraorder: Nepomorpha
  - Infraorder: Pentatomomorpha

General characteristics and body description of the adult

The order Hemiptera is a very numerous and considerably morphologically and bionomically heterogeneous group. Due to this heterogeneity, each suborder will be described individually.

Nevertheless, all suborders are united by the presence of piercing-sucking mouthparts. In Auchenorrhyncha, the rostrum is positioned on the underside of the head and shifted strongly backwards. In Sternorrhyncha, it is similarly shifted, but is only positioned between the coxae of the forelegs. In Heteroptera, the rostrum is positioned in the centre or on the front end of the head.



Suborder: AUCHENORRHYNCHA

General characteristics and body description of the adult

About 600 species in the Czech Republic, around 30,000 in the world. Inconspicuous to very colourful species with body sizes from several mm to 10 cm (species in the Czech Republic), tropical species with a wingspan up to 20 cm.

Head is opisthognathous with piercing-sucking mouthparts and a well-developed proboscis visibly protruding from the head. Antennae are relatively short (relative to Sternorrhyncha and Heteroptera), with two strong basal segments connected to a setaceous segmented flagellum. Eyes are relatively large and laterally positioned; 2–3 ocelli (or not developed).

Thorax is powerfully developed. The prothorax is scutellate to hypertrophied with a conspicuous mesoscutellum. Scent glands are not developed.

Legs are gressorial, capable of jumping. Tarsi have 3 segments.

Wings are present in 2 pairs. Forewings are slightly more strongly sclerotized (tegmina); sometimes, however, they are almost membranous, and usually also more distinctly coloured. Wings significantly prolong short jumps which are frequently followed by continuous flight. At rest, they are folded like a roof over the abdomen.

Abdomen – the first segment is reduced; thus the abdomen has 9 segments. Females have a developed ovipositor (3 pairs of valves). Stridulatory organs can be found on the ventral side of the 1st and 2nd segments, and auditory organs (tympanal organs) on the 1st segment.

Egg

Eggs are mostly oval-shaped, whitish, and laid into plant tissues (occasionally on their surface).

Larva

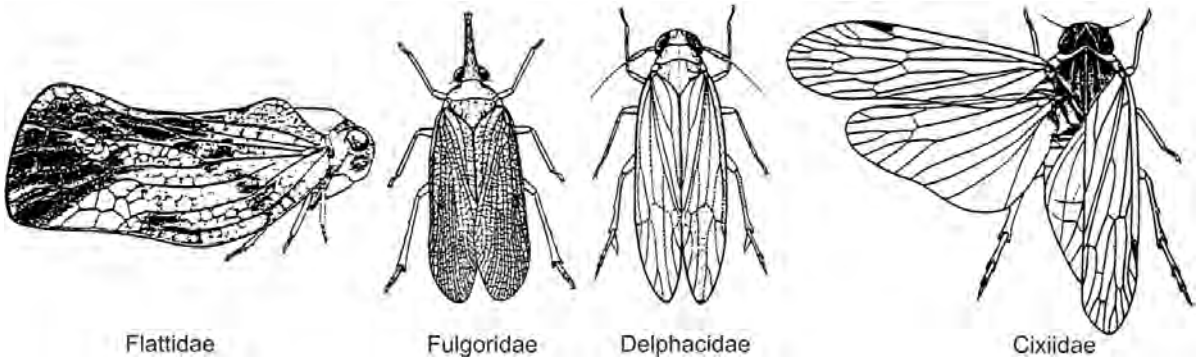
Development is paurometabolous, which means that the larva is similar to the adult, with wing sheaths gradually growing.

Food

All species without exception are phytophagous, sucking on plant juices. Due to the high intake of plant juices, the alimentary canal is equipped with a filtration chamber that accelerates the movement of sweet water outside of the body (so-called honeydew).

Infraorder: FULGOROMORPHA *(planthoppers)*

Antennae are set under the eyes, the pedicellus (first antennal segment) is elongated, and the head has longitudinal frontal keels. If ocelli are present, they are under the eyes or close to them, but always on the ventral side of the head. Tegulae (scaly sclerites) are developed over the bases of the forewings. Many representatives are important transmitters of plant viruses.

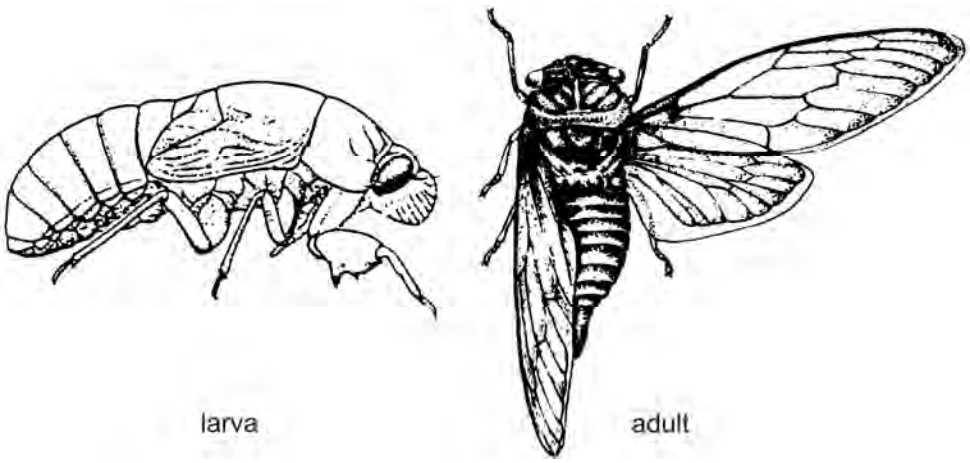


Infraorder: CICADOMORPHA

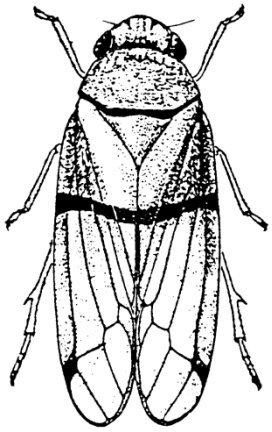
Antennae are set between the eyes (may also be on the ventral side of the head); the head lacks longitudinal frontal keels. If ocelli are present, they are between the eyes and always on the dorsal side of the head. Tegulae are not developed and hind coxae are immotile.

Superfamily: *CICADOIDEA (cicadas)*

In the Czech Republic, this superfamily is represented by only a few species. They are known for their ability to emit distinctive sounds. Males have a sound organ developed on the 1st abdominal tergite in the form of a membranous window (a number of other Auchenorrhyncha have been found to produce sounds, but they are imperceptible to the human ear). Eggs are laid with the help of an ovipositor in several clutches into weak branches of trees and bushes or stronger plant stems. Nymphs of the 1st instar then fall to the ground and develop further in the soil. They are morphologically marked by their extended (fossorial) forelegs and a bulging, bladder-like forehead. Their development usually takes several years. The American cicada *Magicicada septendecim* has the longest development, which lasts for 17 years. The protected species *Tibicina haematodes* and New Forest cicada *Cicadetta montana* are known in the Czech Republic.



Superfamily: *CERCOPOIDEA (froghoppers)*

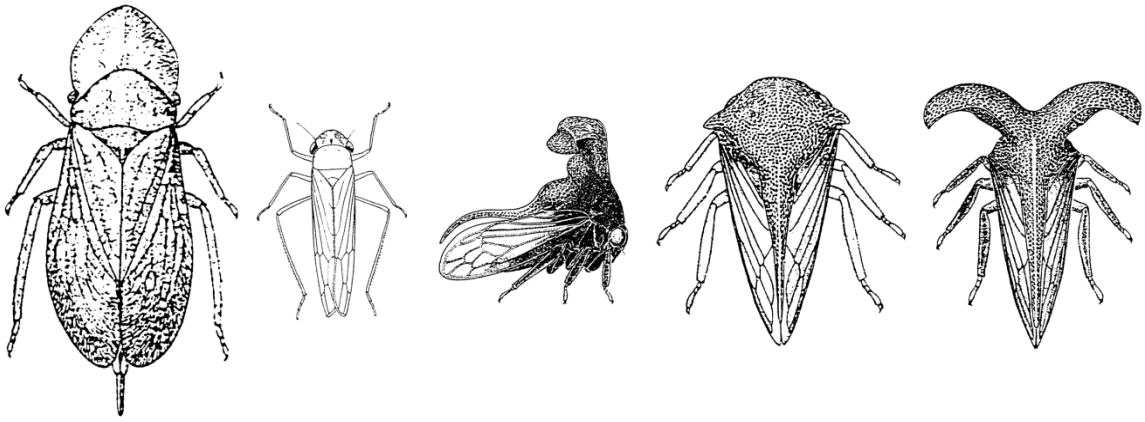


In the Czech Republic, they are only represented by less than twenty species. Their nymphs are particularly characteristic, sucking on plants and forming a frothy casing around themselves (as a product of respiration and secretion) in which the entire development takes place.

Most species develop on the above-ground parts of herbaceous plants, trees, and bushes; less frequently the nymphs develop on roots of herbaceous plants (e.g. the conspicuously red-black coloured species of the genus *Cercopis*). Certain arboreal species (representatives of the genus *Aphrophora*) frequently inflict damage by sucking on willows and alders.

Superfamily: *MEMBRACOIDEA*

This is by far the most numerous group of the entire suborder Auchenorrhyncha, encompassing mostly very small forms. Host plants are primarily grasses and herbaceous plants, woody vegetation altogether rarely. The number of generations varies from 1 to several (3) per year. They overwinter most frequently as eggs, more rarely as nymphs or imagos. A number of species are among direct pests in agriculture. They cause indirect damage by transmitting various plant viruses.



Suborder: STERNORRHYNCHA

General characteristics and body description of the adult

There are about 800 species in the Czech Republic and around 12,000 species in the world. They are small, inconspicuously coloured species with a body size of only a few mm, and in exceptional cases larger.

Head is opisthognathous, without a gula (throat). Antennae have 3–10 segments without a flagellar ending. They have piercing-sucking mouthparts, shifted strongly backwards to the area of the middle coxae. In certain groups, a crumena (endocephalic sheath of stylets) is developed. Compound eyes are developed or reduced; there are either 2 to 3 ocelli or they are not developed.

Thorax is well developed; the pronotum is neither enlarged nor scutellate (as it is in Auchenorrhyncha and Heteroptera). Scent glands are not developed.

Legs are gressorial. Certain groups have developed the ability to jump. Tarsi have 1–2 segments (sometimes the tibia and tarsus are merged into a tibiotarsus).

Wings are present or absent (sometimes depending on the generation, sometimes on sex). Alate (winged) forms have 2 pairs of wings (male scale insects have only one pair). The 1st pair of wings is membranous (in Psylloidea, tegmina); the 2nd pair always membranous. At rest, they are in most cases folded over the abdomen, either flatly or like a roof.

Abdomen has 9 segments. Waxy appendages are found on the apex of male scale insects.

Egg

Eggs are described below for the individual groups.

Larva

Development is hemimetabolous (incomplete metamorphosis). In individual groups, however, it is often typically modified and has various names (see below).

Food

All species without exception are phytophagous, sucking on plant juices. Due to the high intake of plant juices, the alimentary canal is equipped with a filtration chamber that accelerates the movement of sweet water outside of the body (so-called honeydew).

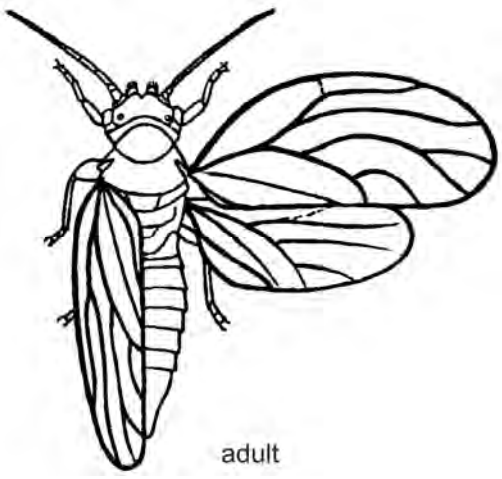
Superfamily: *PSYLLOIDEA*

Psylloidea (=Psyllinea) is a numerically small superfamily encompassing around 130 species in the Czech Republic. They somewhat resemble leafhoppers (Cicadellidae) in appearance.

The eyes are large and ocelli are developed. Antennae almost always have 10 segments (rarely 8); the scape and pedicle are short and wide, other segments (flagellum) are narrow, and the last segment ends with two bristles. The tarsi have two segments, two claws, and glassy transparent pulvilli. Wings are developed, with rather poor venation. Imagos jump and the length of the jump is usually extended by short flight.

Imagos and nymphs suck on the soft parts of plants above-ground, on leaves, stems, and blossoms. Nymphs are predominantly monophagous and, in most cases, imagos are not as strictly tied to the host plant species. They are generally hydrophilic species.

Using the developed ovipositor, females deposit eggs into the surface parts of plant organs, and the egg is anchored in the plant tissue by a short stalk. Development is paurometabolous; nymphs are flattened and in all instars considerably unlike the adult. The head and thorax are large in relation to the total length of the body. Wing sheaths do not emerge until the final instars. The first instar seeks a suitable place for sucking; other instars are practically completely sessile. The total number of instars is 5. Due to intensive sucking and imperfect use of food, the nymphs cover their surroundings with a large amount of honeydew (limited respiration and assimilation, development of black epiphytic fungi). They often produce waxy filaments. Development lasts usually for one year; only in certain species are more generations per year observed. It is usually the imago that overwinters, sometimes the eggs or nymphs of the first instar.


adult

Together with other Homoptera, they are significant as transmitters of viruses.

Superfamily: *ALEYRODOIDEA (whiteflies)*

In the Czech Republic, Aleyrodoidea (=Aleyrodinea) is represented by approximately 10 species.

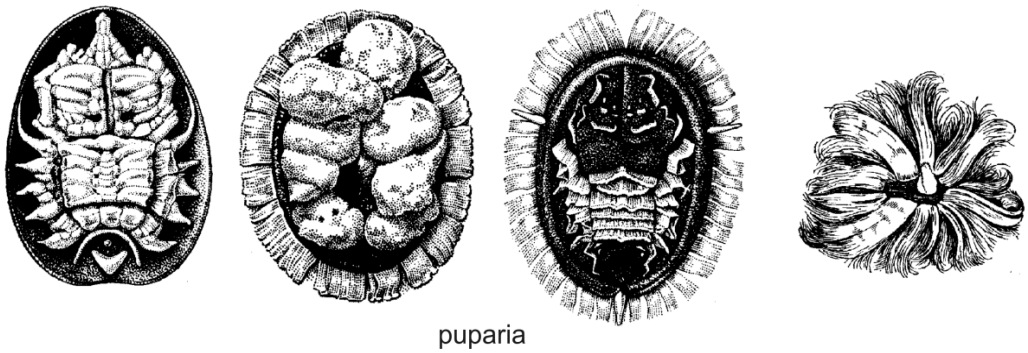
Eyes are well developed; two ocelli. Antennae are formed similarly as in Psylloidea, although they only have 7 segments and the last segment of the flagellum ends with only one bristle. Wings are developed and, like the body, covered in a white waxy dusting that is produced by glands at the base of the abdomen and spread by the legs and wings over the entire surface of the body. The tarsi have 2 segments; the final segment terminates in two claws and an unpaired, often prickle-like arolium. Venation is greatly reduced. Imagos also jump. Sexual dimorphism is not developed; the imago offers few characteristics useful for determination.

After copulation, which may be preceded by epigamic displays (male dances involving circular movement around the female and touches with the antennae), the females deposit eggs with a characteristic short stalk (similarly to Psylloidea) on the surface of plant tissues with the help of the ovipositor. Eggs are most frequently deposited on the underside of leaves. It is assumed that eggs gain a certain amount of moisture from the plant tissues in the course of embryonic development. Eggs are also covered by a waxy powder. They are commonly laid in a circle, as the female turns around the centre that constitutes the sucking place.


adult

Nymphs are flat and even less similar to adults than in the case of Psylloidea. The head and thorax form one whole and this state is preserved until the end of development. The nymphs also produce wax. The total number of instars is 4. Only the 1st instar is mobile and, after sucking, the

legs and antennae of the following instars shorten. In the second half of development of the final (4th) instar, the nymph stops ingesting food, the production of wax increases, and the shape changes into a structure that, to a certain extent, resembles a pupa (a so-called puparium that provides the highest number of characteristics for determination of the species). In the puparium, it undergoes an extensive metamorphosis into a winged imago. This type of incomplete metamorphosis is called allometaboly and it constitutes a certain variant of, or perhaps a transition to, complete metamorphosis.



puparia

Most species have 1–2 generations per year. They overwinter either as imagos or puparia.

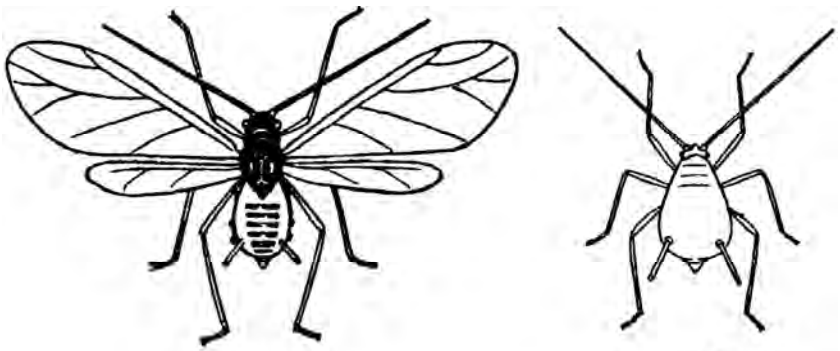
The fauna of the Czech Republic only includes a small number of free-living species (about 10), usually not very abundant. In most cases, they are broadly oligophagous to polyphagous and have a large geographic distribution. Several species of various genera of woody plants are hosts, especially maples (mainly *Aleurochiton complanatus*), hazel, oak, hornbeam, and willow trees.

Locally, they can cause damage as pests, such as the Cabbage Whitefly (*Aleyrodes proletella*) on vegetables (polyphagous species) and the introduced greenhouse whitefly (*Trialeurodes vaporariorum*) on ornamental plants in greenhouses.

Superfamily: *APHIDOIDEA* *(aphids)*

There are approximately 750 species in the Czech Republic. They include lightly sclerotized and generally small species of a size no more than a few mm (max. 8 mm). With minor exceptions (Callaphididae), aphids do not jump.

Head is hypognathous, with the hind side firmly attached to the thorax (in nymphs and wingless females of certain species, such as *Thelaxes*, it even completely fuses with the thorax). Eyes are usually well-developed and multifaceted, although exceptionally also even only three-faceted (in most species, at the back edge of each faceted eye there is also a protrusion of three ommatidia [triommatidium]). Antennae have 3–6 segments (most often 6) and are equipped with sensory organs (rhinaria). Winged females have 3 ocelli developed.



winged female wingless female

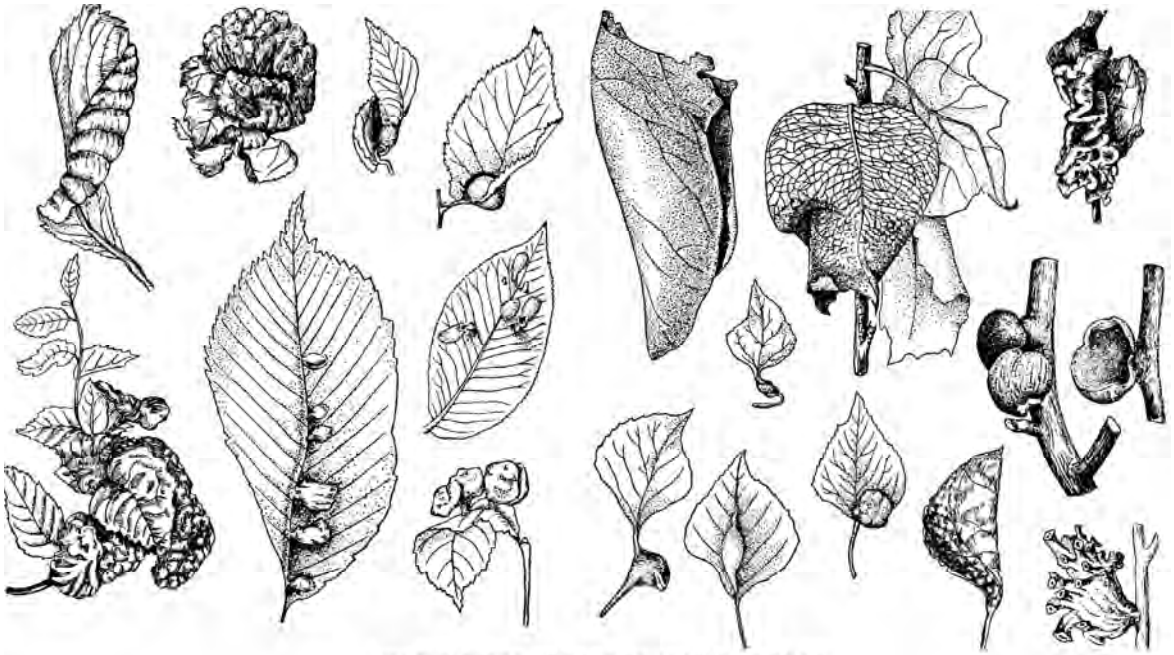
Both pairs of wings are membranous, in most species folded like a roof and more rarely (Phylloxeridae and Thelaxidae) horizontally. Venation is relatively sparse, with a pterostigma. The tarsus has 2 segments; the first segment is short and the terminal one has two claws.

There are frequently characteristic siphunculi of various shapes on the abdomen (usually between the 5th and 6th segments).

Nymphs are considerably similar to adults. A large variety of forms exists in adults of a single species, both winged and wingless. Mass occurrence in colonies is common.

The development of aphids is often very complicated. It is especially characterized by the alternation of parthenogenetic generations (usually parthenogenetic thelytoky is distinctively dominant) with sexual reproduction, so-called heterogony.

In parthenogenetic females, vivipary is almost regular. Members of the families Phylloxeridae and Adelgidae constitute the only exceptions, where even parthenogenetic females are oviparous. Parthenogenesis connected with vivipary is the main strategy of aphids, allowing maximal use of resources at the most suitable time, and thus enabling an uncommonly rapid population increase.



various types of galls caused by aphids

Development is frequently accompanied further by changes of the host plant or organs on which the individual forms suck.

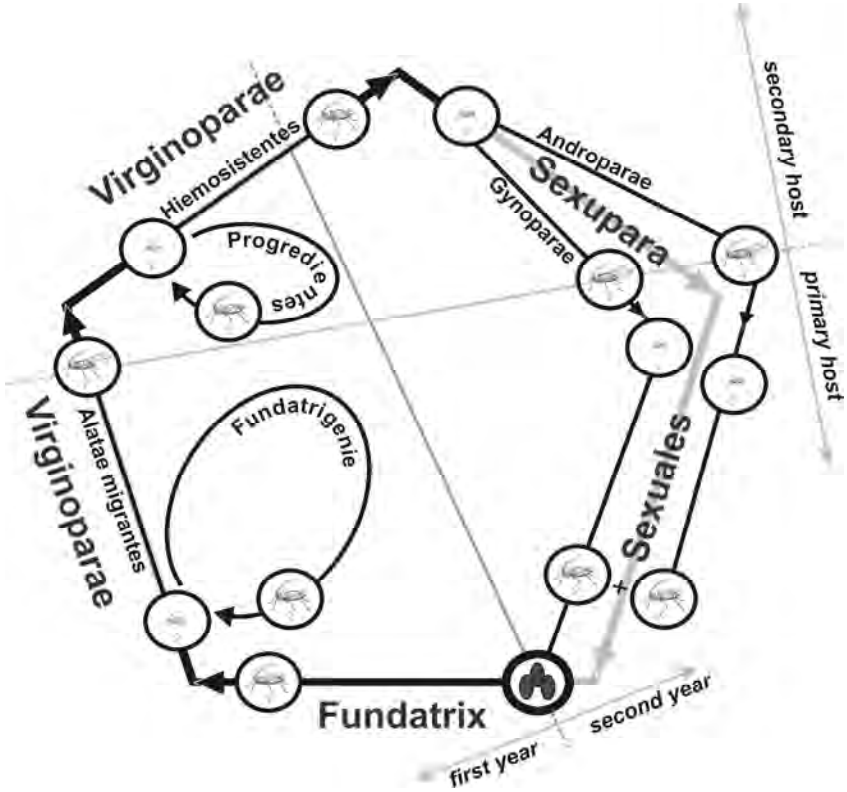
The following species can be distinguished:

- monocyclic (monoecious), which permanently live on one species of host plant; and
- dicyclic (dioecious), which alternate between two hosts during development:
    - the primary host is the host on which the sexual generation develops and where wintering eggs are laid, and
    - the second host (which may often be tens or hundreds of species of plants) is called secondary and serves only for multiplication of the population.

The general complete cycle of aphids is as follows:

The entire cycle is essentially pentamorphous. It starts with the

- **fundatrix (foundress)** – the fertilized egg overwinters (on the primary host) from which a founding female (fundatrix) hatches in the spring. It is highly fertile and gives birth to 100–370 nymphs. As these nymphs develop from unfertilized females (virgins), the generations newly emerged from them are called virginoparae (in general, virginoparae are already significantly less fertile than the foundresses, usually 20–65 nymphs).
- **Virginoparae** develop into either:
  - wingless adults that stay with the foundress on the same plant (primary host) and continue to reproduce by parthenogenetic vivipary (**fundatrigeniae** generation), or
  - winged adults that fly over to the secondary host where they also reproduce by parthenogenetic vivipary (**migrantes alatae** generation).
- Another generation of **virginoparae** (progeny of the migrantes alatae generation) always develop into wingless individuals:
  - generation of **progredientes** which only multiplies the colony on the secondary host and then give rise to the
  - generation of **hiemosostentes** which is adapted for overwintering.
- Another generation of virginoparae bears a special designation, **sexupara** (the last virginoparous generation of the entire cycle), which is usually winged and migrates back to the primary host (sometimes called **remigrantes alatae**). Some of this generation reproduces by
  - parthenogenetic thelytoky – generation of gynoparae (only females arising from their progeny), and
  - parthenogenetic arrhenotoky – generation of androparae (only males arising from their progeny).
- In the entire cycle, the first generation thus emerges when males and females occur (so-called amphigonous generation=mixed). This generation is called **sexuales**. Both sexes mate and the females lay a small number (1–14) of fertilized eggs that overwinter, and from which larvae of foundresses (fundatrices) hatch in the spring and the entire cycle repeats itself.



Males are thus always formed parthenogenetically in aphids, and females parthenogenetically or sexually.

Aphids of individual generations are morphologically different, adapted to their purposes within the overall cycle. This general cycle of aphid development, however, can be modified in various ways within individual species or even within the distribution of a single species.

- The egg may not overwinter on the primary host, but rather larvae of the first or second instar (*Adelgidae*).
- Virginoparae may not always have 2 generations (or 3, if the last virginogenetically formed generation of the sexupara is counted). This number often tends to be 4–6 or even more, depending on the suitability of development conditions (e.g. host or weather conditions).
- Winged sexupara may not return to the primary host, but rather the winged sexuales. In this case, the sexuales generation is called remigrantes alatae.
- The entire cycle may take place on just a single host.

Apart from the complete cycle according to the basic scheme above, paracycles may occur on one of the hosts, for which parthenogenesis may be continually maintained. This also applies to introduced species that are only maintained by parthenogenetic reproduction (e.g. *Viteus vitifoliae*, woolly apple aphids [*Eriosoma lanigerum*], certain Adelgidae).

The incomplete cycle is called anholocycly and arises

- due to suppression of the bisexual generation (aposexuality), in which case aphids develop only parthenogenetically; or
- on the other hand, due to suppression of a parthenogenetic generation.

If the typical heterogony is maintained, with parthenogenetic generations alternating with one amphigonous generation, it is then referred to as a complete cycle, or holocycly.

A number of species form species-specific galls. A generation that feeds in galls is called gallicolae (or cellares).

Postembryonic development is paurometabolous with 4 instars, where nymphs are quite similar to adults.

Importance

Aphids are significant pests in forestry and especially agriculture. They cause direct damage by actual sucking and indirect damage by transmission of a number of viruses. Staining of leaves by the production of honeydew can also be considered indirect damage.

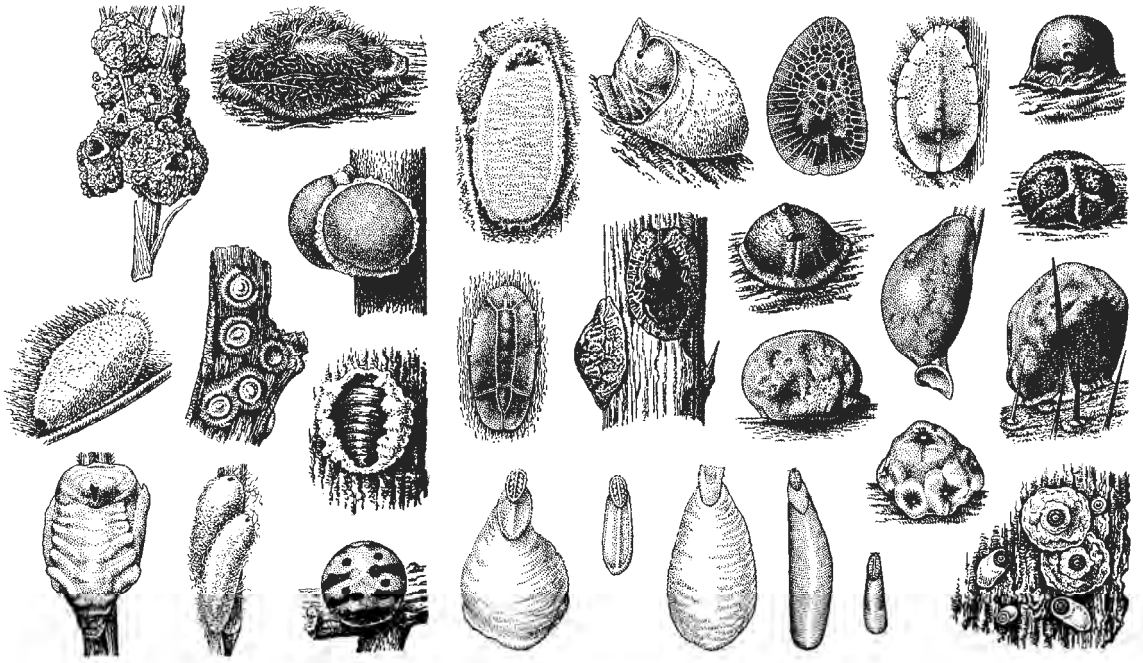
Overview of the most important species and their host plants

Aphid species	Primary host	Secondary host
Sacchiphantes abietis	spruce	–
Sacchiphantes viridis	spruce	larch
Adelges laricis	spruce	larch
Gilletteella cooleyi	spruce (except for the Norway Spruce)	Douglas fir
Dreyfusia nordmannianae (silver fir woolly aphid)	Caucasian Spruce	fir
Dreyfusia piceae	–	fir
Pineus pini (pine woolly aphid)	–	pine
Myzus persicae (green peach aphid)	stone fruits of the genus *Prunus*	over 100 different plants
Aphis fabae (black bean aphid)	*Viburnum*, spindle tree, Mock-orange	several hundred plant species
Rhopalosiphum padi (bird cherry-oat aphid)	Bird Cherry	cereals and grasses
Phorodon humuli (damson-hop aphid)	Genus *Prunus* (especially plums)	hops
Eriosoma lanigerum (woolly apple aphid)	–	apple trees and Cotoneasters

Superfamily: *COCCOIDEA* *(scale insects)*

There are around 200 species in the Czech Republic, and a number of species have been introduced into greenhouses with ornamental plants. They constitute one of the most peculiar groups of insects. They are generally of small size. Their characteristic feature is immense sexual dimorphism.

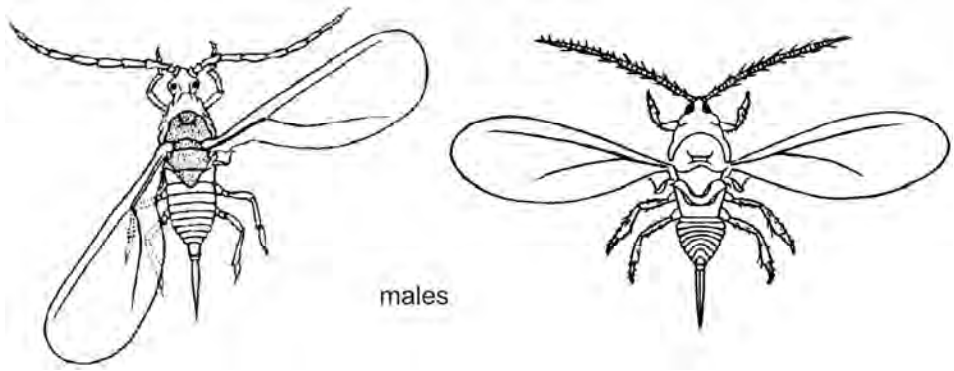
Females are always wingless, with legs either developed or absent. The body frequently has little apparent segmentation; the head mostly merges with the thorax. Compound eyes are not developed. The body is frequently covered with waxy formations or covered under the scutum. A sexually mature individual is only slightly different from a nymph, rather resembling a neotenic larva.



females of various species

Males are winged (only exceptionally wingless), with only the first pair of wings being well-developed; the hind pair is reduced to rod-shaped formations resembling halteres. They have well-

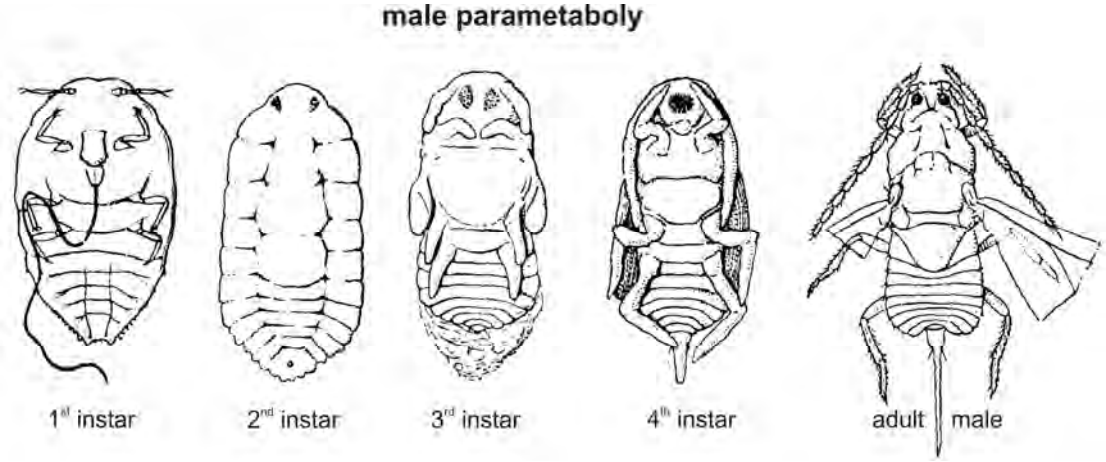
developed eyes, antennae, and legs; however, the mouthparts and digestive tract are strongly reduced. The tarsus has 1 segment with only one claw (exceptionally 2 segments, as in Xylococcidae). The tarsal segment and claw feature extended bristles (digitules). Antennae have 1–11 segments, most frequently 7–9.



Reproduction is mostly sexual, although in certain cases parthenogenetic (arrhenotoky and thelytoky). Females are mostly oviparous, but ovovivipary and vivipary (armoured scale insects [Diaspididae]) may also be encountered. Deposited eggs are protected in a sac or entirely under the female's scutum.

Postembryonic development is different in females and males.

- The first nymphal instar is common for both sexes. It is mobile, equipped with limbs and sensory organs, and it seeks a suitable place to cling to. This is followed by
    - 3–4 instars in males, in which the wing sheaths, antennae, and legs gradually emerge. The last 2 instars develop under variously formed casings and do not ingest food. This development, resembling complete metamorphosis, is called parametaboly.
    - only 1–2 further instars in females, development by paurometaboly. Development finishes in a stage that looks like a nymph but has functioning sexual organs capable of further reproduction. Exuviae are visible on the scutum, usually as darker spots.



They often have several generations per year.

Importance

A number of species are vicious pests in agriculture and horticulture.

Overview of species with great significance to forestry

Species of scale insect	Biology
Physokermes piceae (spruce bud scale)	1-year generation, overwintering larvae in the 2nd instar, exclusively sexual reproduction, damages spruce.
Physokermes hemicryphus (smaller spruce bud scale)	Biology identical to *P. piceae*. The number of males is negligible and the species mostly develops parthenogenetically. It sucks on older spruce and possibly firs.
Leucaspis loewi	1-year generation, white scuta, sucks on Scots Pine, Mountain Pine, European black pine, and other species.

Suborder: HETEROPTERA (typical bugs)

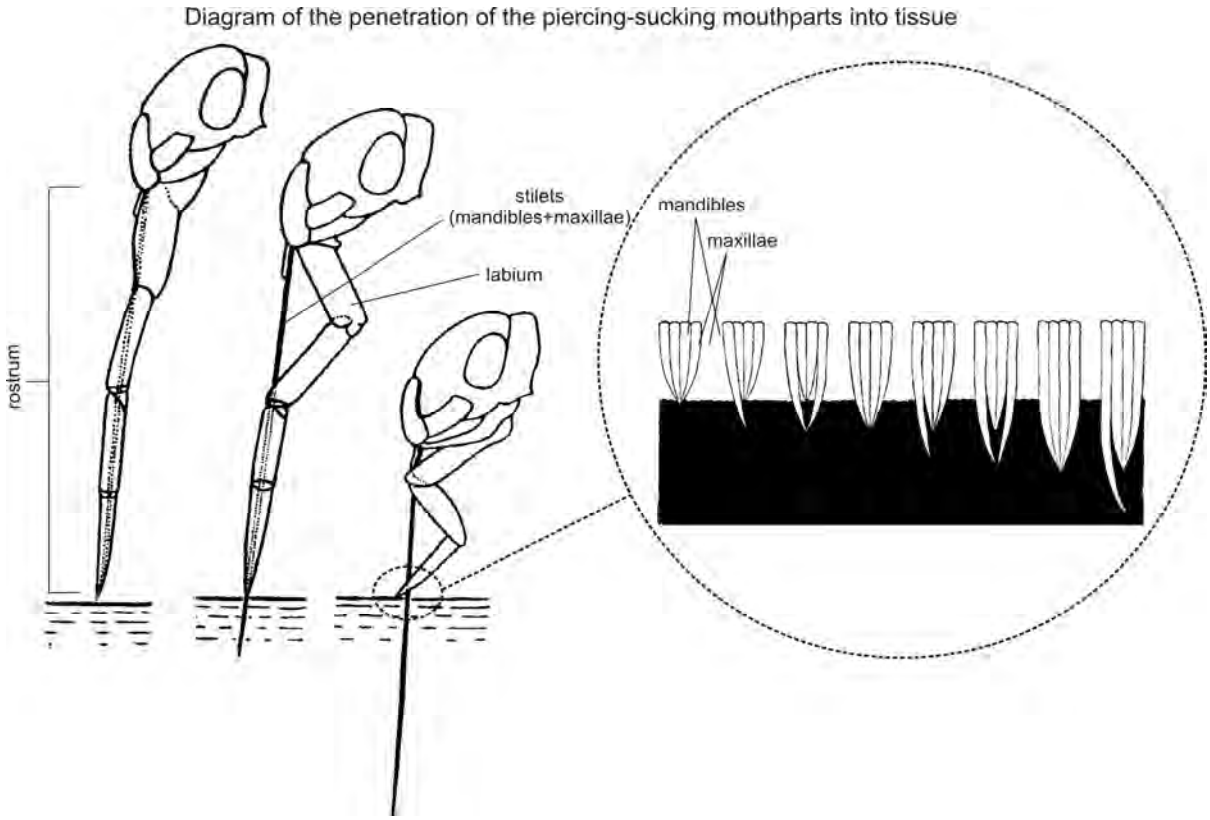
General characteristics and body description of the adult

There are around 850 species in the Czech Republic and around 40,000 in the world. In terms of size, it is a diverse group including small, medium, and large-sized species with relatively quite sclerotized integument. The body has a more or less oval outline, is flattened, and usually with inconspicuous coloration (Reduviidae and certain species of the families Miridae and Pentatomidae are exceptions).

Their characteristic features are primarily

- forewings transformed into hemelytra, and
- piercing-sucking mouthparts based on the front end of the head.

Head bears piercing-sucking mouthparts. The rostrum grows on the front end of the head and is tilted backwards (often in a recessed strip), whereas in Sternorrhyncha and Auchenorrhyncha it is based at the back of the head. The piercing parts (so-called stylets) are formed by the maxillae and mandibles, and the supporting parts are formed by the labium and labrum. The stylets are sometimes so long that they are rolled up in a spiral in a special sac inside the head. Their length can be many times longer than the entire body, as for example in Aradidae. The main part of the stylet is formed by the mandibles, which enter first, in turns, and after which the maxillae penetrate, serving as a pump for supplying saliva (in predatory species it causes paralysis, prevents blood coagulation, and pre-digests food). In phytophagous Heteroptera, the rostrum can only be turned to a position perpendicular to the body axis, while in predatory species it can be aimed almost completely forward.



Eyes are well-developed, and if ocelli are developed there are always only two. Antennae are either not visible from the top, short, hidden, or clearly visible. The total number of segments ranges from 3 to 5, but most often with 4 segments.

Thorax

Legs are gressorial, and walking is the preferred method of movement; sometimes the first pair is transformed into raptorial legs. Tarsi usually have 3 segments, rarely 2 segments (Aradidae, Tingitidae, and Piemidae) and exceptionally 1 segment (in the water bugs Corixidae and Nepidae). The final segment has two claws and, moreover, in practically all Heteroptera (with the exception of water bugs, predatory Reduviidae, and water striders [Gerridae]) is also equipped with gripping pads, enabling skilled climbing.

The overall form and length of the leg corresponds to adaptation to the environment. Many of them jump, although the formation of the hind legs does not show any features corresponding to this manner of movement. In water bugs, the forelegs are frequently modified into raptorial legs; in the family Nepidae, they are practically unusable for movement.

Wings are developed in 2 pairs. The fore pair is strongly sclerotized and variously coloured (so-called hemelytra). The second pair is membranous. The forewings play the largest role in flight, which corresponds to the development of the relevant thoracic segment (mesothorax). The majority of Heteroptera are good flyers, with the two pairs of wings interconnected during flight. Some species have reduced wings (more common in females). Sometimes wings are developed but the musculature insufficiently so. In other cases, the wings are vestigial (Cimicidae).

Abdomen has 11 segments, but the first and last segments are strongly reduced.

Scent glands

A rather typical characteristic of Heteroptera is the unpleasantly smelling secretion secreted by the scent glands. The glands are situated in the metathorax and the opening in the imago is close to the hind coxae, while in larvae it is on the front edge of the 4th–6th abdominal segment. There are usually three unpaired ducts. In the imago, there is usually rougher sculpture on the surroundings of the duct (improved evaporation of the secretion). A number of species can regulate the secretion with a closing mechanism, but in cimicids (Cimicidae) the product flows out constantly. Their greatest significance is probably as a defence mechanism, but they may also have sexual importance.

Stridulation

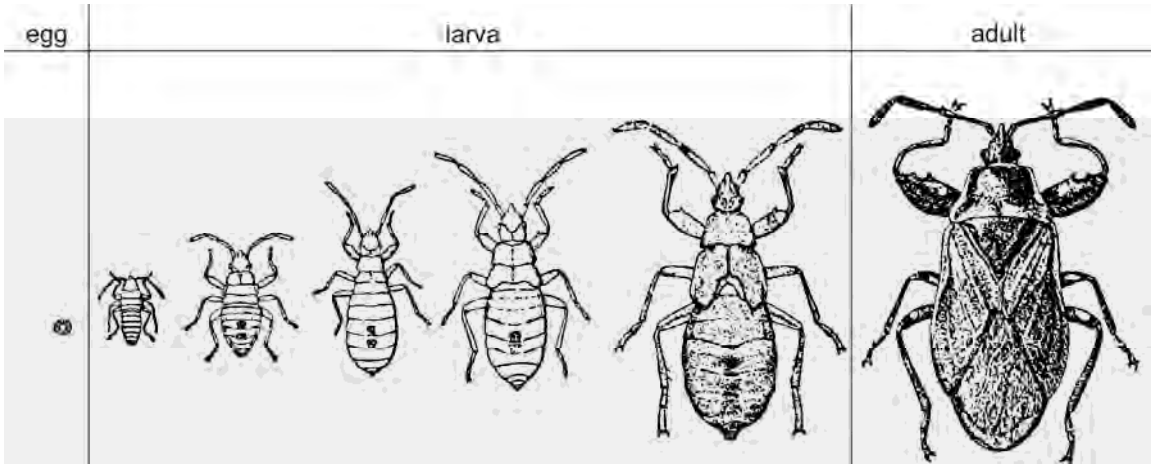
A number of species produce sounds. The method varies. Usually the mouthparts and their position on the underside of the prothorax are involved. In other cases it is the hind wing, and in others the hind tibia and hairs on the abdomen (Nabidae). To date, however, tympanal-type auditory organs have been determined only in certain water bugs. Low frequencies can be perceived by the Johnston's organ at the base of the antennae.

Egg

Eggs are most frequently laid in groups and are fixed to the surface through the help of secretions from accessory glands. The most common surfaces are plants, although certain species lay eggs into soil, litter, and the like. They are oviparous with the exception of the small family of tropical Polyctenidae (permanent parasites of bats), for which vivipary is evident. In certain exotic species, the eggs are placed on the dorsal side of the male's body, where they remain until hatching. Certain species in the fauna of the Czech Republic remain with the eggs until hatching.

Larva

Postembryonic development is paurometabolous. There are 5 larval instars (exceptionally in riffle bugs [Veliidae] there are 4). The nymph lacks ocelli and wings and has only 2 tarsal segments.



Ecology

Females are evidently sought (males are more sexually active) by smell, though in certain representatives sight dominates (Hydrometridae).

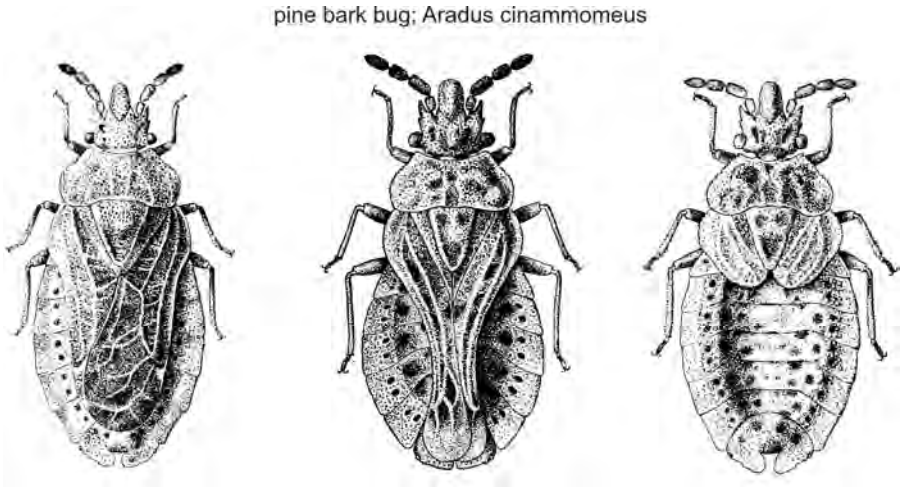
Copulation is normal. Sperm is transferred into the female's sexual organs with the exception of Cimicidae, in which case the male pierces the abdominal wall at any place or transfers the sperm into a special organ (organ of Berlese) between the 4th–5th sternite of the female's abdomen. In both cases, sperm reaches the eggs along with haemolymph.

They mostly have 1 generation per year. Both egg and imago overwinter (rarely also the nymph).

Food

Larvae and adults are mostly herbivores, sucking on various plant tissues. Nevertheless, a considerable number of species are predatory (for example, almost all water species; and among terrestrial species Reduviidae), and certain species even suck the blood of vertebrates, including humans (Cimicidae). Aradidae (flat bugs) are food specialists, feeding by sucking mycelia, able to reach great depths of the narrowest crevices (extremely long proboscis). In this regard, some species of the genus *Aradus* are

atypical, such as, for example, the pine bark bug (*Aradus cinnamomeus*), which sucks on the trunks of various conifers, especially pine, but also on alders and birches. A number of other species of this genus suck on various broadleaved trees, causing damage.

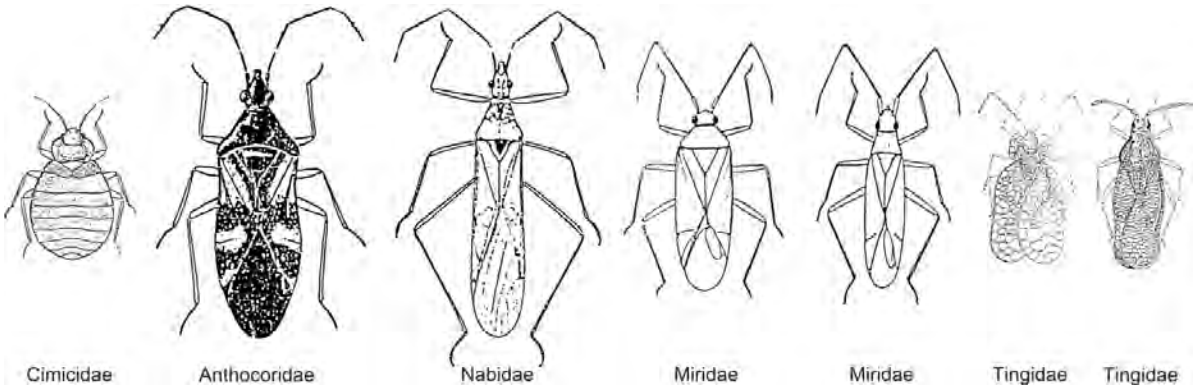


Overview of species with great significance to forestry and agriculture

Species of Heteroptera	Harmfulness
Aradus cinnamomeus (pine bark bug)	conifers (especially pine) as well as certain broadleaved trees
Lygus rugulipennis (European tarnished plant bug)	widely polyphagous; damaging alfalfa, vegetables, root crops, hops, fodder crops, ornamental plants, and fruit orchards (especially apple trees and small fruits)
Lygus pratensis	
Lygocoris lucorum	
Lygocoris pabulinus (common green capsid)	
Orthops kalmii	
Orthops campestris	
Adelphocoris lineolatus (alfalfa plant bug)	alfalfa, vegetables, flowers, small fruit
Closterotomus norvegicus (potato capsid)	legumes, potatoes, cereals, tomatoes, ornamental plants, poppy

Illustrations of certain representatives of all suborders of Heteroptera found in the territory of the Czech Republic

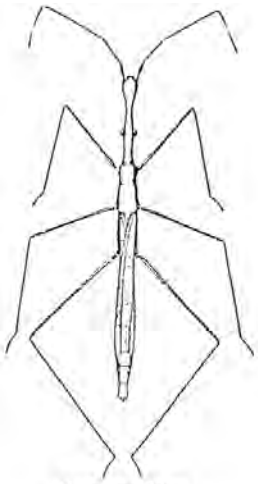
Infraorder: CIMICOMORPHA



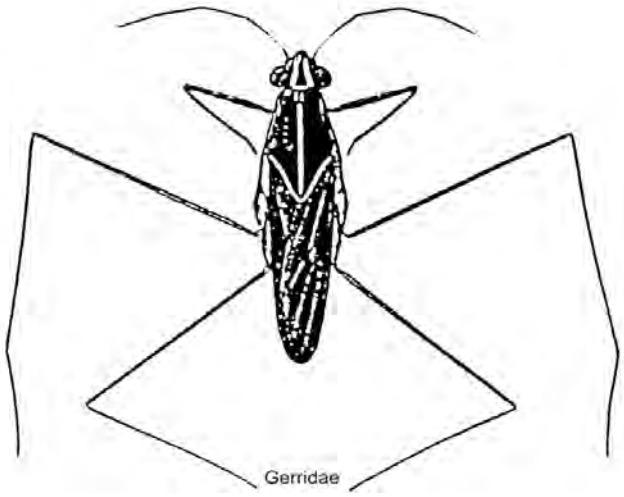
Infraorder: DISPSOCOROMORPHA

Ceratocombidae

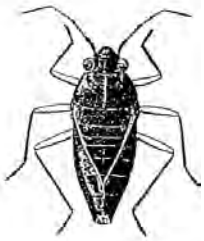
Infraorder: GERROMORPHA



Hydrometridae

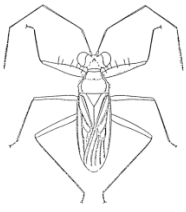


Gerridae



Veliidae

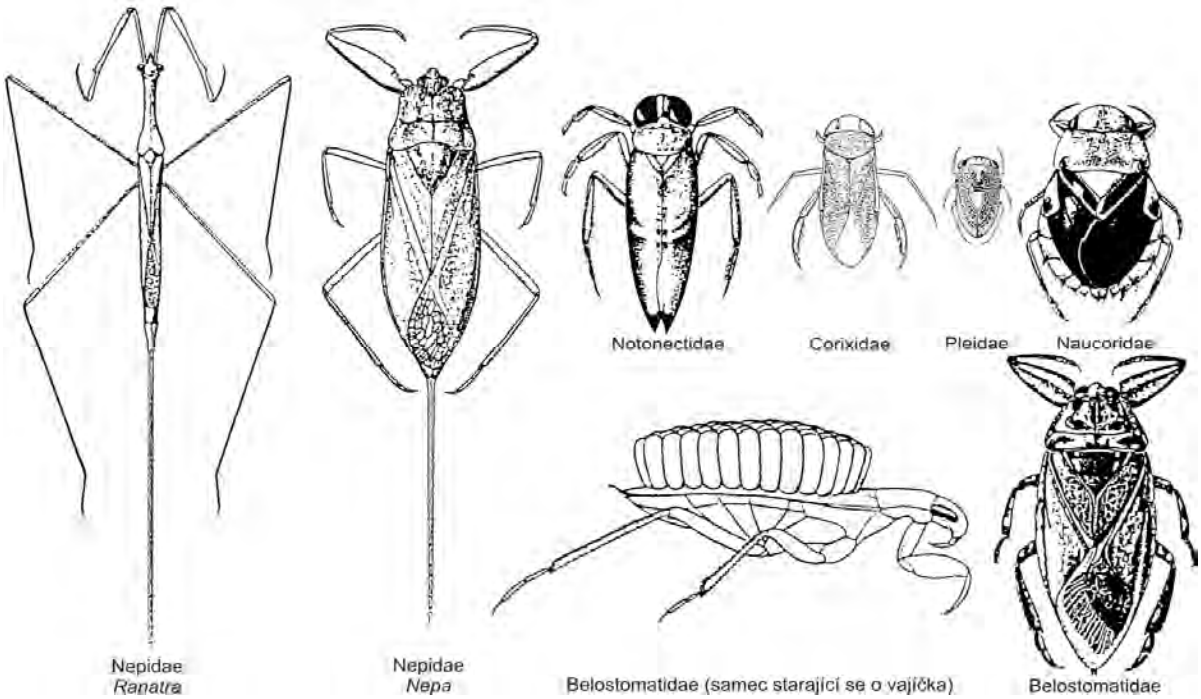
Infraorder: LEPTOPODOMORPHA



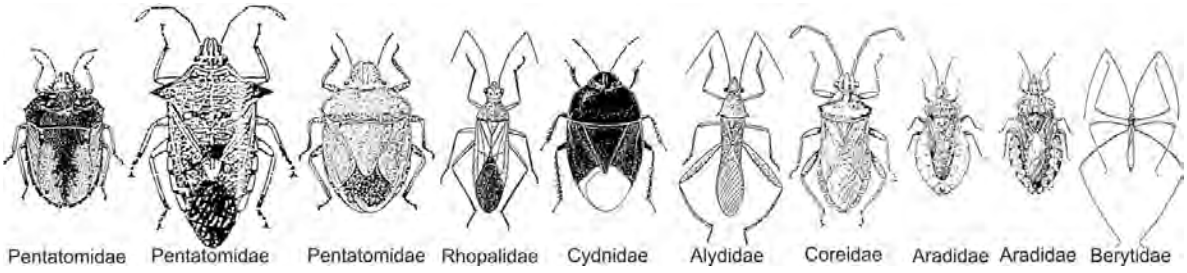
Leptopodidae

Saldidae

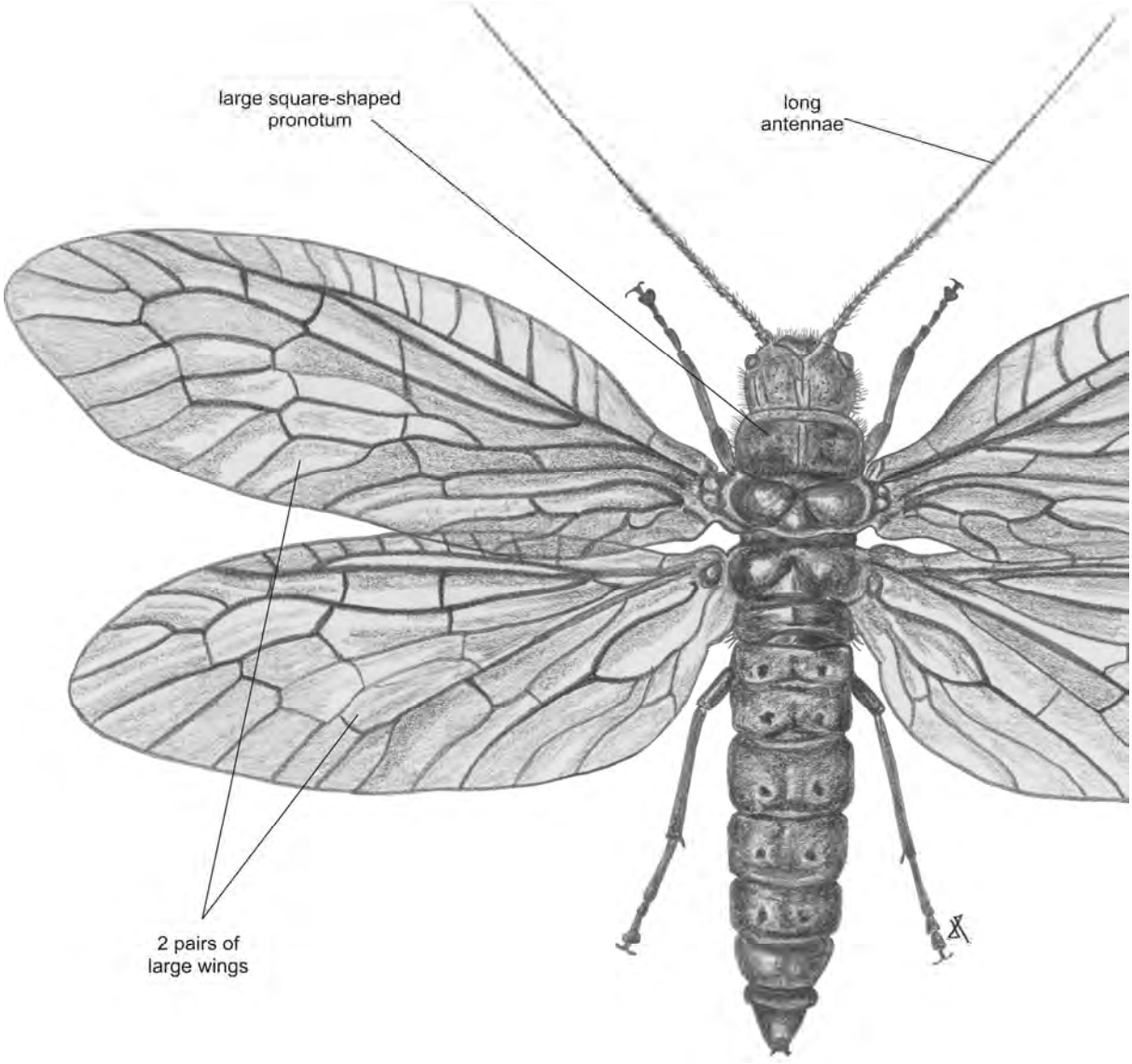
Infraorder: NEPOMORPHA



Infraorder: PENTATOMORPHA



Order: **MEGALOPTERA**		
derivation of the order's name megalo (Greek) = large = pteron (Latin) = wing	number of known species in the world 300	number of known species in the Czech Republic 3
Metamorphosis: **holometaboly**		



Systematics

A very old order dating back to as early as the Permian. They are probably the predecessors of the entire group Neuropteroidea (including the orders Megaloptera, Raphidioptera, and Neuroptera).

- Suborder: **Sialina** – alderflies (only one family in the world, Sialidae; in Central Europe, only 3 species living in the Czech Republic)
- Suborder: **Corydalina** – dobsonflies and fishflies (one family in the world, Corydalidae; found throughout the Northern Hemisphere and in South America, but do not live in Central Europe)

General characteristics and body description of the adult

Body size 1–2 cm (2–4 cm wingspan). Body coloration is inconspicuous, dark brown; wings are smoky brown.

Head is prognathous, flat, and strongly sclerotized with semicircular, bulging, forward-facing eyes; ocelli are absent (however, Corydalina have 3). Chewing mouthparts are well-developed (the imago, however, does not ingest food at all during its short life; at the most perhaps liquid food). The antennae are long, setaceous, consisting at most of 40 segments (growing from in front of the eyes).

Thorax is well developed; thoracic segments are large and movable. The prothorax is large and square-shaped. Two pairs of wings are developed. They are membranous, of a generally oval shape, and usually smoky brown with venation protruding from the surface and with many cross-veins. Pterostigmata are miniscule or entirely absent. At rest, the wings are folded roof-like over the body, extending to the end of the abdomen. The movement of the two pairs of wings is simultaneous, although the wings are not equipped with any connecting mechanism. They fly clumsily and only short distances.

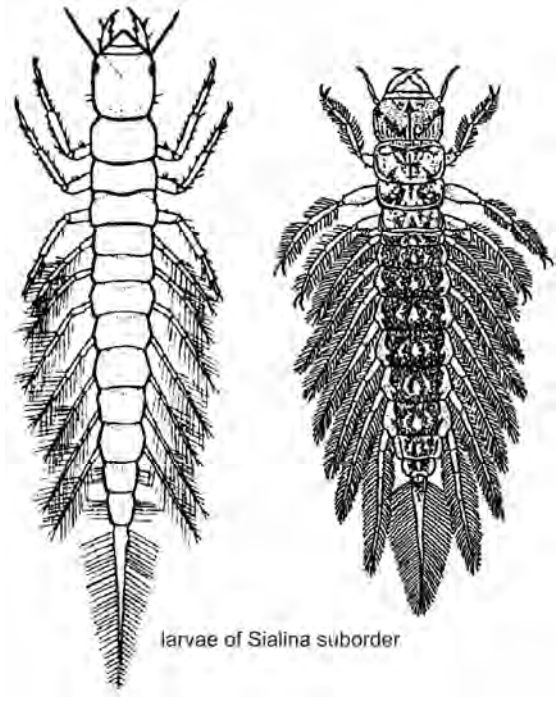
Legs are gressorial; tarsi have 5 segments (underside covered with prehensile hairs) with 2 claws.

Abdomen is cylindrical, soft and flexible, with 9 distinct equivalent segments. Males have a pair of strong gonopods, and females have a short ovipositor. Fertilization occurs with the help of a spermatheca.

Egg

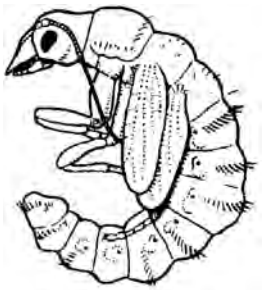
Eggs are elongated, oval, and brown. The female lays large numbers of eggs (500–2,000 in *Sialis lutaria*), which are connected by a secretion and thus create a band or surface densely covered with eggs. Embryonic development takes 8–18 days.

Larva


larvae of Sialina suborder

The larva is an aquatic, polypod, campodeoid type. The body is elongated, narrowing at the back. The head is well-developed, square-shaped, flat, and prognathous, with chewing mouthparts and relatively long antennae. The prothorax is large, legs are long, and tarsi have 1 segment with 1 claw. On the abdominal segments, there are 5-segmented laterally positioned tracheal gills (in Sialina on the 1st–7th segment, in Corydalina on the 1st–8th segment). On the 10th abdominal segment in Sialina, there is an unpaired terminal filament. In Corydalina, the apex is divided into 2 pseudopodial appendages, each bearing 2 claws. The tracheal gills also serve the larva for movement. The first stage is very mobile, has unsegmented abdominal appendages, and swims and moves amongst plants. The more mature stages live on the bottom surface or in the mud. They have a total of 10 larval instars.

Pupa


pupa

The pupa is capable of biting (pupa dectica). Pupation occurs without a cocoon.

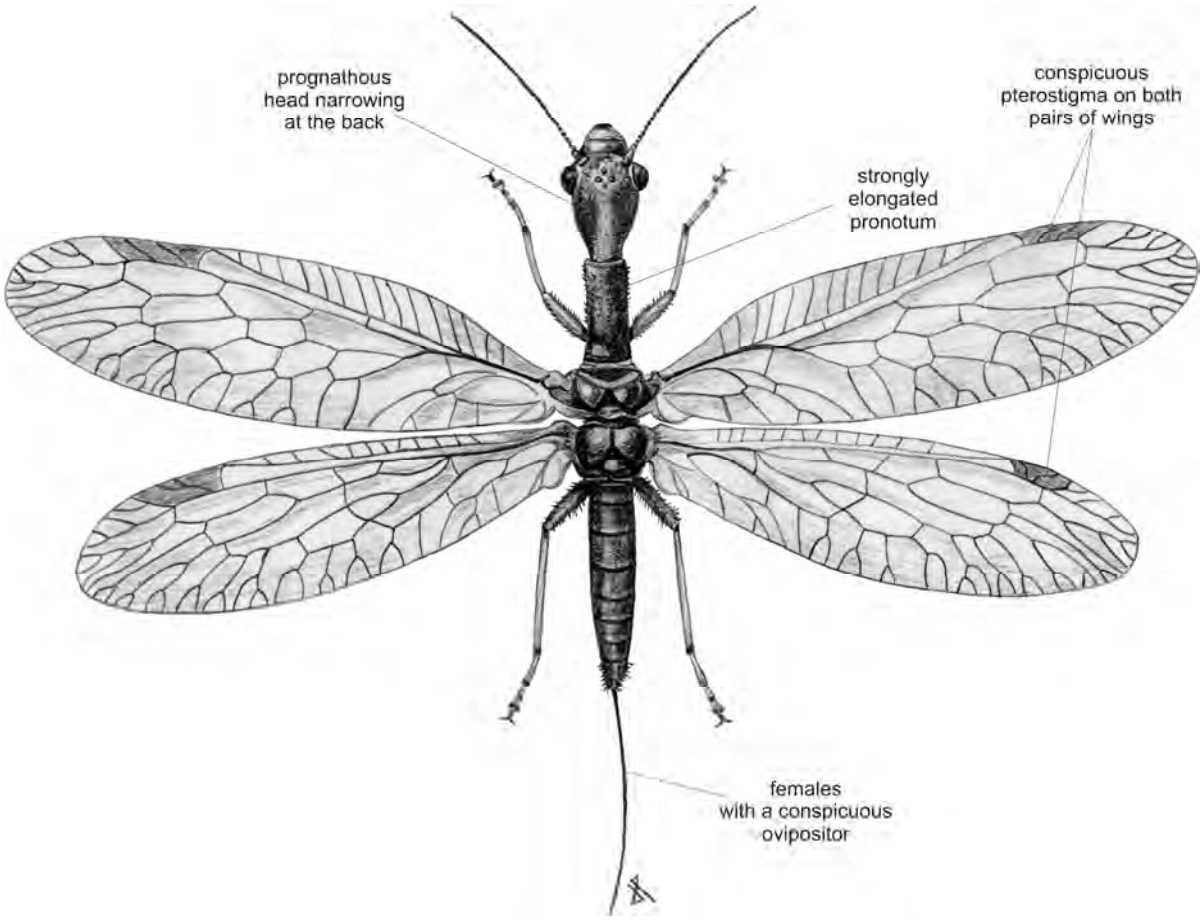
Ecology

Megaloptera populate still and moderately flowing waters. Imagos most frequently perch on the surrounding vegetation, where copulation also occurs. Soon after fertilization (in central European conditions usually in April and May), the female lays all the eggs in 1 clutch (max. 2). The eggs are attached to vegetation and various objects on dry land, in the immediate vicinity of water. The hatched larvae either fall directly into water or try to reach it as quickly as possible. Full entire larval development occurs in the water and lasts almost 2 years. It overwinters first in the 7th instar, and for a second time in the 10th instar. Before pupation (in the spring of the third year, most often in April), the larva leaves the water and after seeking a suitable moist place in the soil, under moss, rocks, and the like, it digs an oval chamber where it pupates. Approximately 14 days after pupation, the pupa (at that time already a pharate imago) works its way to the surface, where the adult hatches. Males live for several days at most, and females for up to 2 weeks.

Food

Larvae are predatory, equipped with strong chewing mouthparts, feeding on larvae, molluscs, and worms living on the bottom. Adults do not ingest food.

Order: **RAPHIDIOPTERA** (snakeflies)		
derivation of the order's name rhaphis (Greek) = needle, rhaphe (Latin) = scar, pteron (Latin) = wing	number of known species in the world about 200	number of known species in the Czech Republic 9
Metamorphosis: **holometaboly**		



Systematics

All species almost without exception have a Holarctic distribution. The majority are distributed in the subtropics in the Palearctic region. The oldest known evidence is from the Jurassic. The order Raphidioptera is systematically divided into 2 families, and representatives of both live in the Czech Republic:

- Family: **Raphidiidae** – 8 species in the Czech Republic, and
- Family: **Inocelliidae** – only 1 species in the Czech Republic.

General characteristics and body description of the adult

Species are typically very slim, with a size of 1–2 cm, usually black, and frequently with a faint metallic shine. Yellowish spots occur quite often on the thorax, head, and sometimes also the abdomen.

Head is prognathous, elongated, and narrowed towards the back. It is exceptionally mobile and bears semicircular eyes that always have a greenish shine. Antennae are not excessively long, are filiform, and consist of 35–75 segments. Three ocelli are developed (absent only in the family Inocelliidae). Very well developed chewing mouthparts.

Thorax is characterized primarily by the freely moving strongly elongated prothorax (always partially raised from the body axis). The meso- and metathorax each bear a pair of wings that are folded over the body roof-like when at rest. The wings are membranous, never smoky, and with relatively rich venation. Pterostigmata are always well developed on both pairs of wings. Although the wings are large and both pairs are connected (due to which the two pairs move simultaneously), snakeflies do not like flying and fly clumsily and only over short distances.

Legs are of medium length and cursorial. Tarsi have 5 segments and 2 claws.

Abdomen is slim, with 10 distinct segments and without cerci. Females have a long and conspicuous ovipositor.

Egg

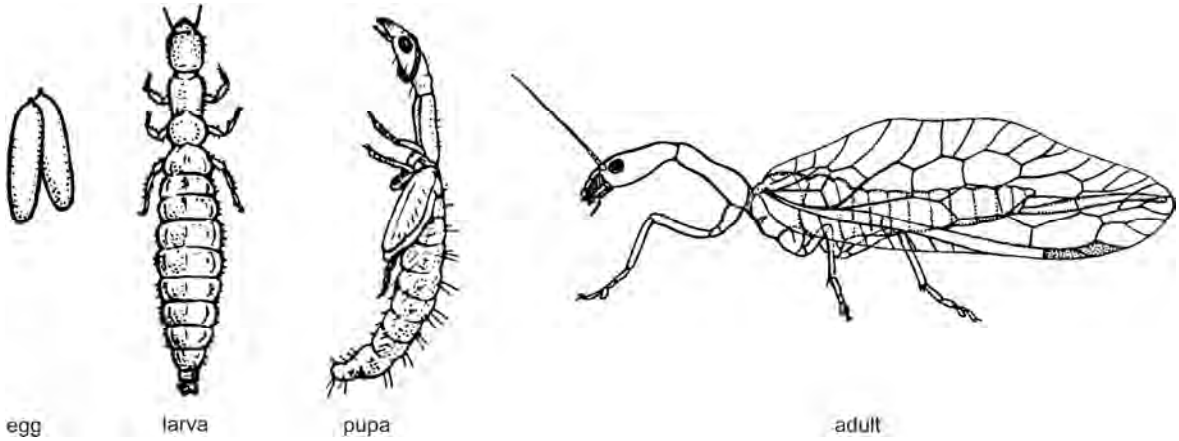
Eggs are long and oval.

Larva

Larvae are similar to the imago in body structure, and in particular the elongated prothorax and head. The legs, however, are shorter and the tarsus has only 1 segment. The body is generally flattened. Head and prothorax are conspicuously strongly sclerotized. The antennae are short and have 3 segments. Eyes consist of 4–7 simple ommatidia. The last abdominal segment directs perpendicularly to the surface and is equipped with an eversible sucker (anus), which plays a very important role in the larva's movement. It is used during forward and backward movement. It moves very quickly and with equal dexterity forward and backward. In a quick succession of movements, it appears as if jumping. The larva moults 6–7 times until autumn of the first year. It overwinters (frequently several larvae together) in crevices under bark, in tunnels of bark beetles, and the like. It moults 3–4 more times in the second year and at the start of winter gnaws out a pupal cradle (usually in the bark at the base of a tree) and overwinters as a larva. From the end of March and through April, it transforms into the pre-pupal stage that lasts approximately 14 days and afterwards transforms into a pupa.

Pupa

The pupa is capable of biting (pupa dectica). After 14 days in the pupal stage, the pupa starts to colour like the imago. The pharate imago leaves the pupal cradle with the help of the mandibles and legs and crawls onto the surface of the bark, where it attaches and the imago hatches. (A mobile pupa dectica is a relatively rare case, otherwise occurring only in Megaloptera and some Neuroptera.)



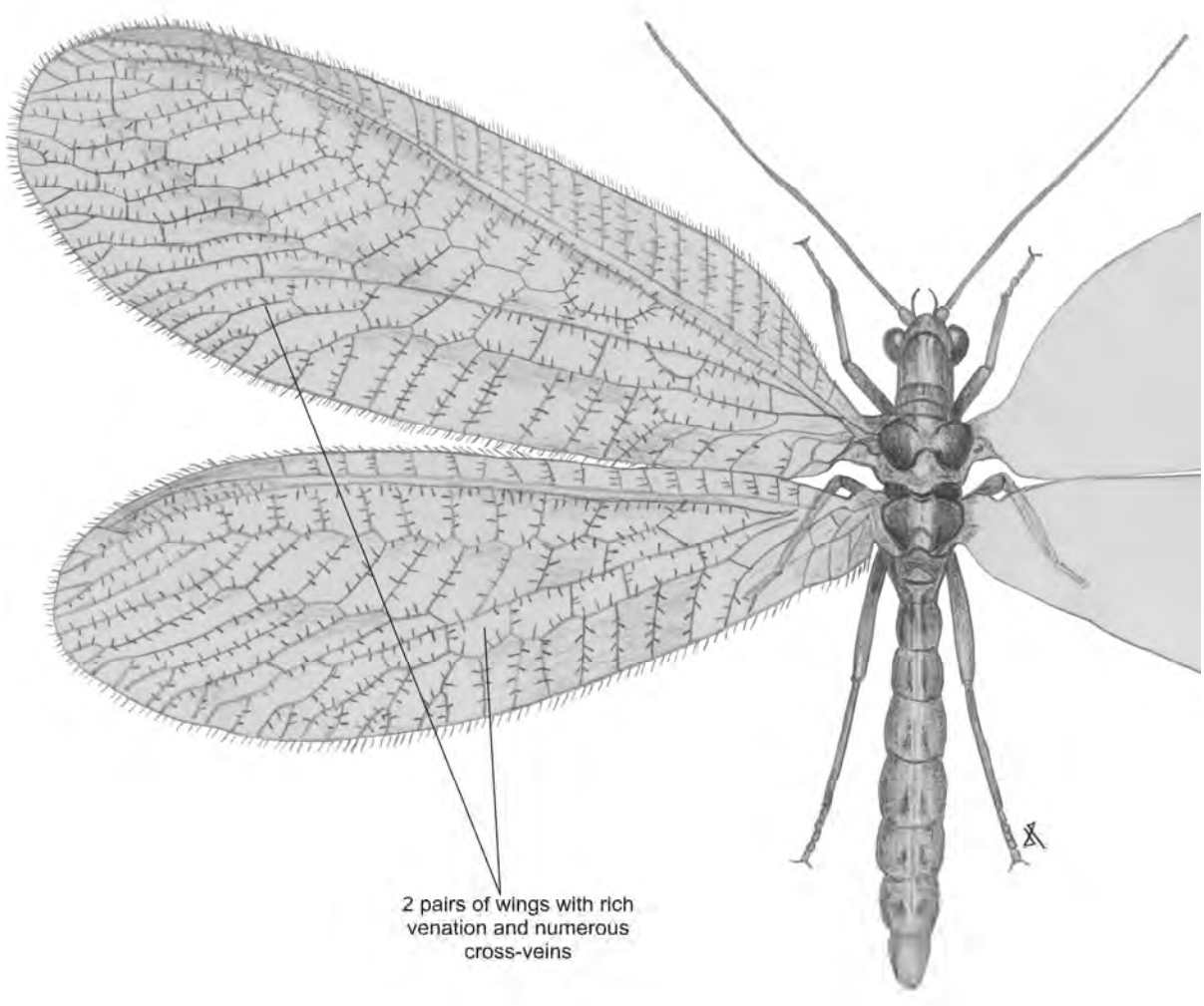
Ecology

The imago usually hatches in early morning hours sometime between April and May, and females hatch somewhat earlier than males. The imagos live for ca 8–10 weeks and have sizeable food consumption. Mating usually occurs in June and is accompanied (as with Megaloptera) by epigamic displays (fast running of the two sexes one after the other interchanged with long standing, with heads towards each other with mutual touching of the antennae). Soon after fertilization, eggs are deposited using an ovipositor into crevices in bark, under free bark, etc. Depending on the size of the area, 2–50 eggs; one female lays around 200–300 eggs in total. Embryonic development lasts around 15–20 days.

Food

Larvae and imagos are exclusive predators with high food consumption. They feed on insects, spiders, and the like, targeting mostly aphids.

Order: **NEUROPTERA** (net-winged insects)		
derivation of the order's name neuro (Greek) = nerve, pteron (Latin) = wing	number of known species in the world 5,000	number of known species in the Czech Republic 90
Metamorphosis: **typical holometaboly and, in mantidflies (Mantispidae), modified holometaboly (polymetaboly)**		



Systematics

An ancient group of insects (known from findings dating back to the Permian, and therefore one of the oldest Holometabola). Neuroptera is divided into 3 suborders (Hemerobiiformia, Myrmeleontiformia, and Nevrorthiformia), of which only the first two are found in the Czech Republic.

General characteristics and body description of the adult

A very diverse group in terms of size and body structure, very close to Megaloptera. Imagos differ from Megaloptera in the location of the antennae between the eyes, certain details of wing morphology, and in that the imagos ingest food (predators). Also in contrast to Megaloptera, development takes place on dry land (with the exception of spongeflies [Sisyridae]). Size from 2–5 mm in dustywings (Coniopterygidae) and up to 115 mm in wingspan in antlions (Myrmeleontidae); the smallest species (family Coniopterygidae) resemble small booklice with wax-dusted wings. Mantispidae appear very similar to mantids and Ascalaphidae to butterflies. Morphology and biology, however, justify their classification into a single order.

Head is generally round, orthognathous, with downward-facing chewing mouthparts. Ocelli are not developed (with the exception of Osmylidae). Antennae are multi-segmented, although they are highly varied in individual groups, from very long filiform (e.g. certain green lacewings [Chrysopidae]), to short (e.g. antlions [Myrmeleontidae]), or even pectinate (certain dustywings [Coniopterygidae]).

Thorax comprised of a mesothorax and metathorax of approximately identical length. The prothorax is very diversely formed, from short to conspicuously elongated in mantidflies (Mantispidae). Wings are developed in 2 pairs. They are large and oval-shaped; the hind wings are mostly very close in shape to the forewings. Wings are usually colourless (green lacewings [Chrysopidae]), and with coloured markings only in some species (owlflies [Ascalaphidae]), featuring dense, net-like venation that branches out to the edges of the wings, with veins connected by various numbers of cross-veins. The majority are bad fliers, even though the wings are large and both pairs move simultaneously. Owlflies (Ascalaphidae) and antlions (Myrmeleontidae), which are active during the day, however, are relatively good fliers.

Legs are gressorial, tarsi have 5 segments, and the last segment has 2 claws and an arolium. In the case of mantidflies (Mantispidae), very complete raptorial forelegs were developed, resembling the legs of mantids.

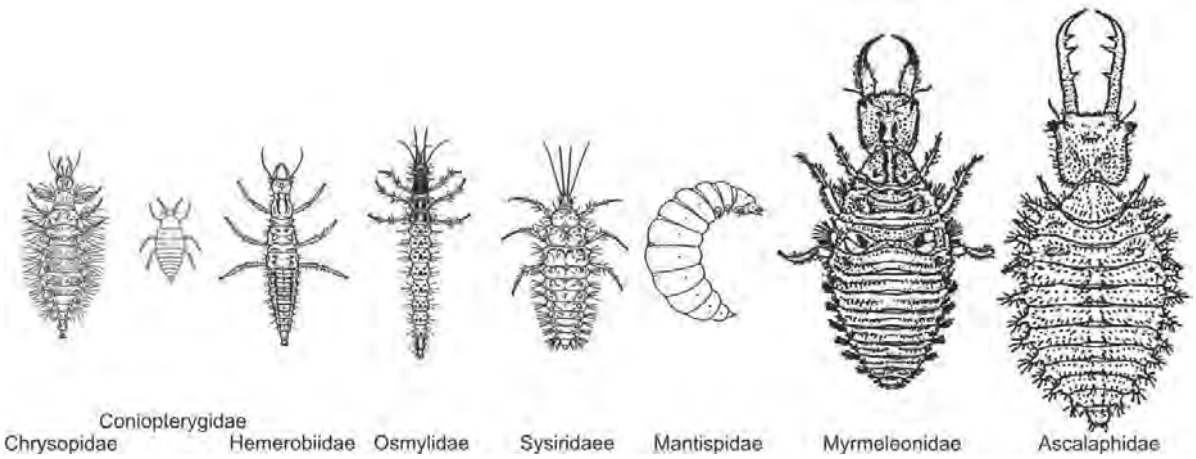
Abdomen has 10 visible segments, is elongated, oval to long, narrow and slim.

Egg

Eggs are oval to elongated oval (in green lacewings [Chrysopidae] and mantidflies [Mantispidae] they are placed on stems). The number of eggs laid by the female varies widely from about 50 to 8,000 (in mantidflies [Mantispidae]).

Larva

Larvae are of highly varied shapes, from chubby (antlions [Myrmeleontidae] and owlflies [Ascalaphidae]) to very thin forms tapered at the back (brown lacewings [Hemerobiidae]). They usually have only three pairs of thoracic legs, with the exception of Sisyridae larvae, for which supplementary appendages serving for respiration developed on the first seven abdominal segments.



The following modifications are typical for larvae of net-winged insects:

- specifically formed mouthparts that are essentially of chewing type, but mandibles and maxillae which are pincer-like and equipped with a duct that serves for injecting venom from maxillary venom glands and digestive fluid, and also for intake of externally pre-digested prey.
- formation of a digestive tract, which terminates at the end of the midgut. Food scraps therefore accumulate here for the entire larval life and only exit the body of the imago.
- Malpighian tubules temporarily change their function and produce a silky liquid which comes out of the anus and is used to spin a cocoon for the larva (it is therefore not the product of labial glands, as in other groups).

Larvae usually go through 3 visually similar instars. Mantidflies (Mantispidae) constitute the only exception, in which case the larva only goes through 2 instars, wherein the second instar is diametrically different from the first.

Pupa

Pupation in a cocoon. The pupa is capable of biting (pupa dectica), and in the final phase it actively seeks a suitable place for the imago to hatch.

Ecology

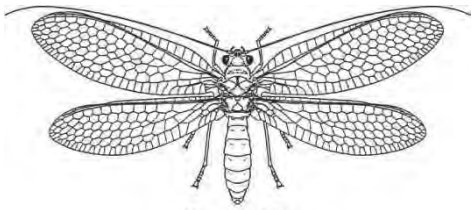
With the exception of one family (spongeflies [Sisyridae], whose larvae develop in water), they are terrestrial species. The female lays eggs soon after fertilization (the sperm is transferred in spermathecae). The clutch differs greatly between individual families. The majority of species lay eggs in rows or in groups on plants (owlflies [Ascalaphidae], green lacewings [Chrysopidae]), while certain species lay them into sand or soil (antlions [Myrmeleontidae]).

Imagos can be encountered throughout the year, but they are most abundant in the summer months. The majority of species are crepuscular and/or nocturnal and frequently (often only males) fly towards light. They usually overwinter as larvae prepared for pupation in a cocoon, more rarely as free larvae or imagos.

Food

Larvae and imagos are without exception predatory. Many species are natural enemies of other insects, especially aphids (mainly green lacewings [Chrysopidae] and dustywings [Coniopterygidae]), having an appreciable impact (1 larva of the species *Chrysopa vulgaris* consumes approximately 150–200 aphids during its life; a *Hemerobius* larva approximately 200).

Family: **CHRYSOPIDAE** (green lacewings)


Chrysopidae

Antennae are long, wings transparent, and venation dense. They are active at dusk and are predatory, feeding on insects (primarily aphids). Eggs are laid in groups (in total around 100–900 from one female) on stalks of up to 1 cm long. Larvae with hook-like cilia go through 3 instars, are predatory, and primarily consume aphids. Larvae are covered with sucked-dry skins of prey and detritus. During larval development (8–22 days), 1 larva of *Chrysopa vulgaris* kills 150–200 aphids. In species living longer as a larva (in some cases for an entire summer), the number of aphids consumed is sometimes more than twice as high. They have 1 or 2 (incomplete) generations per year.

Family: **CONIOPTERYGIDAE** (dustywings)

They include very small species with a size of around 5 mm. Wing venation is very simple in this family. The body and wings are covered by a whitish or brownish waxy dusting secreted by the numerous wax glands on the abdomen (similar to whiteflies). They are an arboricolous species. Eggs are laid in smaller numbers and without stalks. Larvae have 3–4 instars and are predatory, sucking on small arthropods, especially mites, aphids, and scale insects. The elongated labrum and extended labial palps are morphologically conspicuous. They have 1 or 2 (incomplete) generations per year.

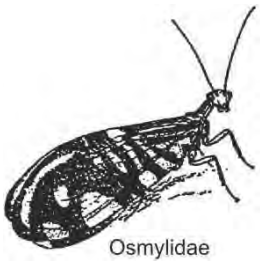
Family: **HEMEROBIIDAE** (brown lacewings)

They are active at night. The number of eggs laid is lower than in green lacewings, and the eggs lack stalks or have only very short ones. Larvae lack tubercules (typical for green lacewings [Chrysopidae]), live freely, and are not covered by the skins of prey and detritus. Most species have 2 (incomplete) generations per year. Food is similar to that of green lacewings (Chrysopidae).

Family: **OSMYLIDAE** (osmylids)

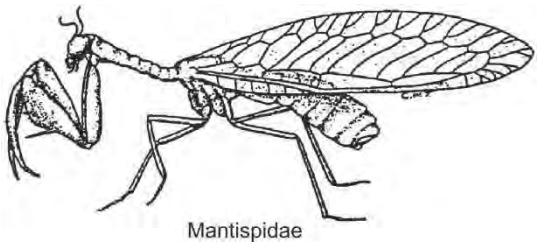
There is a single species in the Czech Republic (*Osmylus chrysops*), which is nocturnal. Ocelli are developed (only species of representatives of the order Neuroptera in Czech Republic). Imagos occur from May to August. Eggs are without stalks, deposited on littoral vegetation. Larvae are semi-aquatic (living on moist banks, partially in the water), mostly hunting larvae of Diptera: Nematocera (chironomids, mosquitoes). The larva has long styliform mandibles and 2 adhesive organs are present at the end of the abdomen (2 eversible prickly sacs). Development lasts one year; the larva overwinters and pupates in the spring.

Family: **SISYRIDAE** (spongeflies)


Osmylidae

Active at night. Wings are brownish. Clutches of eggs on plants are covered by a fine fibrous cocoon. Hatching larvae fall into the water and in the first instar do not yet have developed tracheal gills. These develop in later instars as segmented appendage-like structures on the first seven abdominal segments (similarly to Megaloptera). They have 3 larval instars. Larvae suck the surface tissues of fungi and mosses. They have a one-year generation, with imagos in May to June, larvae overwintering in a cocoon, and pupation in April.

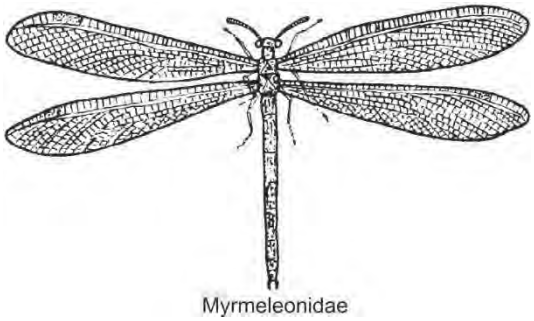
Family: **MANTISPIDAE** (mantidflies)


Mantispidae

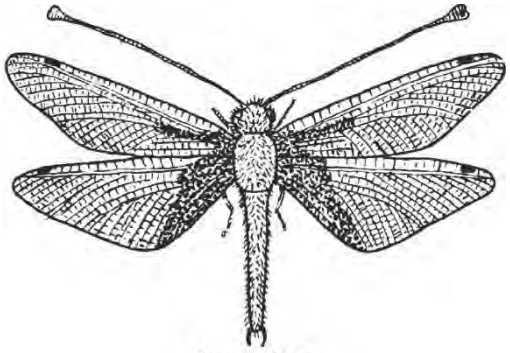
In the Czech Republic, there is a single thermophilic species, the European mantispid (*Mantispa styriaca*). They differ from the other families by a long prothorax and raptorial forelegs formed similarly to mantids. They hunt primarily true flies (Diptera), in the same manner as mantids. Development is polymetabolous, connected with interesting biology. The female lays a vast number of eggs (up to several thousand) placed on short stalks on vegetation (bark, leaves, and twigs). Towards the end of July, campodeoid (invasive) larvae hatch that overwinter without ingesting food. In the spring, the larvae seek spider cocoons, especially of the families Lycosidae (wolf spiders), Salticidae (jumping spiders), and Gnaphosidae (ground spiders), and penetrate the cocoon. As predators, they suck up the eggs and hatching spiders inside. They change into the second instar of maggot-like appearance, and in a period of several days they pupate inside the skin of the last larval instar, under the protection of both the spider's and its own cocoons. The generation is one-year.

Family: **MYRMELEONTIDAE** (antlions)

The largest representatives of net-winged insects with long, thin wings with typical venation. Antennae are short and capitate; long palps. Imagos are active during dusk and at night, feeding on small insects. They are decidedly thermophilic animals of dry and warm areas. Of the ca 2,500 described species, the fauna of the Czech Republic contains only about 12. Eggs are laid individually into dry land. Larvae have a wide abdomen, large head, and mandibles equipped with sharp spikes on the inner side. The larval eyes (7) are on a hump-like protrusion. Larvae of certain species (in the Czech Republic only the two common species *Myrmeleon formicarius* and *Euroleon nostras*) construct funnel-shaped traps underground, although most species live freely in litter and decomposed wood. The larva goes through 3 instars and its development lasts 2 years in the conditions of the Czech Republic. Larvae overwinter in cocoons and pupate in the spring. The pupal stage lasts around 4 weeks. Imagos occur at the beginning of summer.

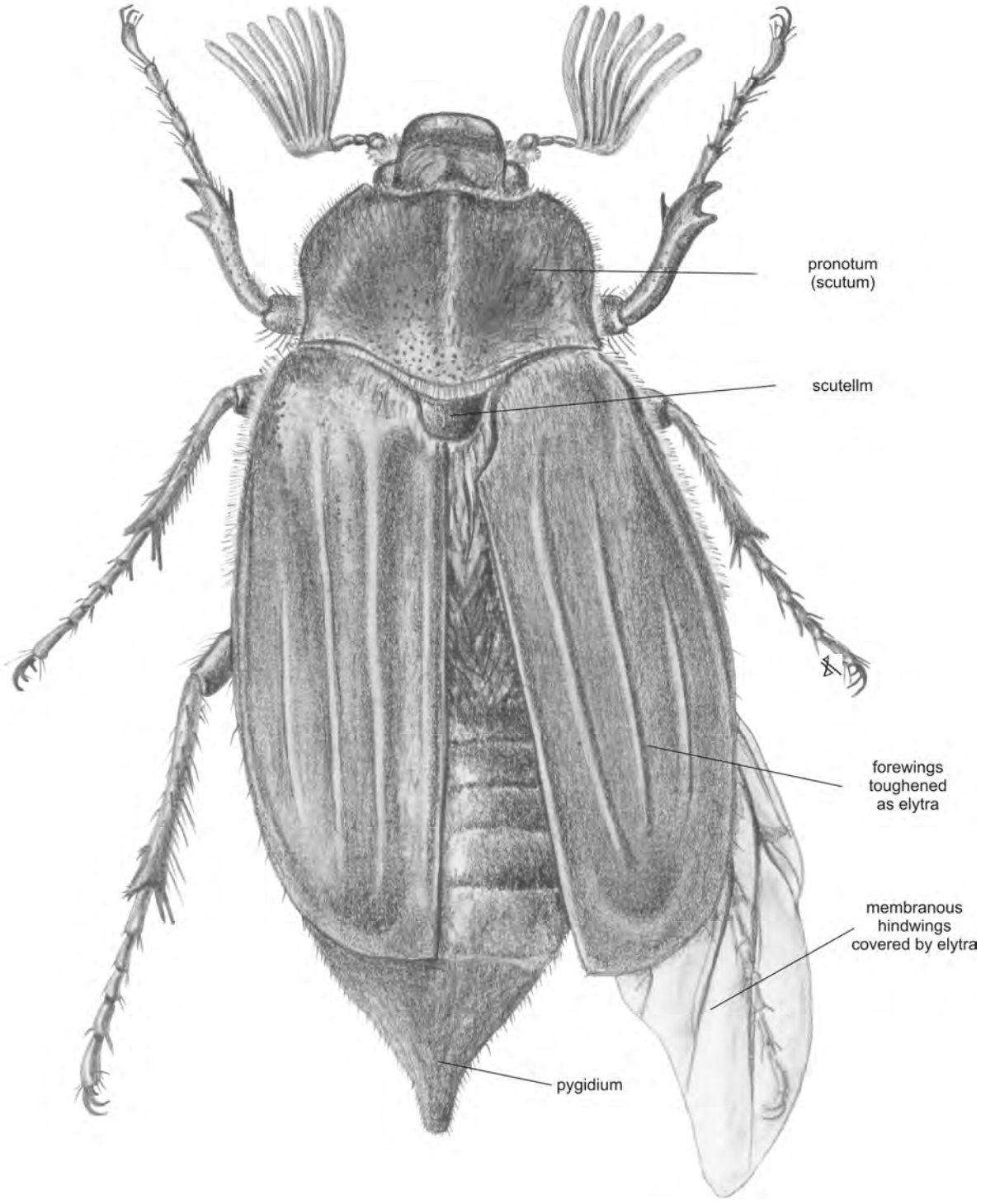

Myrmeleonidae

Family: **ASCALAPHIDAE** (owlflies)


Ascalaphidae

Antennae are also capitate, but long. Wings are relatively wide, triangular, and spotted. The spots are yellow, brown, or black. Besides Mantispidae, it is the only group of net-winged insects where the imago is active during the day, especially in strong sunlight. They fly very well and hunt insects in flight. In the fauna of the Czech Republic, they are represented by only two species limited to the warmest forest steppe areas, mostly on limestone. A total of around 300 species have been described. Eggs do not have stalks and are laid in double rows on low vegetation. Larvae strongly resemble antlion larvae, from which they differ by a slightly wider body and other small details, as well as prominent tubercules on the sides of the thorax and abdomen. The larva has 3 instars and lives on the surface of the soil, often masked by detritus particles. They feed on small arthropods and overwinter twice. They pupate in a cocoon affixed to vegetation at the end of spring and in early summer. The pupal stage is short.

Order: **COLEOPTERA** (beetles)		
derivation of the order's name koleos (Greek) = sheath, pteron (Latin) = wing	number of known species in the world > 350,000	number of known species in the Czech Republic 6,000
Metamorphosis: **typical holometaboly or modified holometaboly: hypermetaboly and polymetaboly**		



Systematics

The Coleoptera order is systematically divided into 4 suborders, only 3 of which live on Czech territory:

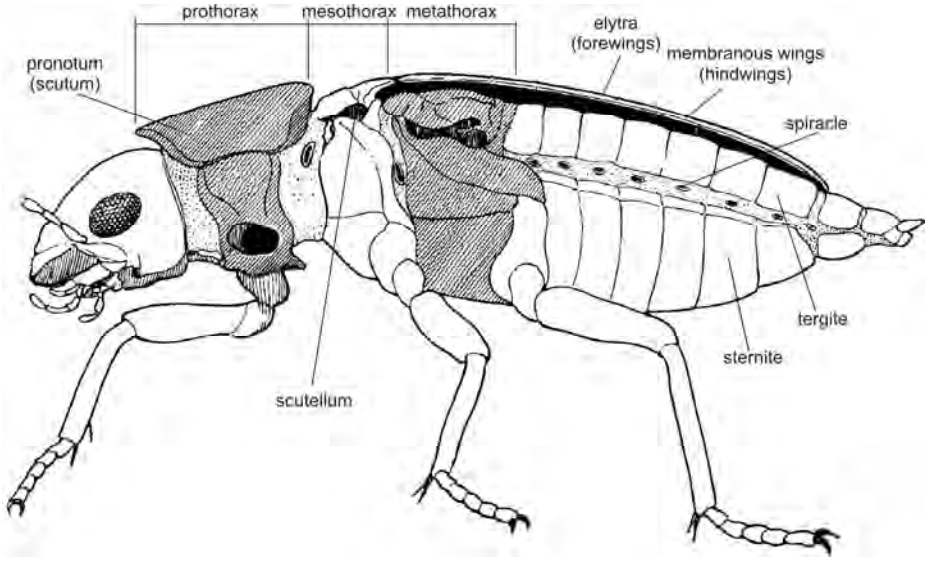
- Suborder: **Archostemata** (worldwide only 30 species, none of which live in Central Europe; they develop in dead wood),
- Suborder: **Adephaga** (7 families in the Czech Republic),
- Suborder: **Myxophaga** (1 family in the Czech Republic with only a single species – *Sphaerius acaroides* [Sphaeriusidae]), and
- Suborder: **Polyphaga** (108 families in the Czech Republic).

General characteristics and body description of adult

Coleoptera is worldwide the richest insect order, containing some 40% of all known insects. They contain approximately 1/3 of the total number of all animal species. Sizes of imagos range from several tenths of a millimetre (Ptiliidae [feather-winged beetles]) to 20 cm (the longhorn beetle *Titanus giganteus*). Among the Czech species, the largest is the stag beetle *Lucanus cervus* (male up to 75 mm, female up to 45 mm). The order is no less diverse in shape, coloration, and way of life.

Sclerotization of the body is mostly *rather strong* to *strong*; the body surface is variously coloured with highly diverse cilia, hairs, scales, and assorted types of sculptures.

Head is prognathous to orthognathous, usually at least partially covered by a scutum, with typical biting mouthparts. Eyes are more or less arched, round, oval to bean-shaped. Eye is sometimes so deeply cleft that it is completely divided into two parts (e.g. whirligig beetles [*Gyrinus*], some bark beetles [*Xyloterus*, *Polygraphus*], and some longhorn beetles [*Tetropium*]). In species living in the dark, terricolous and cave species, eyes are strongly reduced and even entirely absent. Ocelli are developed only very rarely (e.g. Dermestidae). Antennae have very diverse shapes and length, most frequently with 10 to 11 segments, rarely 12 segments, but the number of segments is often significantly reduced. In certain species, the head is extended into a more or less prominent **rostrum** (e.g. true weevils [Curculionidae] and related families, exceptionally also others). Certain sections of mouthparts can be enlarged. For example, enlarged palpus maxillaris is a typical feature for the entire superfamily Palpicornia and in the family of water scavenger beetles (Hydrophilidae), while the males of ship-timber beetles (Lymexylidae) have branched bushy palpi, and the male stag beetles *Lucanus cervus* have large mandibles.



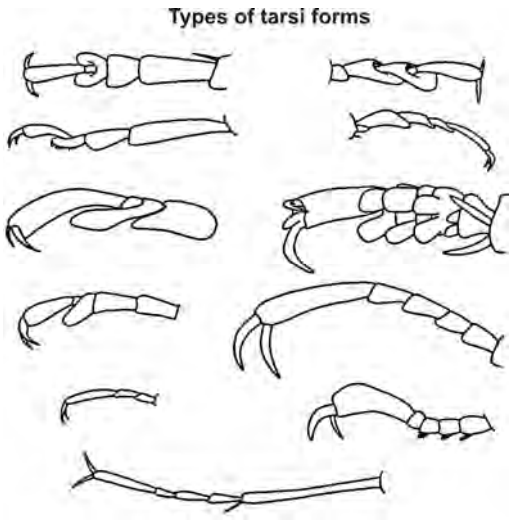
Thorax – only prothorax (pronotum), its dorsal part forming a large shield (**scutum**), and a small part of the mesothorax, apparent as a small triangular shield (**scutellum**) between the base of the elytra, are visible from the thoracic segments. The remaining part of the mesothorax, the entire metathorax, and usually also the entire abdomen are covered from the top by a stiff, rather strongly sclerotized first pair of wings (**elytra**). The hind pair of wings is larger than the fore pair and is hidden beneath the elytra.

The hind wings are the main flight organs, and therefore the metathorax is the most strongly developed thoracic segment. With rare exceptions, the elytra open during flight (exceptionally they may be closed in species where the elytra are sufficiently "cut away" on the sides [e.g. certain flower chafers]). Elytra are frequently shortened, not covering the entire abdomen (e.g. in all rove beetles [Staphylinidae] and certain other related families, sporadically also in other systematic groups). Hind wings can also sometimes be reduced or absent entirely. In such cases, the elytra frequently merge on the seam (e.g. the *Otiorhynchus* family or certain ground beetles [Carabidae], female fireflies [*Lampyris noctiluca* and *Lamprohiza splendidula*]). Exceptionally, both pairs of wings can be absent entirely (e.g. the females of the firefly *Phosphaenus hemipterus*). The prothorax is relatively free, while the meso- and metathorax are mutually immobile and firmly connected to the abdomen.

Legs are most frequently of gressorial type, but they are subject to various adaptations to environmental conditions. Of the conspicuously shaped variants, the following are noteworthy:

- fossorial – tibiae are extended, frequently with various outgrowths, e.g. in scarabs (Scarabaeidae);
- saltatorial – femora are thickened, tibiae elongated spur-wise (in certain leaf beetles [Phyllotreta], certain true weevils [Curculionidae]); and
- natatorial – hind legs flattened to various degrees, with long and thick bristles (Gyrinidae, Dytiscidae, Haliplidae, Hydrophilidae); exceptionally hind and middle legs also thusly adapted (e.g. predaceous diving beetles [Dytiscidae of the genus *Acilius*]).

Exceptionally, thickened femora can also be encountered in species that do not jump (in the most typical form, for example, the genus *Oedemera* of the pollen-feeding beetles family [Oedemeridae]).



Tarsi usually have 5 segments (typical state in the entire suborder Adephaga and elsewhere), although the number of segments is frequently reduced to 4 and even 3. In certain groups the tarsi even have heteromerous structure. In addition to the typical 555 form, beetles with forms 554, 444, 333, 445, 344 can be encountered.

Coxae are rather frequently enlarged and flattened, covering not only part of the femora, but also the basal segments of the abdomen.

Abdomen is mostly visible only from the underside and side, usually with just 6 visible segments. Tergites are covered by elytra, weakly sclerotized, and the last tergite (**pygidium**) is usually more strongly sclerotized. It typically has a triangular shape and protrudes at the end of the elytra (conspicuously formed, for example, in cockchafers of the genus *Melolontha*).

Egg and reproduction

The males usually actively seek females, sensing (frequently over large distances) sexual pheromones produced by the females. An exceptional and rare method is connected to the light signals in fireflies (Lampyridae).

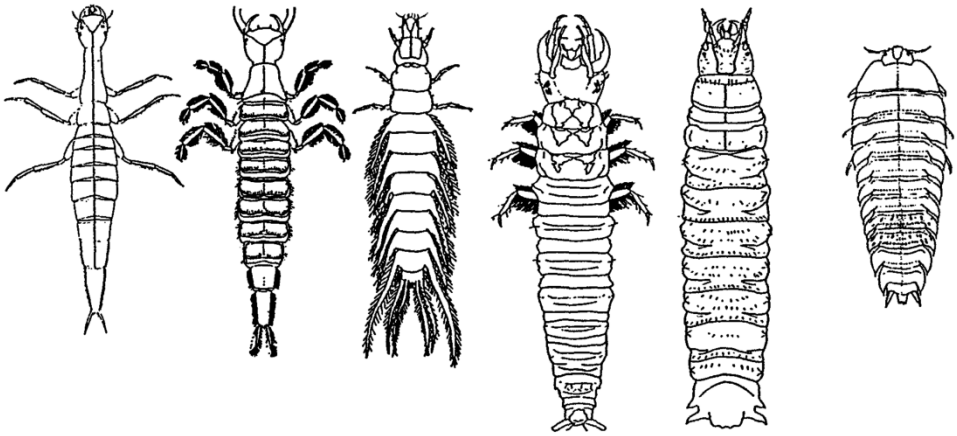
Eggs are usually more or less oval; sometimes the chorion is even sculptured, endowed with protrusions and the like (certain leaf beetles [Chrysomelidae]). The number of eggs laid varies greatly, from one or a few to several thousand (e.g. oil beetles of the genus *Meloe* often have even monstrously enlarged abdomens).

Parthenogenesis (thelytoky) is in general a very rare phenomenon (in certain true weevils [e.g., *Otiorhynchus*] and certain leaf beetles [Chrysomelidae]). The majority of species is oviparous; ovovivipary only occurs in certain genera of European leaf beetles (Chrysomela).

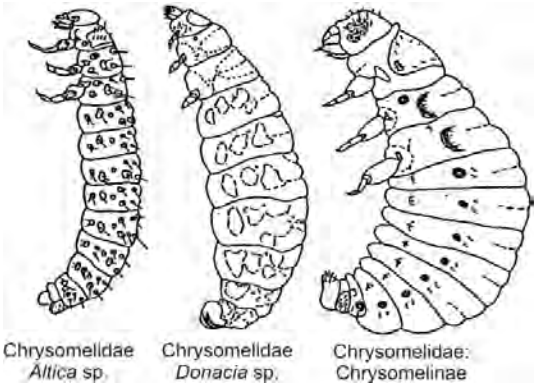
Larva

Larvae can be divided into 4 basic types:

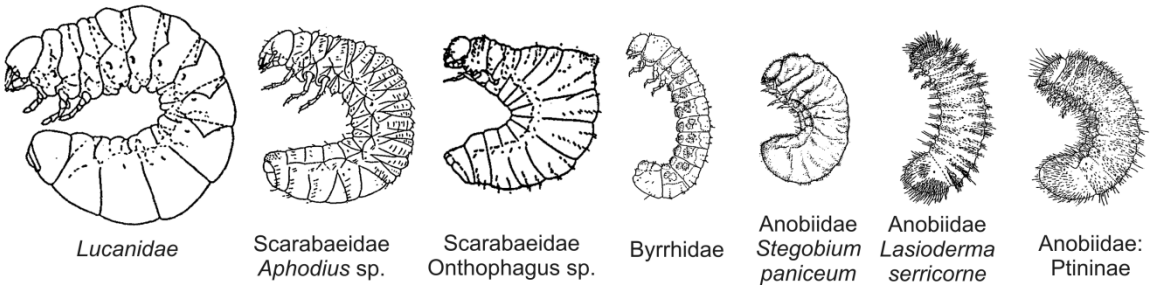
- **campodeiform** – body flattened from the top, elongated shape, head prognathous, thoracic limbs long, predators (e.g. Carabidae [ground beetles], Staphylinidae [rove beetles], and Cleridae [chequered beetles]);



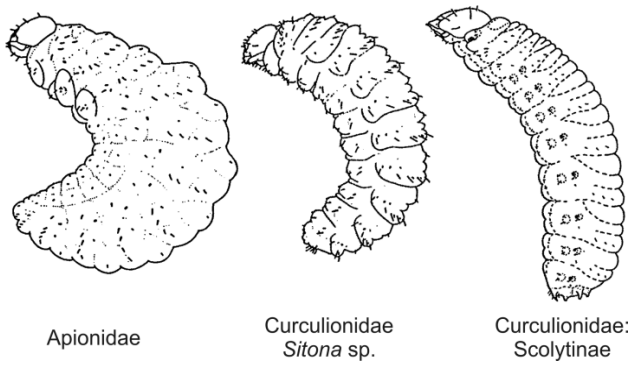
- **eruciform** (caterpillar-like) – body cylindrical, legs short, movement slow, herbivores (e.g. Chrysomelidae [leaf beetles]);



- **scarabaeiform** (grublike) – arched into a C-shape, have well-developed thoracic legs, live in soil and decayed wood (Scarabaeidae [carab beetles] and Lucanidae [stag beetles]); and



- **apod** – legless, living in plant tissues (Buprestidae [jewel beetles], Cerambycidae [longhorn beetles], Curculionidae [true weevils], and others).



Larvae are eucephalous, exceptionally hemicephalous, with typical biting mouthparts. Rarely, the mandibles are adapted for extracorporeal digestion (sucking the prey [in Dytiscidae, Haliplidae, Gyrinidae and Lampyridae]). There are two types of maxillae: adephagoid in predators and catopoid in herbivores and saprophages. Antennae are short, most frequently with 3–4 segments, and in species mining in plant

tissues frequently only with a single short segment (e.g. Scolytidae [bark beetles], Platypodidae [ambrosia beetles]); along the sides of their heads they have at most 6 stemma that can also be absent (in species living in soil and plants). Bodies have various shapes and the abdomen has 10 segments.

Formation of legs is typical for the suborders Adephaga and Polyphaga:

- In Adephaga, the legs have 5 segments (coxa, trochanter, femur, tibia, and a single-segmented tarsus with a claw).
- In Polyphaga they have 4 segments (tibia and tarsus are not separated but form a tibiotarsus).

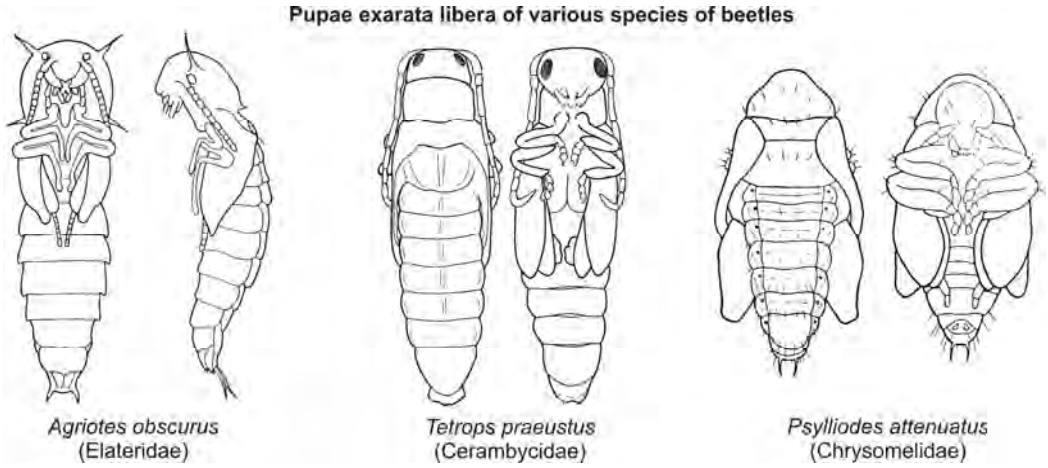
In certain groups (generally species developing inside plant tissues), legs are partially or totally reduced (e.g. Scolytidae, Platypodidae, Cerambycidae, Buprestidae). Among species developing in soil, pseudo-segmentation is frequent (each segment is secondarily divided from the top by multiple narrowing). In certain water larvae, unsegmented and segmented tracheal gills are developed on the abdomen.

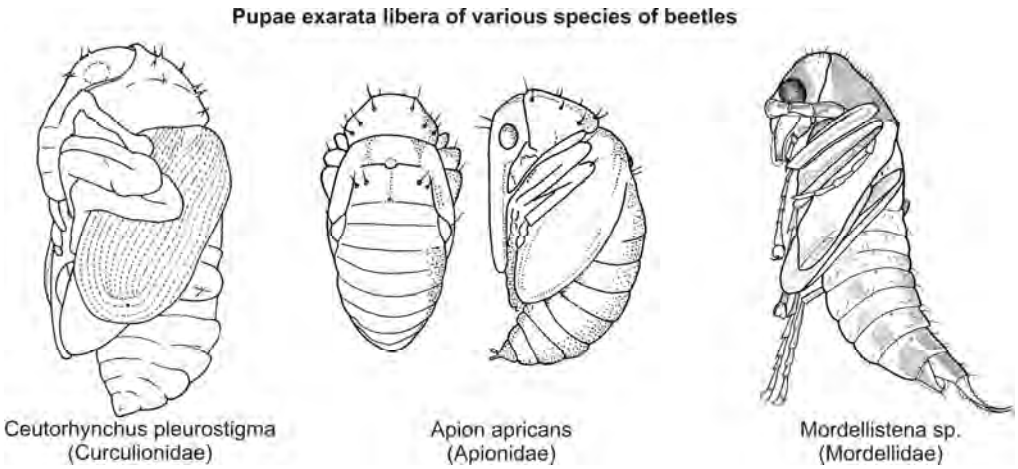
The number of larval instars is most frequently 3–6 and more (e.g. 7–9 in Cantharidae [soldier beetles], even up to 14 in the longhorn beetle *Prionus coriaceus*). Otherwise, the number of instars is not constant for a given species. Development is from several generations per year over a single-year generation to development lasting several years (such as certain Elateridae), or the duration of development varies in length depending on the conditions, especially the state and quality of food (e.g. in the case of the old-house borer [*Hylotrupes bajulus*], according to the content of water).

In certain beetle families, hypermetaboly (blister beetles [Meloidae]) and polymetaboly (genera *Lebia* and *Brachinus* in the family Carabidae [ground beetles] and Ripiphoridae [wedge-shaped beetles]) occur.

Pupa

The pupa is generally free (pupa exarata libera) and only very rarely obtect (pupa obtecta) in tortoise beetles (Chrysomelidae family [leaf beetles]), certain rove beetles (Staphylinidae), and the ladybird family (Coccinellidae). Many beetles pupate in the ground and in rigid parts of plants.





Ecology

The overwhelming majority of beetles develop on land, in conditions varying from hot and arid deserts to cold and moist mountain conditions, to biotopes in the far north, and in the extreme conditions of caves and subterranean areas. Certain species, however, secondarily passed from humid biotopes around waters to the water environment, even adapting to brackish water.

A number of species of various families live in moist places and at the edges of water even though their development is usually not tied to the water environment. Transfer from dry land to an aquatic environment is represented by Helodidae, where the phytophagous imagos live in wet places surrounding water while their larvae develop in the water and developed rectal gills (although without tracheoles).

Typical representatives of species living in the water as imagos and also developing in the water include predaceous diving beetles (Dytiscidae), crawling water beetles (Haliplidae), and whirligig beetles (Gyrinidae). In all those families mentioned, the mandibles of the larvae are equipped with a channel and the food is consumed partially digested. Dytiscidae and Gyrinidae are predators, while Haliplidae are mostly phytophagous and suck algae.

From the suborder Polyphaga, too, a significant portion of water scavenger beetles (Hydrophilidae [imagos of certain species are phytophagous and the larvae predatory]) develop in water. Also living in water are the imagos and larvae of representatives of the families Dryopidae (phytophagous, in rapidly flowing water; exotic species live even in Himalayan rivers and Niagara Falls, with typically formed legs), Georyssidae (which dig in the wet mud of embankments rich in the organic substances they consume; they live in still and slowly flowing waters), and Heteroceridae (with biology similar to that of Georyssidae).

Food

- **Predators** – a considerable number of species are predatory and therefore consuming animal prey. Almost all members of the suborder Adephaga and a number of species of the suborder Polyphaga are predators. Other insects are the most common food of predators, being hunted by e.g. Cleridae [chequered beetles], Melyridae [soft-wing flower beetles], and many others. However, some groups of beetles also hunt other invertebrates, such as gastropods that are consumed by many water beetles as well as certain other terrestrial species (e.g. Lampyridae [fireflies], Cantharidae [soldier beetles], and Carabidae [ground beetles)].

- **Necrophages** – beetles can also feed on dead animals, most typically vertebrates (Silphidae [carrion beetles]). Along with the necrophages, however, a number of other beetle groups occur on a corpse – and particularly the predators of various fly larvae.
- **Saprophages** – dead plant parts also are frequent food for beetles (typical saprophages), sometimes also with remains of dead animals. There are many representatives in this group, including Tenebrionidae [darkling beetles, eating plant remains), part of the family Leiodidae (plant and animal remains), Dermestidae (skin beetles, feeding only on materials of animal origin), Trogidae (also animal remains), and certain others.
- **Coprophages** – coprophagous species are a very special group, developing in faeces and most frequently using undigested plant substances. In addition, there exist large numbers of predatory species in faeces, feeding on saprophagous species (Geotrupidae [dor beetles] and many Scarabaeidae [scarabs]).
- **Omnivores** – indiscriminate species non-specialized in food, consuming dead substances of plant and animal origin (e.g. Ptinidae [spider beetles]).
- **Mycophages** – feed on mycelia and fruiting bodies of fungi. This type of feeding is characteristic for a number of beetle species and occurs, for example, in a part of the family Leiodidae (feeding on underground fungi, mycelium of fungi, and moulds), in Erotylidae and Scaphidiidae (feeding on mycelium and fruiting bodies of fungi, especially bracket fungi), certain Staphylinidae (rove beetles [e.g. genus Gyrophaena]), Ptiliidae (fungi spores), Phalacridae (genus *Phalacrus* consumes rusts and smut fungi), Lathridiidae (mycelium in various biotopes, including bird nests, mammal dens, insect hives, stables, cellars, etc.; *Cartodere filum* is also known as a pest of cultivated fungi cultures, even consuming ergot without problem), Endomychidae (mycelium under bark, development also in fruiting bodies of bracket fungi; the genus *Lycoperdina* is specialized on Lycoperdaceae), certain Scolytidae (the genera *Xyloterus*, *Xyleborus* [mycelium of symbiotic fungi growing on the walls of corridors in galleries]), Platypodidae (mycelium of symbiotic fungi in galleries), and Lymexylidae (here only *Hylecoetus dermestoides*, also feeding on the mycelium of a symbiotic fungus in galleries in wood).
- **Phytophages** – consume plant food, most frequently fresh (live) or in a certain phase of wilting of the wood and bast.
    - **Herbivorous species** – herbivorous species consume various herbaceous plant materials (most frequently leaves and stems but also roots). These include most Chrysomelidae (leaf-eating beetles), certain Buprestidae (jewel beetles, and in particular the **borers** [eating only the parenchyma of leaves, the epidermis remaining undamaged), many Curculionidae (true weevils), and certain Cerambycidae (longhorn beetles).
    - **Defoliators** – feed on assimilative organs of trees. These include Chrysomelidae (leaf beetles) and Curculionidae (true weevils).
    - **Species developing on blossoms, seeds, and fruits** – can be significant farming pests. Examples include Byturidae (fruitworms, causing worm infestations of raspberries), Bruchidae (bean weevils, damaging seeds [especially of Fabaceae plants]), and certain Curculionidae (true weevils [e.g. species of the genus *Curculio*, damaging acorns and hazelnuts; species of the genus *Lignyodes*, damaging seeds of ash; *Pissodes validirostris*, damaging pine cones; the genus *Anthonomus*, damaging blossoms of various plants), and a number of others.
    - **Xylophages** – unquestionably comprise an important group. Xylophages include the most economically important beetle species. They develop under the bark and in the wood of trees. Several types can be distinguished here:
        - **Insects developing under bark or in the wood and that attack standing, living, but mostly already damaged trees** include certain species of Scolytidae (bark beetles [e.g. the species of the genera *Ips*, *Pityogenes*, *Pityokteines*, *Polygraphus*, *Scolytus*, and a number of others]), certain Cerambycidae (longhorn beetles [e.g. the species of the genera *Tetropium*, *Saperda*, *Oberea*, and a number of others]), some Buprestidae (jewel beetles), some Curculionidae (true weevils [especially species of the genus *Pissodes* on conifers and *Cryptorrhynchus lapathi* on alder]).
        - **Species damaging harvested wood, windfalls (dead, with various degrees of humidity, or damaged by processes of decomposition**) include a considerable part of Cerambycidae; part of Scolytidae; the families Anobiidae, Lymexylidae, and certain others.

- **Species damaging built-in wood** include certain Cerambycidae (long-horn beetles [e.g. *Hylotrupes bajulus*, significantly damaging rather dry coniferous wood, such as roof trusses; *Callidium violaceum* with damage similar to that of *H. bajulus*; as well as *Phymatodes testaceus* and *Isotomus speciosus*, similarly damaging deciduous-wood structures]) and Anobiidae woodworms (e.g. common furniture beetle [*Anobium punctatum*] as well as *Hadrobregmus pertinax*).

The type of food can be the same in both the active stages (imago and larva). For example, in Carabidae and Dytiscidae the larvae and adults are predatory and live in the same environment. In phytophages, the consumed organ can be different. Thus, for example, the imagos can consume the nectar and pollen on the blossoms or chew on soft tissues while the larvae develop under the bark (e.g. in Pyrochroidae [larvae under the bark of dead trees], Oedemeridae [larvae in stems of more robust plants and in wood]). Imagos of certain species of Cerambycidae chew on the soft surface tissues of plants while the larvae develop under the bark or in the wood stems and roots of herbaceous vegetation or consume the roots of herbs freely in the ground (Dorcadion).

However, the type of food can also differ. Even within a single family there can be species feeding on various types of food (plant or animal) in imagos and larvae. In the family of ladybugs (Coccinellidae), for example, the larvae and imagos are predatory, except for minor exceptions, but *Epilachninae* consume vegetable leaves (pumpkins and cucumbers). Similarly, in the family of sap beetles (Nitidulidae), there are species in which the imago and larva are either phytophagous (they are frequently on flowers, where they consume pollen, nectar, and fermenting juices) or at other times necrophagous on animal remains, and certain species are predatory (*Glischrochilus*). Click beetles (Elateridae) are another example. Here the imagos are on grasses, herbs and bushes, where they feed on surface tissues, and the larvae are mostly predatory, beneath the bark, in decomposing wood or in the soil. A small proportion of the species, however, are phytophagous, consuming grass roots, herbs, and trees (especially *Agriotes linearis*, *A. rufus*, *A. spoliatus* and certain species of the genera *Selatosomus* and *Athous*).

Species with unusual biology

Besides the most usual biotopes (soil and its surface, the surface of plants, plant tissues, decomposing organic matter, and stored products), certain species live in unusual conditions and biotopes.

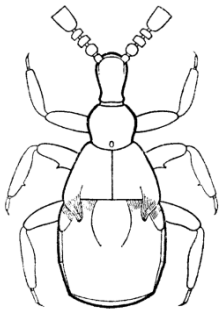
- **Myrmecophilous species** – live in anthills. This group includes various species from the families Staphylinidae, certain flower chafers (Scarabaeidae: Cetoniinae), leaf beetles of the subfamily Clytrinae, but also Leiodidae, Ptiliidae (feather-winged beetles), Histeridae, and a number of members of other families.

  Myrmecophilous species can behave in accordance with the following relationships with ants:
  - **Synoecy** – species seeking anthills for easy collection of food (moulds, skins of larvae, and various insects) or shelter. They are in a mutually indifferent relationship with the ants.
  - **Synechtry** – feed on ant eggs and larvae or directly on sick ants, and therefore they are zealously pursued by the ants. They are in a mutually hostile relationship with ants. For example, the rove beetles of the genus *Zyras*.
  - **Symphily** – live in a mutually friendly relationship. The relationship of the ants and their cherished symphiles is so strong that sometimes when the hive is breached, the ants may first carry away their symphiles and only then their own progeny.

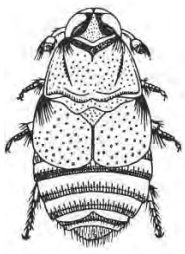
  Of species in the Czech Republic, especially certain rove beetles (Staphylinidae) of the genera *Lomechusa* and *Atemeles* are strongly dependent on ants, living with ants of the genus *Formica*. Exudates of these rove beetles produced by both adults and larvae are irresistibly attractive to the ants; so strong that the scarcely mature *Atemeles* imagos hatching in autumn must leave the hive and

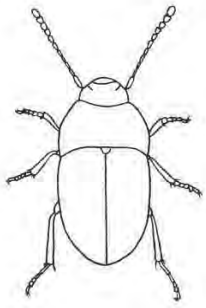
overwinter among less exudates-craving ants of the genus *Myrmica*, then attempt in spring to return to the *Formica* anthill.

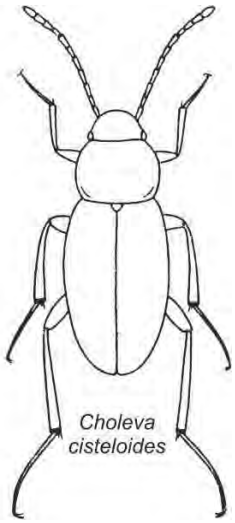
Especially interesting are certain rove beetles of the Clavigerini tribe (Staphylinidae: Clavigerini), differing from the other representatives of the family especially by their antennae with 2–6 segments and terminating in conspicuous clubs. They are true guests of ants, moving within the anthills in complete safety. They have little-developed mouthparts, are frequently blind, and are fed by the ants. At the end of their abdomens, in places where they secrete aromatic substances, they have a wisp of long bristles. The ants lick these eagerly. Even in Czech fauna two species of the *Claviger* genus with this lifestyle can be encountered. They are small, yellowish in colour, blind and their mouthparts are weakly developed. While ant embryos are not directly endangered by them, the ants can significantly neglect caring for their own progeny in their stead.


Claviger sp.

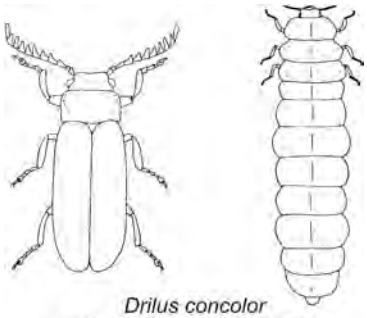
- **Termitophilous species** are similar to myrmecophiles, inhabiting termite mounds. They obviously do not live in the Czech Republic. Relations identical to those types seen in myrmecophiles can be discerned between termitophilous species and their hosts.
- *Velleius dilatatus* (Staphylinidae [rove beetles]) lives in hornet nests, where it probably hunts other species of invertebrates.
- In the family Ripiphoridae (wedge-shaped beetles), a certain combination of predation and parasitization of other insects occurs. Three species occur in the Czech Republic: *Metoecus paradoxus* are parasites on social wasps living in the ground, *Ripidius quadriceps* are parasites on cockroaches (Blattodea), and *Pelecotoma fennica* parasitize woodworms of the genus *Ptilinus*. During their development, several morphologically distinct types of larvae occur, and therefore their postembryonic development is polymetabolous.
- **Nidicolous species** live in nests and structures of vertebrates (typically rodents, insectivores, larger mammals, and also birds).
    - **Staphylinidae** – many species.
    - *Leptinus testaceus* (Leiodidae) lives in underground corridors and in the hairs of various Muridae. Imagos of these species are of a dirty yellow colour, the body is dorsoventrally flattened (in contrast to similarly living fleas), the overall body shape is rather wedge-shaped, they do not have developed eyes, and the antennae are directed towards the back.
    - *Platypsyllus castoris* (Leiodidae) lives permanently in the fur of beavers. Its habits are very similar to those of *Leptinus testaceus*, although the body has much more extensive adaptations due to the lifestyle (e.g. partial reduction of antennae and elytra). Even the aquatic lifestyle is not a problem, as there is always sufficient air to breathe in the thick fur.


Platypsyllus castoris


Leptinus testaceus


Choleva cisteloides

- Beetles of the genus *Drilus* (Drilidae) develop inside shelled gastropods. The first invasive larval instar seeks the first gastropod. Then immobile instars alternate with mobile, where each mobile instar kills off one gastropod. Therefore their development is polymetabolous.
- Larvae of beetles of the family Lycidae feed on microorganisms they consume along with fluids from rotting wood.
- Adults of the Asian species *Caccobius mutans*, *Onthophagus bifasciatus*, and *O. unifasciatus* (Scarabaeidae) can cause so-called intestinal scarabiasis in humans. This means they live in human intestines.
- Adults of the Australian species *Macropocopris symbioticus* live regularly in the anus of kangaroo's and other marsupials of the genus *Macropus*.



Drilus concolor
male on left, female on right

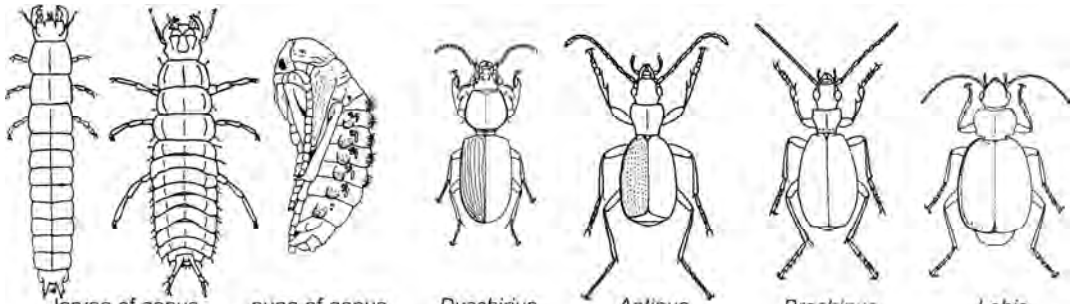
Suborder: ADEPHAGA

There are 7 families of this suborder living in the Czech Republic.

Family: **CARABIDAE** (ground beetles)

Worldwide this is a very abundant family with as many as 35,000 species. In the Czech Republic, 519 species are known, of which 15 have become extinct in relatively recent times primarily due to insensitive water management modifications. Body size of the local species ranges from 1.6 mm to 40 mm. Larvae are of campodeoid type. Most species are predatory, hunting prey of appropriate size, especially insect larvae, springtails, small gastropods, earthworms, etc. Ground beetles generally live **epigeically** (on the surface of the soil) and are very abundant, performing a very important role as predators. Many species can hunt bark beetle adults overwintering in the topmost layer of litter. A smaller number of species is probably exceptionally phytophagous (chiefly seed eaters), including, for example, members of the genera *Ophonus*, *Zabrus*, and *Bradycellus*. Other species are rather phytophagous, but occasionally hunt also animal food (e.g. certain species of the genera *Amara* and *Harpalus*). Larvae of species of the genera *Brachinus* and *Lebia* are ectoparasites of pupae of other beetle species.

For example, the species of the genus *Cychrus* feed on shelled gastropods, which is also supported by the body structure of the imagos that are slimmer and have an elongated head.



larvae of genus *Carabus* | pupa of genus *Carabus* | *Dyschirius nitidus* | *Aplinus bombarda* | *Brachinus explodens* | *Lebia chlorocephala*

Tribe: **Cicindelini**

This is a group of fast-moving thermophilic species, with not many representatives in the Czech Republic. The most common species is *Cicindela campestris*, a species that grabs attention by its colourful pigmentation and running speed that is combined with a flight 10–15 m long. Upon landing the beetle's head is directed back towards the source of the stimulus. However, they are only this mobile on hot summer days. Also, not all species fly this way (e.g. the more sparingly occurring and much less colourful species *Cicindela germanica* only runs fast). In all species, sight is their most important sense, corresponding to the large hemispherically bulging eyes. Legs are also well-adapted to rapid movement, as they are slim and long. Larvae of most Cicindelidae live in galleries burrowed almost directly perpendicularly into the ground that can reach depths of one-half metre. The entrance is blocked by the head and the tergal part of the prothorax. In warm weather the larva is in the upper part of the corridor, waiting for prey which it

seizes and quickly drags into the gallery. In cold weather and for pupation it crawls to the bottom part of the gallery.

Tribe: **Carabini**

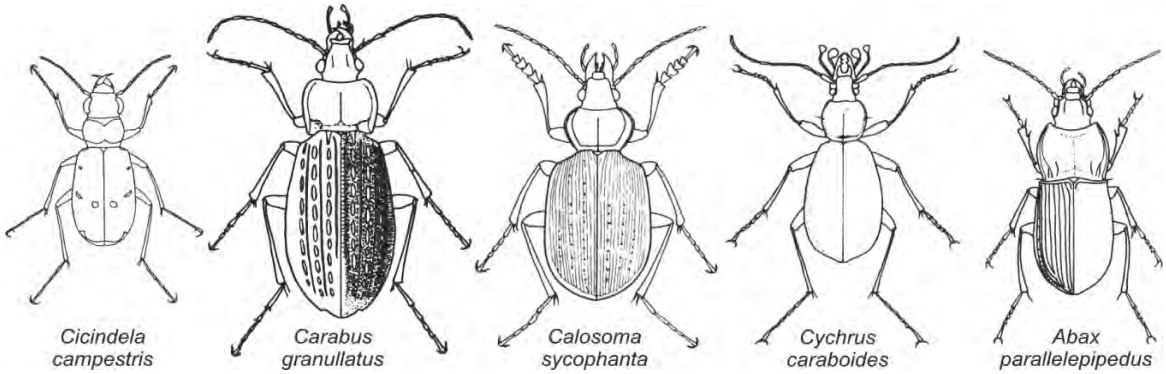
These include the species of the genera *Carabus* and *Calosoma*. Species of the genus *Carabus* range only in the temperate zone of the Holarctic. They generally include species of large size (e.g. *Carabus auratus*, *C. nemoralis*, *C. granulatus*, and others). The majority of the species of the genus *Carabus* hunt during the night, although some species hunt during the day (e.g. *Carabus auratus*). Eggs are laid in the spring and develop into black, also predatory, larvae. They undergo 3 instars, and, under favourable circumstances, new imagos hatch at the end of summer and then overwinter. In certain species, however, this development takes 2 years (e.g. *Carabus sylvestris* and *C. linei*). Adults of the large species consume many hundreds of individual prey items per year, frequently being species categorized as pests from the human perspective (slugs, caterpillars, elateriforms, grubs, etc.). Even though they are mostly purely terrestrial species, some species can also search for food underwater (*Carabus clathratus* and *C. variolosus*).

Morphologically, the species of the genus *Carabus* are also interesting for their frequently rudimentary hind wings and fused elytra. Vestigiality of hind wings obviously occurs also in other families, but in the genus *Carabus* there frequently occur side by side individuals with fully developed wings and those with wings almost entirely missing. In ground beetles we also encounter another interesting phenomenon: extraintestinal digestion. A drop of dark liquid containing digestive enzymes is disgorged onto prey seized by the strong mandibles, and food pre-digested in this manner is then sucked in. This method of ingesting food is not always so pronounced, however.

The genus ***Calosoma*** is represented by 4 species in the Czech Republic, 2 of which can have important application in forestry. Adults and larvae of both species climb very nimbly on bushes and trees, seeking especially butterfly caterpillars and pupae.

Calosoma sycophanta – the imago lives for 2–3 years. The development of this large (24–30 mm) species is extremely short – just 2–3 weeks. Larvae and adults have identical food – caterpillars and pupae of large butterflies, especially of the genus *Lymantria*. During massive outbreaks of *Lymantria*, it becomes their important natural enemy. The female lays about 150 eggs from which larvae develop, consuming more than 40 caterpillars during their development. During its life (2–3 years), the imago also consumes considerable amount of food, which can be calculated to exceed approximately 1,000 caterpillars and pupae. During 1905–1910, this species was imported to North America against the introduced species *Euproctis chrysorrhoea* and *Lymantria dispar*.

Calosoma inquisitor is the second, as this beneficial species is specialized mainly on caterpillars of the Larentiinae.



Tribe: **Harpalini**

This is a group very rich in species (around 2,500 in the world). It contains mainly species consuming mixed food but also explicit herbivores (*Ophonus*).

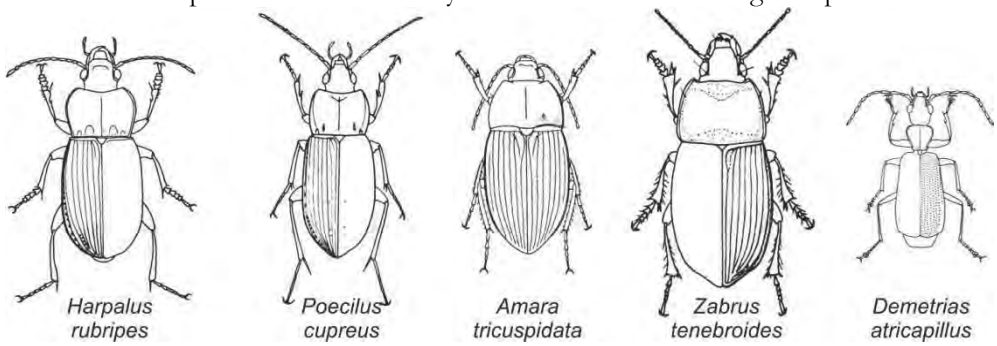
Species that can damage the production of agronomic plants include the very abundant species *Pseudoophonus rufipes* (11–16 mm) with softly felted elytra. Larvae are generally predatory but occasionally herbivorous. Adults are mainly active at night, frequently consuming germinating seeds and freshly emerging seeds of deciduous and coniferous trees (damage can be horrific especially in tree nurseries).

Tribe: **Zabrini**

The tribe includes some 600 species. Just two genera occur in the Czech Republic: *Zabrus* (2 species) and the numerous genus *Amara*. The entire group is substantially phytophagous.

Zabrus tenebrioides is a species that can be considered a definite pest. This species (14–16 mm long) lays eggs into soil in August and the hatched larvae live in the ground. They crawl to the surface at night, chewing and sucking the soft vegetative organs of cereals. They often drag the above-surface parts under the ground, but they do not consume the underground parts. After overwintering, the larva continues feeding. At the end of spring, the larvae pupate on the bottom of the galleries. Subsequently the hatched beetles damage blossoms and caryopses at milk maturity. Therefore, it has but one generation per year. Larvae are considerably more damaging than are the adults. The species can also overpopulate in calamitous proportions. Among large outbreaks of this species, a calamity in Moravia in 1918 is noteworthy.

Amara includes species that can similarly suck the seeds of certain grass species.



Family: **DYTISCIDAE** (predaceous diving beetles)

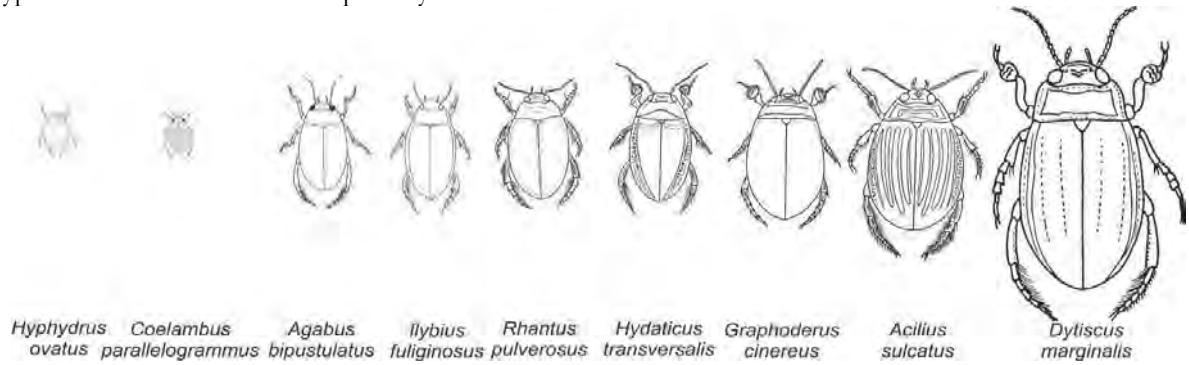
The Czech species are 2–44 mm long. Larvae can be up to 70 mm long. All representatives live in water in both larval and imaginal stages, feeding as predators upon various prey, including vertebrates. Adults have strongly bristled hind tibiae and tarsal segments, adapted for swimming. In males, the first 2–3 tarsal segments are frequently extended and equipped with very effective suction bristles, used for keeping the male on the female's body during mating. Glands present on the prothorax produce substances poisonous to fish and amphibians. Abdominal glands excrete white to yellowish cream-like substances smeared by the adult over the body and which provides effective protection from microorganisms.

Adults breathe atmospheric oxygen from the air, keeping a supply under the elytra that is regularly replenished. Larvae also do not have tracheal gills, and breathe atmospheric oxygen from the water surface through open spiracles positioned at the end of the abdomen. Larvae, in contrast to adults, mostly have extracorporeal digestion. They inject digesting enzymes into the prey through hollow mandibles, then suck the pre-digested food. Adults can fly.

They inhabit mostly still or slowly flowing waters (there they stay among the vegetation). Certain species do, however, live in fast-flowing water (especially under rocks).

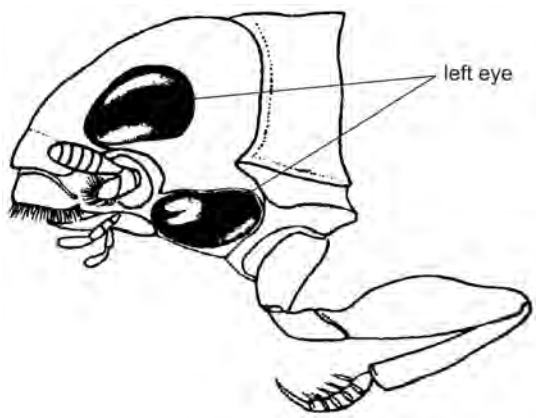
Dytiscus latisimus is the largest species of the entire family, with length of 36–44 mm and larvae up to 70 mm long. It inhabits ponds and lakes with natural chemistry. The species is extinct in the Czech Republic.

Dytiscus marginalis is another relatively large predaceous diving beetle (27–35 mm), abundant on all types of water. It can live for up to 5 years.



Family: **GYRINIDAE** (whirligig beetles)

Similar by habit to the predaceous diving beetle species, but with body size of only around 3.5–8 mm. In contrast to Dytiscidae, they have short and strong antennae, but two pairs of hind natatorial legs that are significantly reduced and an extended pair of forelegs. Eyes are specially adapted for life on the water's surface, as they are divided into upper and lower halves for vision above and below water. On the water's surface, the adults hunt for small live and dead prey, which they seize with their forelegs. Larvae are also predatory, and, like Dytiscidae, they suck their prey. They do, however, breather through tracheal gills.



Suborder: POLYPHAGA

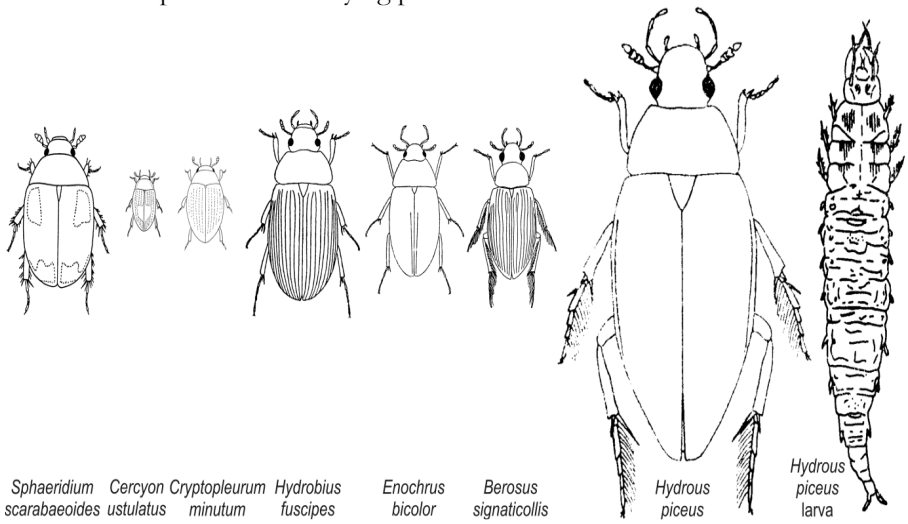
Most species and families living in Czech territory belong to this suborder (over 100 families).

Superfamily: *HYDROPHILOIDEA*

There are three families in the Czech Republic.

Family: **HYDROPHILIDAE** (water scavenger beetles)

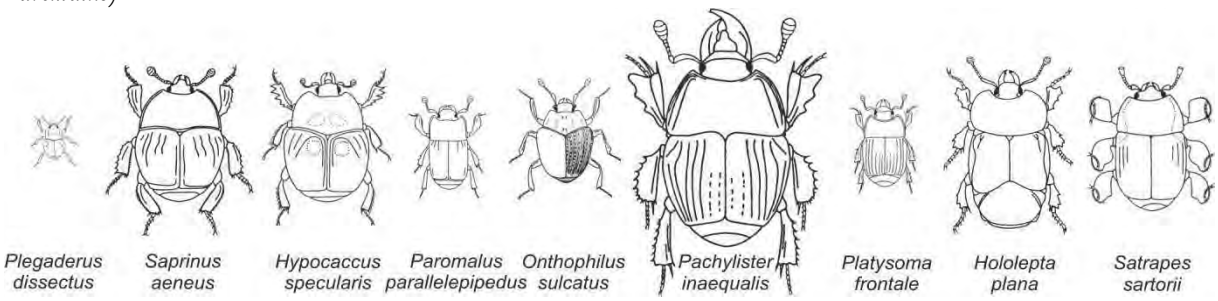
Size of these beetles ranges from 1 to 50 mm, with larvae up to 60 mm long. They include terrestrial as well as aquatic species. Water species are similar in their habits to predaceous water beetles. Maxillary palps take over the sensory role of the antennae, and therefore are longer than the antennae. In contrast to Dytiscidae, antennae are short and capitate. When swimming, the hind pair of legs moves asynchronously (i.e. as during walking). Females can weave threads from glands complementary to the reproductive organs, using these to construct specific egg cocoons. They are predominantly predatory, hunting small arthropods and gastropods. They have extracorporeal digestion. Some species are phytophagous. Terrestrial species seek decaying plant matter or faeces of herbivores.



Family: **HISTERIDAE** (clown beetles)

Terrestrial species have body size of 1.5–12 mm. Beetles are strongly sclerotized, mostly black in colour. Forelegs are fossorial. The first antennal segment is long, mostly as long as the remainder of the antenna together. Adults and larvae are predatory, living mostly on larvae of Diptera: Cyclorrhapha. Therefore, they are encountered most frequently on decaying plant matter, rotting fungi, corpses, and faeces. Certain species are myrmecophilous. Some species can also be found inside the galleries of

ligniperdous insects. Some species pursue bark beetle larvae (species of the genera *Platysoma*, *Plegaderus*, and *Paromalus*).

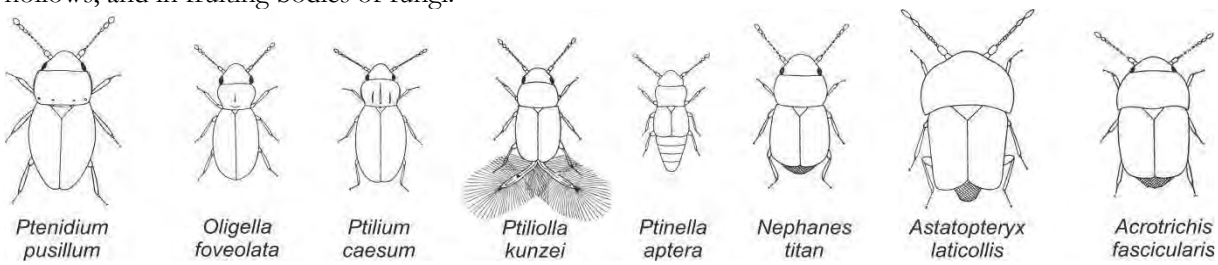


Superfamily: *STAPHYLINOIDEA*

There are 7 families in the Czech Republic.

Family: **PTILIIDAE** (feather-winged beetles)

The smallest known species of beetles are included in this family. Body size seldom exceeds 1.1 mm. The North American species *Nanosella fungi* has body size of only 0.25 mm. In the Czech Republic, about 50 species are known. Adults have characteristically formed wings similar to feathers (thus their English name: feather-winged beetles). All species feed on spores of deuteromycotina and fungi imperfecti, and therefore they can be found in various moulding substrates, faeces of vertebrates, tree hollows, and in fruiting bodies of fungi.

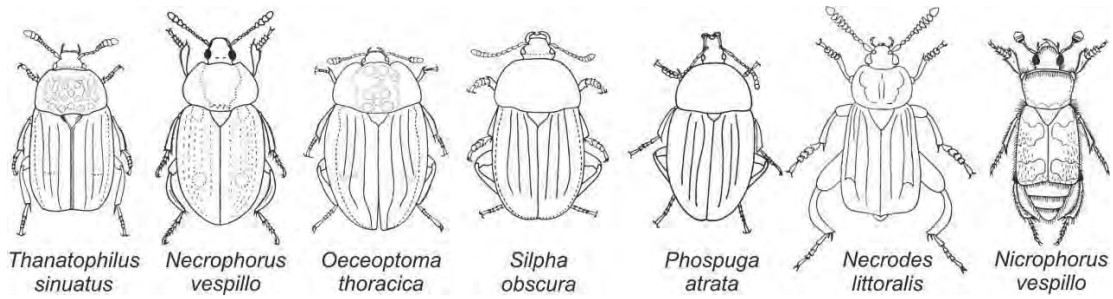


Family: **SILPHIDAE**

Body size ranges between 8 mm and 30 mm. The family includes 2 larger groups: the subfamilies Silphinae and Nicrophorinae. Silphinae do not have capitate antennae and have not developed care for their young. They feed on carrion or are herbivorous. The species *Phosphuga atrata* is a predator of shelled gastropods.

An important species is *Dendroxena quadripunctata*, which preys upon caterpillars of moths, especially tortrix moths, Larentiinae, and *Lymantria*. Adults appear in the spring and hunt in treetops. The larvae are also carnivorous, but they hunt on the ground. The larvae pupate in the soil and the hatched adult overwinters.

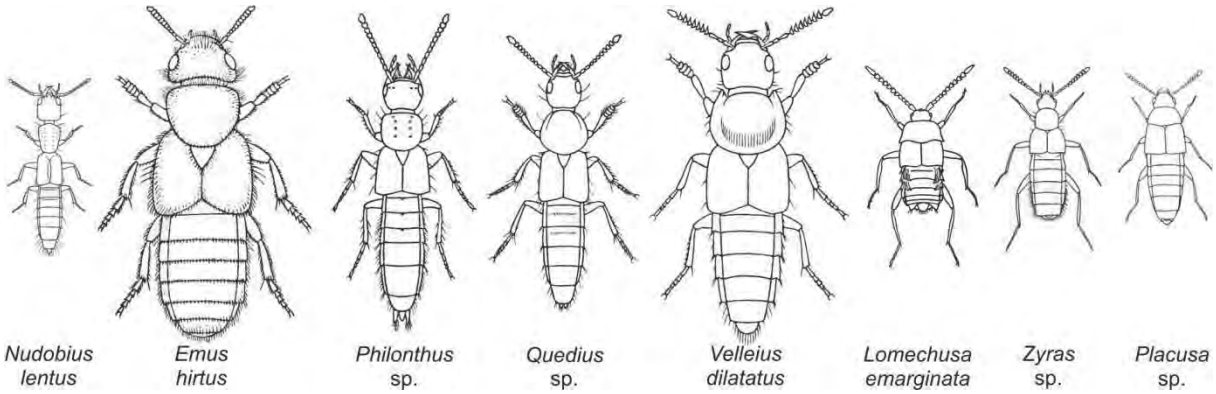
Nicrophorinae all feed on carrion. In the Czech Republic, they are represented by a single genus: *Nicrophorus*. They have developed capitate antennae and care for the young. They are frequently found in bark beetle pheromone traps, attracted by the smell of the decomposing bark beetle bodies (if the bark beetles end in water due to clogged outlets of the trap, the decomposition process is very intensive).



Family: **STAPHYLINIDAE** (rove beetles)

Sizes of the local species range from 0.5 mm to 34 mm. This family is very rich in the number of species, including around 1,300 species in the Czech Republic (over 40,000 worldwide). The body habitus is generally very elongated with more or less shortened elytra. At the end of the abdomen there is at least one pair of glands, and their secretion has defensive function. The overwhelming majority of the species are predatory in both the larval and imaginal stages. Certain species, however, are herbivorous and chew the blossoms of various plants. Mycophagous species are also known (e.g. *Gyrophaena*). Species of the genus *Aleochara* are parasitoids of puparia of Diptera: Cyclorrhapha. They inhabit diverse biotopes sufficiently supplied with food. They live in the soil, in litter, decaying wood, in tree hollows, on decaying plant substances, on carrion, and on leaves of various plants. A number of myrmecophilous species are known; many species also live on water banks, in bird nests, and in mammal dens.

Numerous species can also be found in the galleries of bark beetles, where they feed especially on the larvae (e.g. *Quedius plagiatus*, *Nudobius lentus*, and certain species of the genus *Placusa*).

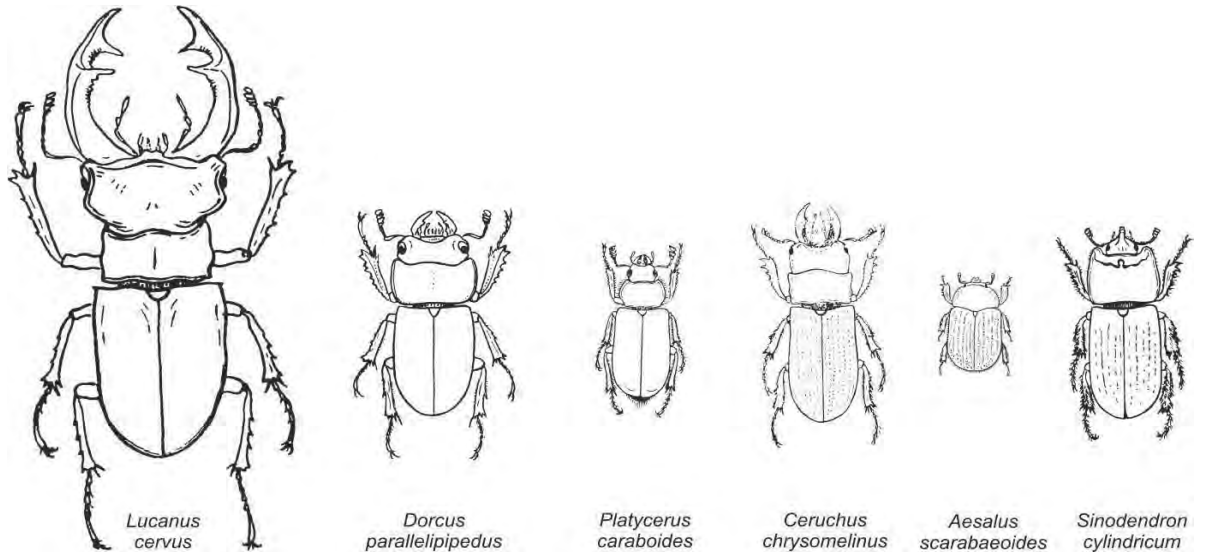


Superfamily: *SCARABAEOIDEA*

There are 6 families in the Czech Republic.

Family: **LUCANIDAE** (stag beetles)

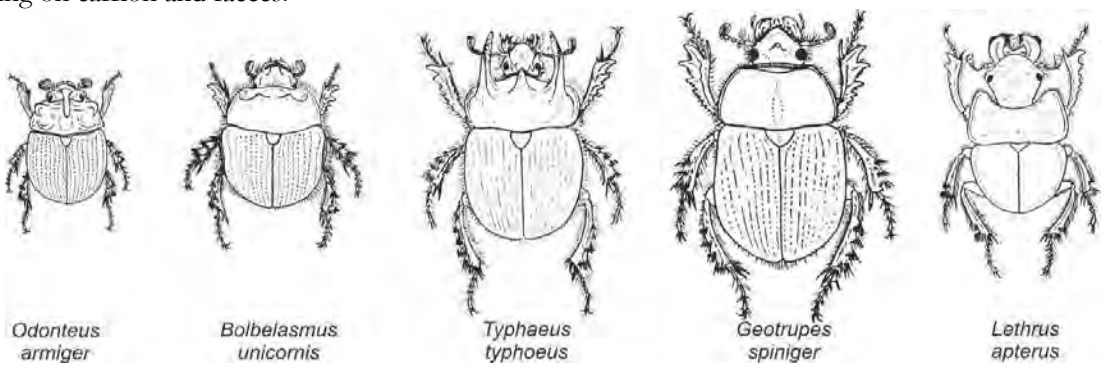
Body size is in the range of 7–75 mm. There are 7 species living in the Czech Republic. Adults mostly have a large head bearing mighty mandibles, especially in males. Their larvae are of the grub type and develop in decaying wood of especially deciduous trees. Only *Ceruchus chrysomelinus* develops in decaying wood of spruces and firs, rarely in deciduous wood (beech or birch). The largest Czech species is *Lucanus cervus*.



Family: **GEOTRUPIDAE** (dor beetles)

In the Czech Republic, this family is represented by 9 species. Larvae are grublike and feed mostly on faeces, decayed plant matter, and rotting fungi. Beneath such materials they construct a system of galleries into which they drag the food. In most species, complex care for their offspring has been observed. The species *Lethrus apterus* consumes fresh plant matter. Particularly interesting is the biology of the species *Odonteus armiger* and *Bolbelasmus unicornis*, which develop in underground fungi.

The most abundant is the forest species *Anoplotrupes stercorosus*, living mostly off fungi, but also feeding on carrion and faeces.

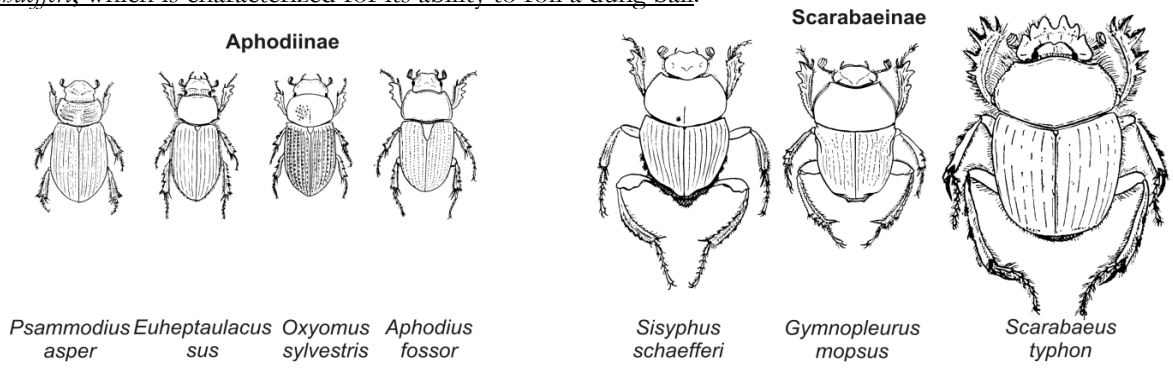


Family: **SCARABAEIDAE** (scarabs)

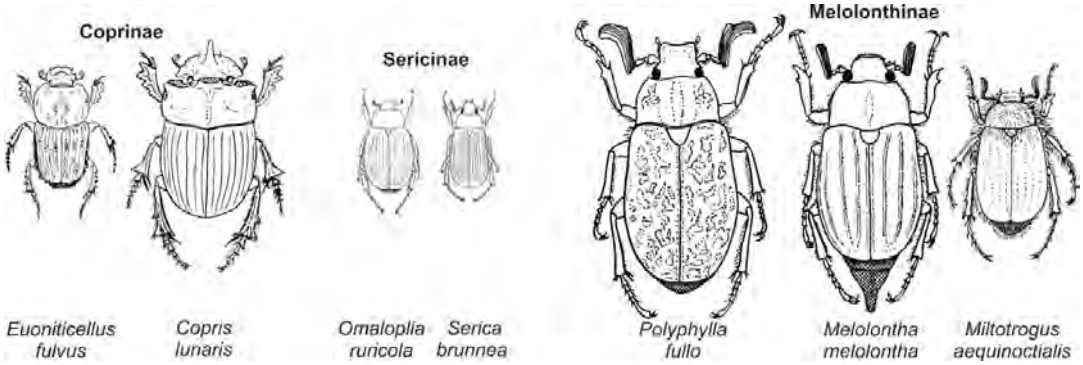
One of the families with the greatest number of species in the Czech Republic, it is represented by 6 subfamilies in the country:

Aphodiinae – small species with no apparent sexual dimorphism. In the Czech Republic, the subfamily consists especially of the extensive genus *Aphodius*, whose grublike larvae develop in the faeces of various (and sometimes even specific) mammals. Care for the offspring is not developed.

Scarabaeinae – these are species frequently with significant care for their offspring. Larvae develop in the soil, living in a mound of faeces prepared by the parents. This subfamily includes *Sisyphus schaefferi*, which is characterized for its ability to roll a dung ball.

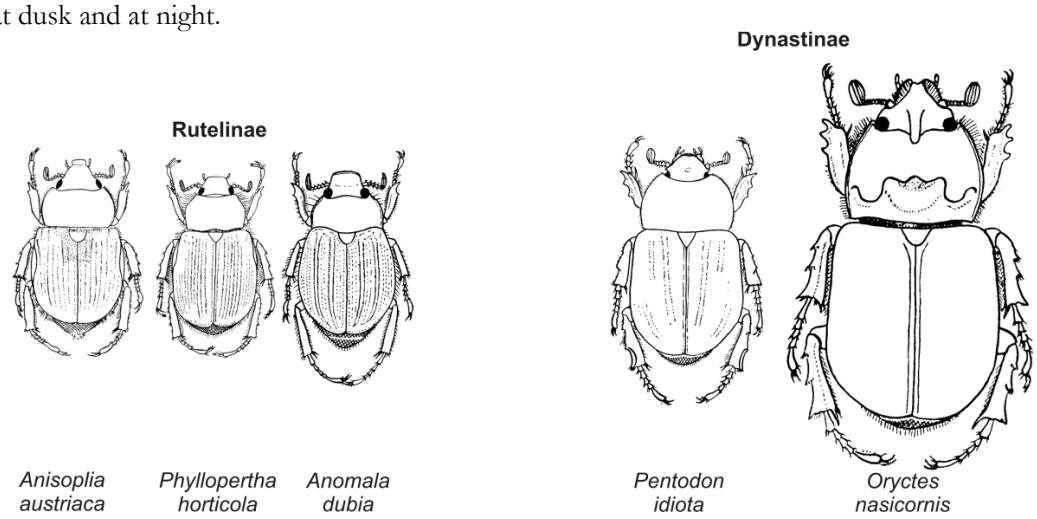


Melolonthinae – herbivorous species consuming live parts of plants. Grublike larvae eat roots in the soil, lower instars, and humus. This group includes, for example, *Melolontha melolontha* (common cockchafer), *M. hippocastani* (forest cockchafer), *Polyphylla fullo*, *Miltotrogus aequinoctialis*, and others.



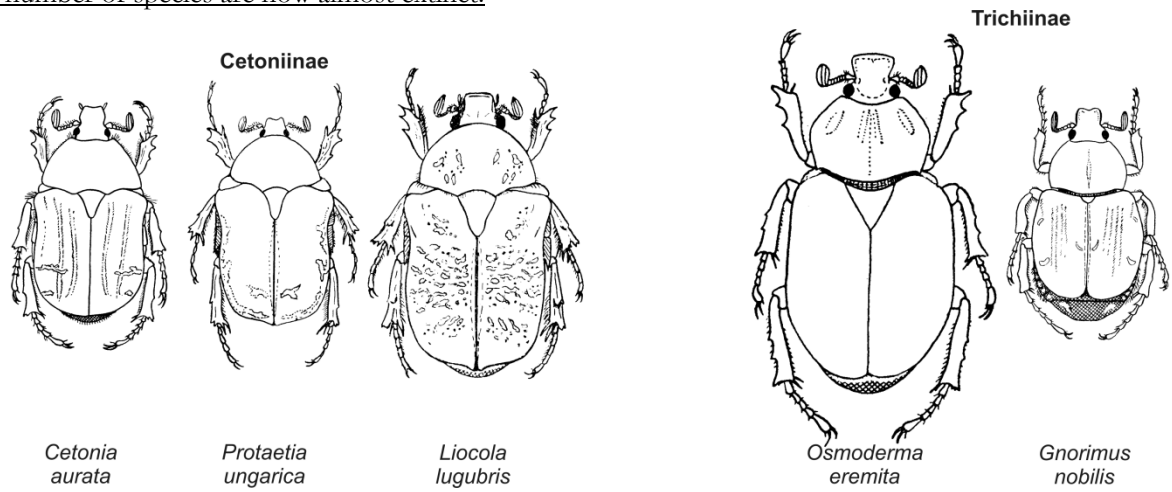
Rutelinae (monkey beetles) – occur on trees, bushes and herbs, frequently on flowers. Grublike larvae live in the soil and chew on plant roots (e.g. *Phyllopertha horticola*).

Dynastinae (rhinoceros beetles) – only *Oryctes nasicornis* (European rhinoceros beetle) occurs in the Czech Republic. Its larvae originally developed in decomposing tree wood. Over time, it gradually has adapted to piles of sawdust and even the gardening compost that is consumed by the larvae. Adults are active at dusk and at night.



Cetoniinae (flower chafers) – medium-sized to large beetles, mostly active in direct sunlight. Larvae develop in dead deciduous wood, in humus, and on plant roots (e.g. *Liocola lugubris*, *Cetonischema aeruginosa*, and *Eupotosia affinis*). These species are associated with the hollows of trees sometimes even centuries old, and, due to insensitive management, they are today among the rarest species in Czech nature and have disappeared from practically the entire territory. Without considerate forest management, they cannot survive in the forest complexes.

Trichiinae – medium-sized to large beetles. Species developing inside the hollows of old trees (mostly oaks, elms, lindens, willows, and beeches) are important from a forestry perspective. These include *Osmoderma eremita* (hermit beetle), *Gnorimus nobilis* (noble chafer), and *G. variabilis* (variable chafer). These species can be found along with Cetoniinae. Due to the removal of old trees from the countryside, a number of species are now almost extinct.



Superfamily: *BUPRESTOIDEA*

Only the 1 family Buprestidae exists in the Czech Republic.

Family: **BUPRESTIDAE** (jewel beetles)

There are 105 species in the Czech Republic. They are small to medium-sized (1.5–32 mm) and active in strong sunlight. The body of imagos is strongly sclerotized, and mostly with strongly metallic

colours. They occur on tree trunks, in wood, and on blossoms and leaves of herbs and trees. Apod larvae are whitish, elongated, without eyes, with strong mandibles directed forward. They are more or less flat, frequently with a conspicuously extended thorax. They live beneath the bark and in the wood of weakened trees (most species), more rarely inside stems and roots of herbs (e.g. some *Coraebus*) and grasses (genus *Cylindromorphus*), or burrow inside the leaves of trees and herbs (genera *Trachys* and *Habroloma*).

A number of species develop on various trees. They are mostly accompanying species developing on trees already much weakened by other pests.

Phaenops cyanea undoubtedly is among the most damaging species. They attack predominantly pines weakened by other insects, but they also can act as the primary pest.

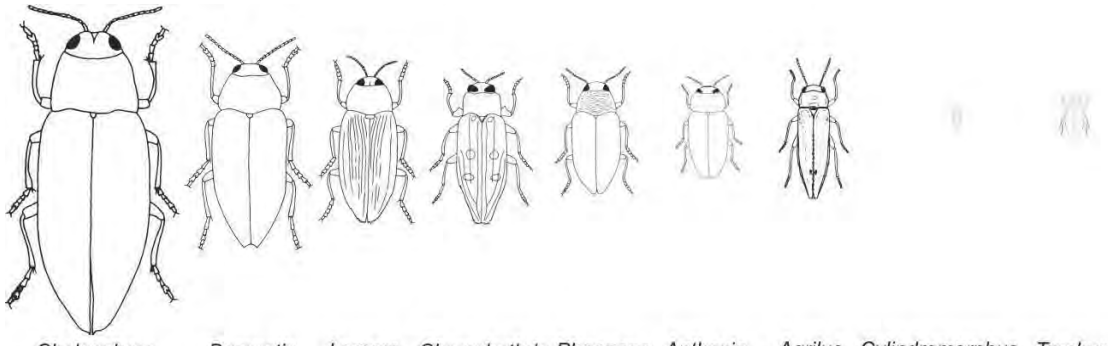
Agrilus is a genus very rich in species, and frequently ones that are difficult to determine. They develop under the bark of various deciduous trees (rarely also in herbaceous plants). The species *Agrilus viridis*, *A. angustulus*, and *A. biguttatus* are important from a forestry viewpoint. These develop on oak and beech, whereupon they are secondary pests.

Anthaxia is a genus rich in species. They develop on various trees (mostly deciduous). An abundant species of this genus is *Anthaxia quadripunctata*, which secondarily attacks withering young forests and the thinner material of grown trees. They develop under the bark of various conifers, especially spruce and pine.

Chalcophora mariana is the largest Czech species. It develops in sandy pine stands under the bark of dead pines.

Melanophila acuminata is a species with interesting biology, developing in charred wood. Beetles often fly onto still-smouldering material, as they are attracted by smoke.

Buprestis rustica can be encountered on spruce, *Buprestis haemorrhoidalis* and *Chrysobothris igniventris* on pine, *Ovalisia rutilans* on linden, *Ovalisia mirifica* and *Anthaxia deaurata* on elm. (Elm chafers are today very rare, and therefore it is necessary to keep the last remains of elms in forests to prevent the total liquidation of these species as in the case of chafers connected to tree hollows.)



Superfamily: *ELATEROIDEA*

There are 9 families in the Czech Republic.

Family: **ELATERIDAE** (click beetles)

Mostly medium-sized beetles (5–15 mm); the smallest local species belong to the genus *Zorochros* (1.5 mm). There are approximately 150 species in the Czech Republic. The body is of a familiar characteristic shape, smooth or lightly haired, sometimes also covered in scales (genera *Agrypnus* and *Lacon*). Metallic shiny species are also known from Europe (*Selatosomus* and *Ctenicera*).

Imagos mostly remain on grasses, herbs, and bushes. They feed on delicate plant parts such as blossoms, buds, and tips of shoots. They have a mechanism (a prosternal protrusion fitting into the mesosternum) by means of which they are able to spring into the air from a position on their backs.

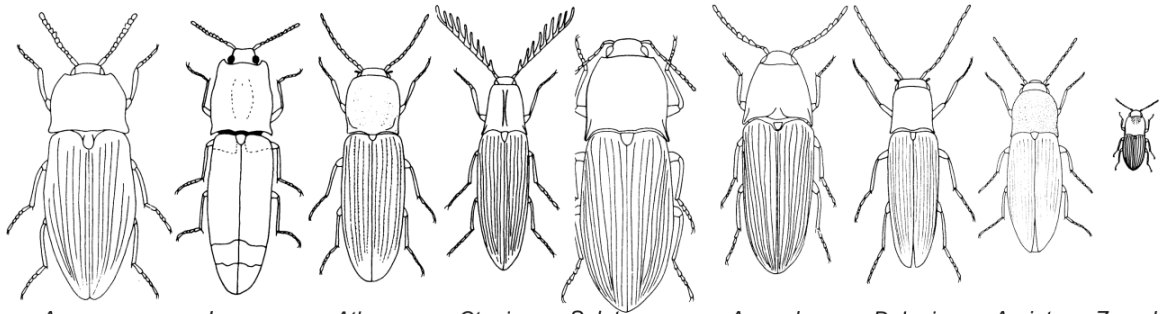
Larvae (so-called wireworms) are firm, slender, cylindrical or slightly flattened, have well-developed legs, and the last sclerites are frequently specifically formed. Mostly carnivorous, they live in the soil or in decaying wood of trees, tree stumps including their underground parts and beneath them, or seek tree hollows where they hunt larvae of other invertebrates. Other species are mostly phytophagous with frequent or occasional carnivory. These species can cause damage both in agriculture and in forestry

(e.g. *Agriotes lineatus*, *A. obscurus*, *A. sputator*, *A. ustulatus*, *Dalopius marginatus*, *Selatosomus aeneus*, *Agrypnus murinus*, *Athous subfuscus*, and *Athous haemorrhoidalis*). They damage roots of grasses, trees and shrubs, but also cultivated plants – especially potatoes, beets, carrots, lettuce, cabbage, and kale. Usually an entire group of plants in an area is damaged (e.g. within a row), which is typical for damage by their larvae. Certain species can also cause significant damage to seedlings in tree nurseries. Species living in forest litter can also attack overwintering pupae of butterflies and caterpillars of picture-winged flies.

Larvae most typically develop for 2–3 years, but sometimes for only 1 year and in other cases even many more years.

Ampedus is an extensive genus of very similar species, most frequently with red elytra. They are carnivorous. The beetles are often found in bark beetle pheromone traps.

Among tropical Central American species, the click beetle *Pyrophorus noctilucus* (known as the "headlight elater" in English and "Cucujo" in Spanish) has very strong luminescence. Therefore, they are often used by the locals as lamps.

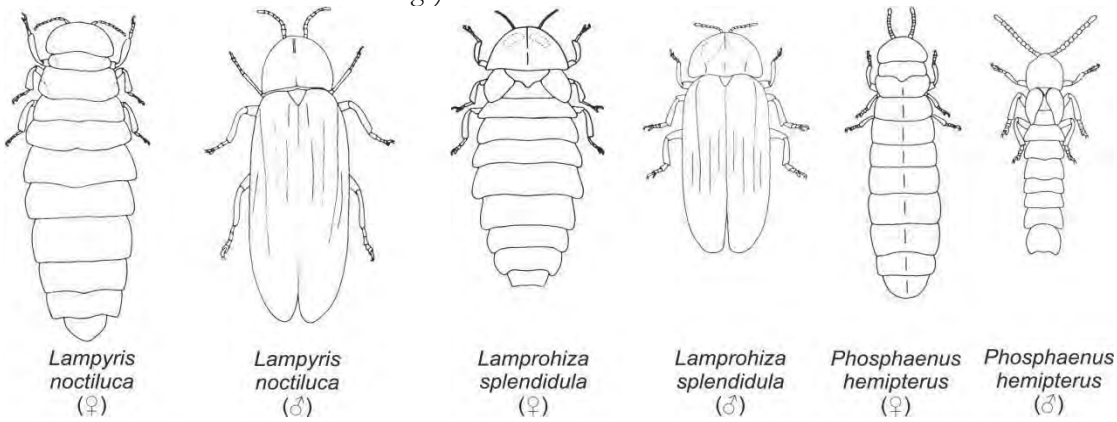


Family: **LAMPYRIDAE** (fireflies)

In the Czech Republic there are only 3 species in 3 genera. The group is most richly represented in the tropics. In all species of this family, either both sexes or at least the females are luminescent. Even though bioluminescence also occurs in certain other beetles (and other insect groups), it is never a characteristic feature for an entire family (luminescence has even been recorded in frogs that had consumed large numbers of fireflies).

Light-producing places are always situated on the bottom side of the body and they are apparent as light-coloured spots, especially on the 6th and 7th segments of the abdomen. Light is yellow-green to orange-red (yellow-green in Czech species). The larvae and pupae also emit light. Females settle on grasses and emit light signals at about one-second intervals. When a flying male approaches, the females lift their abdomens so that the light is better perceptible. After the males have finished swarming, the females no longer respond in this manner.

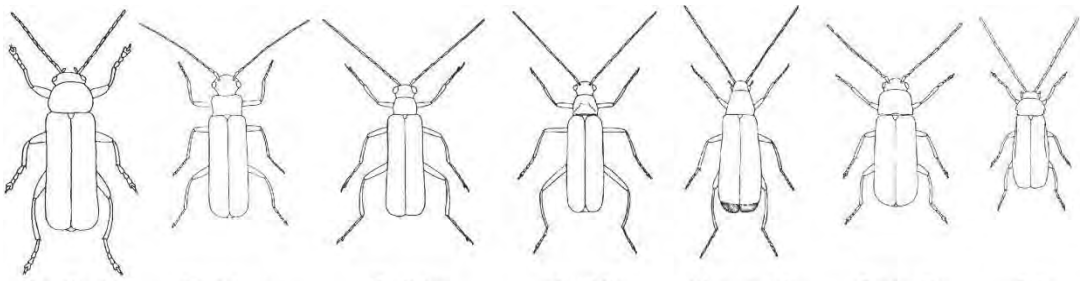
Another specific characteristic is that females of many species have strongly reduced wings. Among Czech species, the females of *Lampyris noctiluca* and *Lamprohiza splendidula* have retained rudimentary wings, while the considerably rarer species *Phosphaenus hemipterus* has no wings whatsoever (in which case even the male has shortened wings).



Imagos ingest no food at all for the duration of their short lives. They appear in early summer in warmer, vegetated, and rather humid biotopes. Eggs are laid into a soil cover (litter). Firefly larvae are predatory (campodeoid) and feed on molluscs, which they pursue by following their slime trail. The mandibles have a hollow channel used for injecting into the prey a secretion that will kill it while the body tissues are simultaneously histolyzed. The liquid contents of the host are then sucked in by the action of the maxillae and labia. The larva moults 5 times and then overwinters; it pupates in the spring. They have a 1-year generation.

Family: **CANTHARIDAE** (soldier beetles)

Beetles of medium size (2–15 mm) with very weakly sclerotized bodies. The imagos feed on nectar and pollen, although sometimes they will consume aphids and other small insects. Their dark and thickly haired larvae are carnivorous, occasionally herbivorous (campodeoid type). They hunt on the surface of the soil, overwinter, and pupate in the spring (they are also active in cold – frequently even on snow cover).

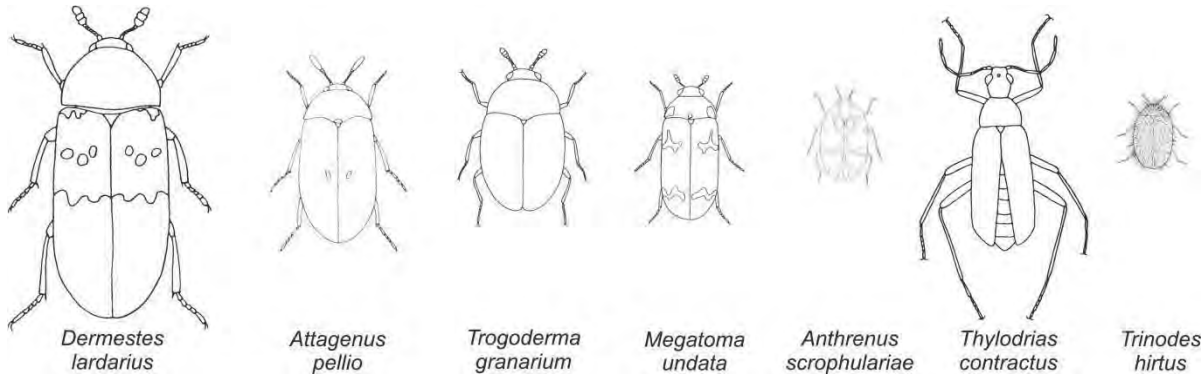


Superfamily: ***BOSTRICHOIDEA***

There are 6 families in the Czech Republic.

Family: **DERMESTIDAE** (skin beetles)

There are in the Czech Republic about 45 species of small to medium size (2–9 mm). An interesting feature is the presence of a single ocellum on the forehead (it is absent in the genus *Dermestes*). In nature, the imagos and larvae of all species feed on animal remains, especially fur, dried body tissues, feathers, horns, and the like. A number of species also invade human houses seeking such items and causing damage (*Trogoderma glabrum* even feeds on plant food and is known as a pest on stored cereal grains). Imagos of certain species feed on nectar and pollen (e.g. *Anthrenus*), while substances of animal origin are consumed by, for example, the genus *Dermestes*. Also known are species occurring in spider webs (*Trinodes hirtus* feeds on insect remains); caterpillar cocoons; hives of ants, termites, wasps, and bees (e.g. *Megatoma undata*); bird nests; and mammal dens.



Some species have been introduced into wide areas, achieving even worldwide distribution. For example, the European species *Dermestes lardarius* is now known from all continents.

Larvae are oval to flattened, very mobile and strongly haired. They frequently undergo an unstable number of instars.

The number of species that can cause damage is relatively significant and include *Dermestes lardarius* (damages materials of animal origin [especially furs], in the imaginal and larval stages); *Attagenus pellio* and *A. smirnovi* (especially larvae cause damage; imagos frequently on blossoms feeding on pollen); as well as *Anthrenus scrophulariae*, *A. museorum*, and *A. olgae* (again, especially larvae cause damage while imagos feed on pollen).

Mainly damaged are any products from animal fibres (wool, silk, but also artificial silk), fur, and leather goods. Species of the genera *Anthrenus* and *Attagenus*, among others, favour consuming chitin, and therefore frequently destroy material in museum collections.

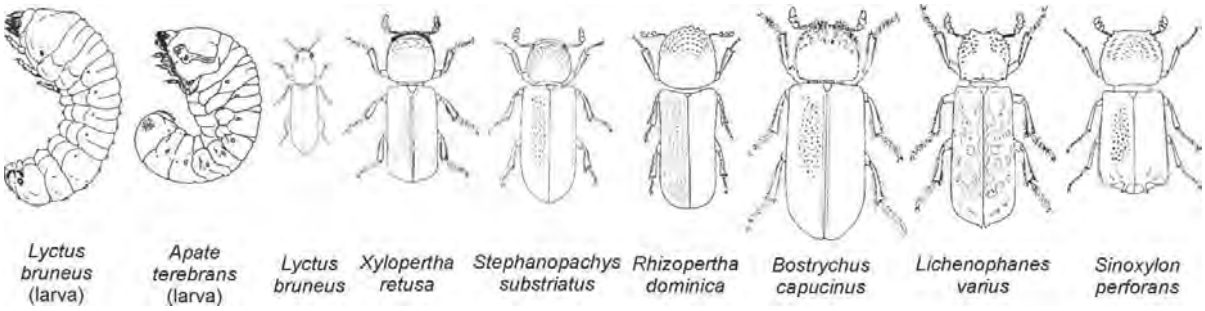
Thylodrias contractus has also been found on ancient Egyptian mummies.

Family: **BOSTRICHIDAE** (auger beetles)

This is a primarily tropical family accounting for about 600 species. There are only 11 species in the Czech Republic, 2–15 mm long. In both larval and imaginal stages they are wood-burrowing species with regularly cylindrical bodies adapted for living in galleries. Certain species are also pests of agricultural products (e.g. *Rhyzopertha dominica* is a cosmopolitan pest especially in stored rice). Larvae are grublike, with a strong "chest" and short legs. The head is prognathous and retractable into the prothorax (Anobiidae [woodworms] have orthognathous and non-retractable heads).

The largest species in the Czech Republic, *Bostrychus capucinus*, is up to 16 mm long and develops in the sapwood of beech, fruit trees, and grapevines. The generations take 1–2 years, and in warm areas of the Czech territory it can cause serious damage to stored wood (and can also damage processed wood). Its natural enemy is the largest local chequered beetle (Cleridae), *Clerus mutillarius*.

Members of the genus *Lyctus* (in the Czech Republic *Lyctus linearis*, *L. bruneus* and *L. pubescens*) develop in dry, already processed deciduous (mainly oak) wood, often used in building construction, in wood flooring, barrels, rafters, old barrels, and the like.



Family: **ANOBIIDAE** (woodworms)

There are more than 100 species in the Czech Republic (including spider beetles [Ptininae]). Small beetles, 1.5–9 mm long, they are mostly yellowish and brown coloured with cylindrical bodies and pronouncedly arched scutum.

Their development is tied especially to wood of various trees where the larvae develop.

The larvae are grublike, whitish with well-developed legs and orthognathous head (although Bostrichidae have a prognathous head). Development of larvae in wood extends over many months and the wood is gradually transformed into fine dust. In the stomach, or rather in the special crypts and protrusions, there exists a microflora of bacteria and fungi contributing to the decomposition of the ground wood.

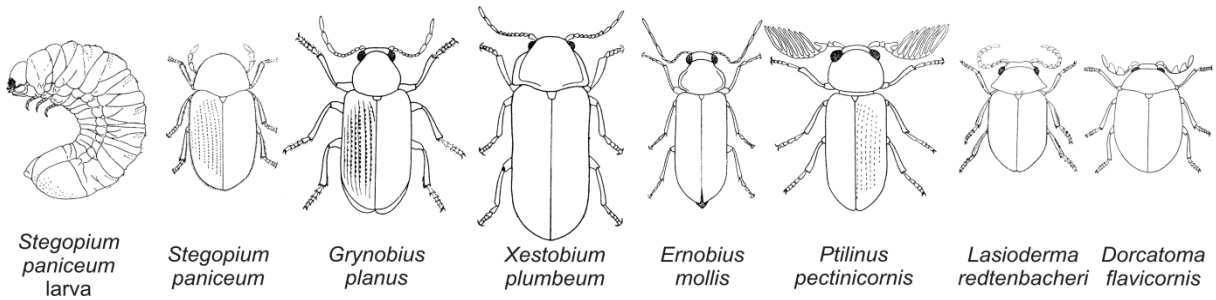
Imagos live very briefly and consume no food. Copulation occurs outside of the corridors. The eggs are laid in the vicinity of the fly-out openings, and the larvae use them to enter the wood.

Eggs are already inoculated during their laying and the larvae use the spores that attach to the surface of the egg cover. When copulation occurs, the individuals of both sexes in some species thump their scuta into the gallery walls so that audible sounds are produced. The partners probably only perceive these signals as vibrations with their tactile organs, as no proper hearing organs have so far been determined.

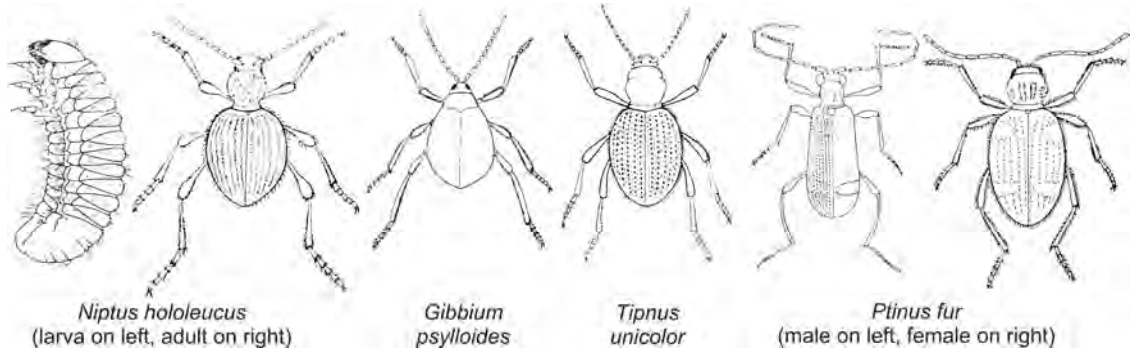
The economically most important species include *Xestobium rufovillosum*, *Anobium punctatum*, *Ernobius mollis*, *E. nigrinus*, *E. abietis*, *Hadrobregmus pertinax*, and certain others.

Ernobius mollis develops in the centres and on the bases of the scales of spruce cones. *Hedobia pubescens* develops in *Loranthus europaeus*, *Mesocoelopus niger* in dry ivy *Hedera helix*, and representatives of the genus *Dorcatoma* in bracket fungi.

In addition to wood pests, this family also includes species damaging foodstuffs. Especially among these are the species *Sitotroga paniceum* (grains and products from flour, pasta, chocolate) and *Lasioderma serricorne*, a pest of tobacco and various spices (including pepper, paprika, and even poisonous drugs [e.g. Belladonna]).



This family also includes the so-called spider beetles (Ptininae) that formerly were considered an independent family Ptinidae. In contrast to woodworms they are pronouncedly arched with filiform antennae. They have very low requirements for humidity. A number of species are synanthropic. Although there are a number of synanthropic species and they occur in old wooden houses, they mostly consume only plant and animal remains and starch-based substances. For example, the drop-shaped *Gibbium psylloides* and the brightly golden-haired *Niptus hololeucus* are conspicuous.

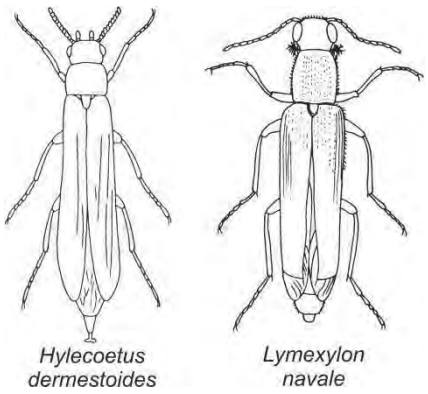


Superfamily: *LYMEXYLOIDEA*

Family: **LYMEXYLIDAE** (ship-timber beetles)

Medium-sized beetles (6–18 mm), with cylindrical and elongated bodies, their eyes protrude from their heads. Legs are long and thin with tarsi of the same length as the tibiae. Tarsi have 5 segments of circular cross-sections, and the elytra are very soft. Sexual dimorphism is conspicuous, the females being significantly larger than males and brown while males are smaller, black, and with bizarrely branched and bushy maxillary palps.

Larvae are long, thin, yellowish-white with circular yellow-brown heads, with markedly enlarged hump-like prothorax, and the anal segment is either elongated into a thin point or has a pronounced hump. They burrow deep horizontal galleries into live or felled wood. Adults probably do not eat and only live for 2–4 days.



In the Czech Republic, there are only 2 species in 2 genera: *Hylecoetus dermestoides* and *Lymexylon navale*.

Hylecoetus dermestoides – larvae feed on mycelium of the symbiotic fungus *Endomyces hylecoeti* which grows on gallery walls. It is polyphagous on conifers and broadleaves; among broadleaves it prefers especially beech, alder, and birch. It is a pest attacking stumps, lying trunks, and standing broken trees, but only rarely live damaged trees. The presence of larvae is indicated by a fine white wood dust cast outside from the galleries.

Lymexylon navale – larvae feed on wood, and the galleries are filled with wood dust that has passed through their digestive tracts. The larval galleries lead inside the heartwood (being up to 2 m long) and then again point back toward the wood's surface. Again this is a pest – developing in oak wood – that predominantly attacks stumps and lying wood, but only rarely merely weakened trees.

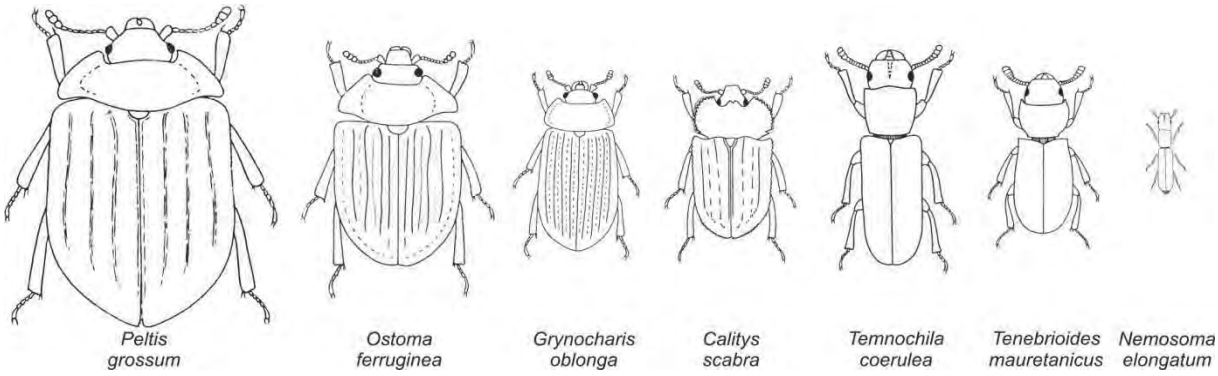
Superfamily: *CLEROIDEA*

There are 6 families in the Czech Republic.

Family: **TROGOSSITIDAE**

There are 8 species in the Czech Republic. Imagos and larvae are predators on other insects (*Nemozoma elongatum*, *Temnoscheila coerulea*) or tied to wood fungi (*Peltis grossum*, *Ostoma ferruginea*, *Grynocharis oblonga*), and less frequently they are warehouse pests with occasional carnivory (*Tenebroides fuscus*, *T. mauritanicus*).

The species *Nemozoma elongatum* is important from a forestry perspective, hunting various species of bark beetles in the larval and imaginal stages (frequently *Pityogenes chalcographus*). It is also found in pheromone traps.



Family: **CLERIDAE** (chequered beetles)

There are 21 species in the Czech Republic. Brightly coloured, most usually hairy species with 3-segmented (although sometimes less obviously so) antennal capitula.

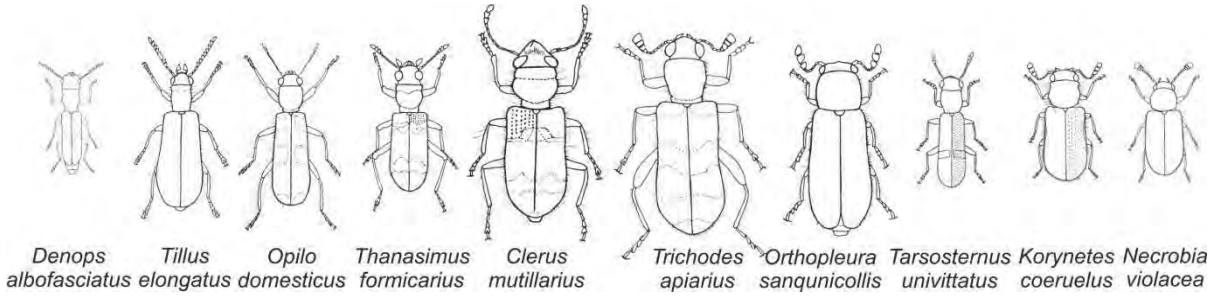
Chequered beetles are mostly predators in the larval and imaginal stages. Exceptionally, the imagos feed on pollen (genus *Trichodes*). Larvae are elongated, thin, frequently pink with a dark head. The 9th abdominal segment carries paired urogomphi.

They are frequently specialized predators of mostly xylophagous insects. For example, *Denops albofasciatus* hunts various Bostrichidae (auger beetles), *Tillus elongatus* hunts bark beetles of the genus *Ptilinus*, *Aporthopleura sanguinicollis* hunts larvae of *Lymexylon navale*, and *Tarsostenus univittatus* is a predator of Bostrichidae: *Lyctus*. Underbark and ligniperdous insects are consumed also by species of the genus *Opilio*. The species *Opilio domesticus* can be encountered in households, where it feeds on woodworm beetles and larvae. It also burrows its own galleries in the wood.

Thanasimus formicarius (ant beetle) is a very abundant species, its larvae and adults primarily hunting bark beetles. The larvae penetrate the bark beetle galleries and feed on larvae, pupae and juvenile imagos. The much sparser but very similar species *T. femoralis* has the same lifestyle, and it is tied rather to pine stands (the two species can be distinguished according to leg coloration: *T. formicarius* has black legs, *T. femoralis* red).

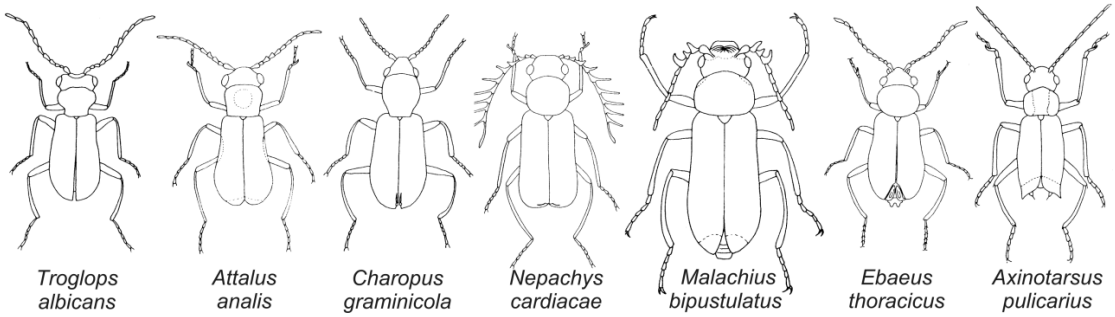
Larvae of the species *Trichodes* eat larvae, pupae, and old and sick imagos of the European honeybee and of solitary bees.

Species of the genus *Necrobia* occur on cadavers, where the imagos and larvae hunt also larvae of Diptera.



Family: **MELYRIDAE** (soft-wing flower beetles)

There are 45 species in the Czech Republic. The beetles have soft elytra and serrate, filiform or pectinate antennae. Malachiinae have eversible, frequently red-coloured vesicles on prothorax and abdomen with presently unknown function. Males of most beetles have secretory organs the secretions of which stimulate mating, as females actively lick them. Larvae are predatory and live under bark (*Malachius*), in wood, in stems, or in hives of solitary bees (*Ebaeus flavicornis*). Adults live on blossoms, where they are predators or consume pollen.



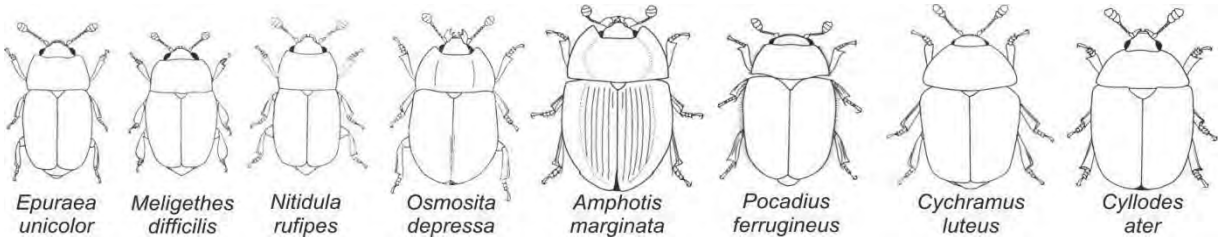
Superfamily: *CUCUJOIDEA*

An extensive superfamily containing 22 families in the Czech Republic.

Family: **NITIDULIDAE** (sap beetles)

There are 135 species in the Czech Republic, most of which are small, shiny species (1.1–7 mm). Imagos and larvae of many species feed on parts of blossoms (*Meligethes*), while other species occur on outflowing sap (certain *Epuraea*). *Amphotis marginata* is a myrmecophilous species, and many species feed on fungi (*Cyllodes* [frequently oyster mushrooms], *Cychramus* [frequently in honey fungus]). Sometimes they are predators of scale insects or bark beetles (occasionally certain *Epuraea*, obligatorily *Pityophagus ferrugineus*), and certain species develop on cadavers (*Nitidula*, *Omosita*).

More than half of the representatives belong to the extensive genera *Epuraea* and *Meligethes*. The genus *Meligethes* in particular contains a complex of very similar species, discernible mainly according to the serration of their fore tibiae.

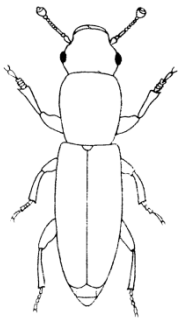


Family: **MONOTOMIDAE** (root-eating beetles)

There are 22 species in the Czech Republic. This is a family with an elongated and very uniform body shape and capitate antennae.

These are small species up to 2.3–5.5 mm long. Representatives of the genus *Monotoma* live in piles of plant remains. Representatives of the genus *Rhizophagus* occur under the bark of deciduous and coniferous trees, frequently in galleries of insects living under bark, and especially those of various bark beetles, where they feed mostly on mycelium of fungi and occasionally prey on the bark beetles.

However, *Rhizophagus grandis* can be an effective regulator of the bark beetle *Dendroctonus micans*. Also interesting is the abundant occurrence of *Rhizophagus parallelicollis* in cemeteries, where it is found on graves and coffins.

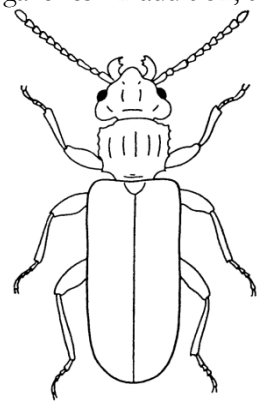


Rhizophagus dispar

Family: **CUCUJIDAE** (flat bark beetles)

There are 4 species in 2 genera in the Czech Republic. The body is strongly flattened, dark red or brown. Size is 3.5–17 mm. Elytra are decorated with soft ridge-like ribs.

They live mostly under bark, where they prey on other insects (adults of *Cucujus* are sapro-xylophages), frequently in the prey's own galleries. In addition, they probably also consume faeces there.

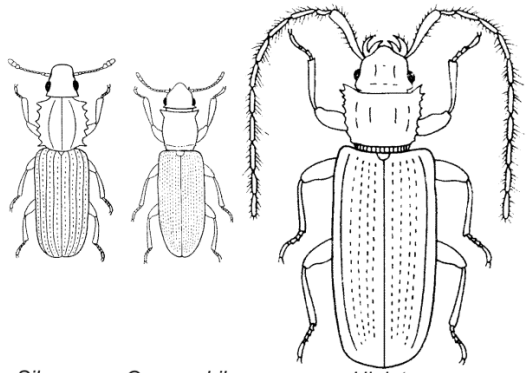


Cucujus cinnaberinus

Family: **SILVANIDAE**

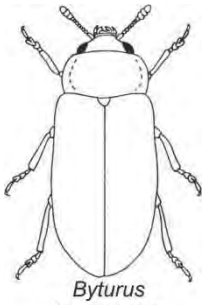
There are only 10 species in the Czech Republic. The body is mostly flat. Most species are probably at least occasionally carnivorous. Certain species can prey on bark beetles (*Silvanus bidentatus*, *S. unidentatus*, *Uleiota planata*).

Some of these species are also considered warehouse pests. It has been proven, however, that the cosmopolitan *Oryzaephilus surinamensis*, for example, actually preys on other warehouse pests (e.g. larvae of Bruchidae, Anobiidae) and consumes both their faeces and the moulted skins of the larvae.



Silvanus unidentatus *Oryzaephilus surinamensis* *Uleiota planata*

Family: **BYTURIDAE** (fruitworms)


Byturus tomentosus

There are only 2 species in the Czech Republic, with body size of 3.2–4.6 mm. Larvae are elongated, almost cylindrical, with pigmented plates on tergites and horn-like urogomphi on the 9th abdominal segment. The adults of the species *Byturus tomentosus* consume pollen of various plants (mainly raspberries and blackberries). Larvae develop on maturing fruits of raspberries and blackberries and cause worminess.

The second species, *Byturus ochraceus*, develops on wood avens (*Geum urbanum*).

Family: **COCCINELLIDAE** (ladybird beetles)

There are 85 species of small to medium size (1.5–9 mm) in the Czech Republic. The body is round to egg-shaped, mostly shiny and colourful (e.g. *Coccinella*), or hairy and of one or two dark colours (the extensive genus *Scymnus*).

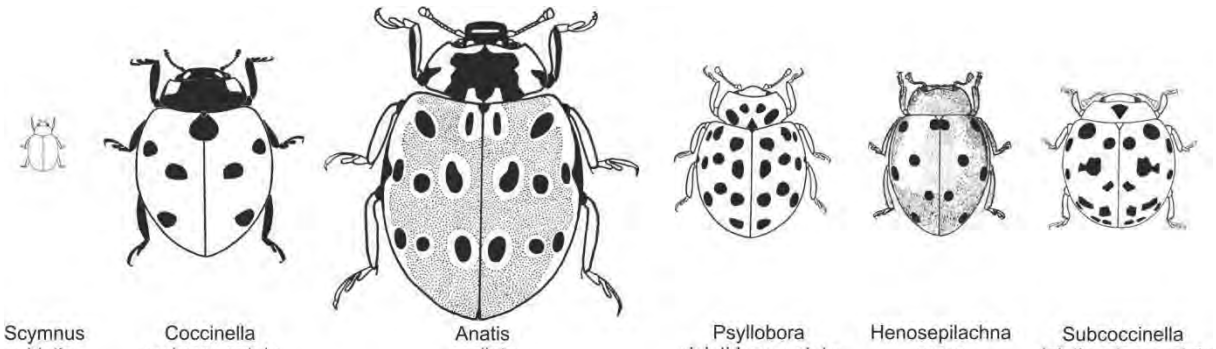
Larvae are mobile (campodeoid type), rarely egg-shaped; their skin is strongly pigmented and colourful, covered with humps, ciliate protrusions, or branching thorns. They pupate most frequently on vegetation. The pupa is obtect, in the end covered with the last larval exuviae. Most ladybird beetles have 1 generation per year and overwinter as imagos.

With minor exceptions, the larvae and imagos are predatory. The overwhelming majority of species feed on aphids, psylloidea, whiteflies, and scale insects. The locally largest species, *Anatis ocellata*, consumes young instars of caterpillars.

Only Epilachninae (just 3 species in the Czech Republic: *Henosepilachna argus*, *H. chrysomelina*, and *Subcoccinella vigintiquatuorpunctata*) are phytophagous and can also damage agricultural or horticultural plants. Psylloborini of the subfamily Coccinellinae are mycophagous and feed on powdery mildew (*Erysiphales*) and moulds (*Phycomycetes*).

The importance of ladybird beetles as natural enemies of aphids is considerable. For example, one larva of *Coccinella septempunctata* (seven-spot ladybird) can kill 600 aphids during its development, and the imago is also predatory.

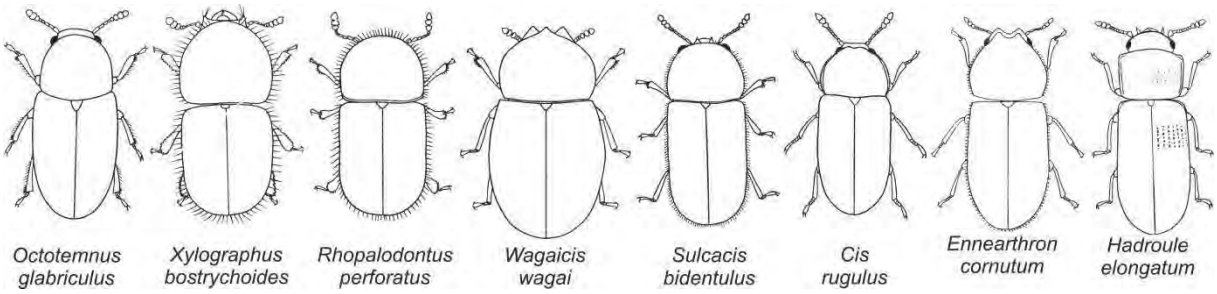
When disturbed, most species secrete a yellow liquid containing poisonous alkaloids from a membrane between the femur and tibia.



Superfamily: *TENEBRIONOIDEA*

Family: **CIIDAE**

There are 42 species in the Czech Republic, 1.2–4.0 mm long. All species are similar in appearance to small bark beetles. They are mostly connected to fruiting bodies of fungi, and especially bracket fungi, which they may repeatedly attack until they are entirely consumed.



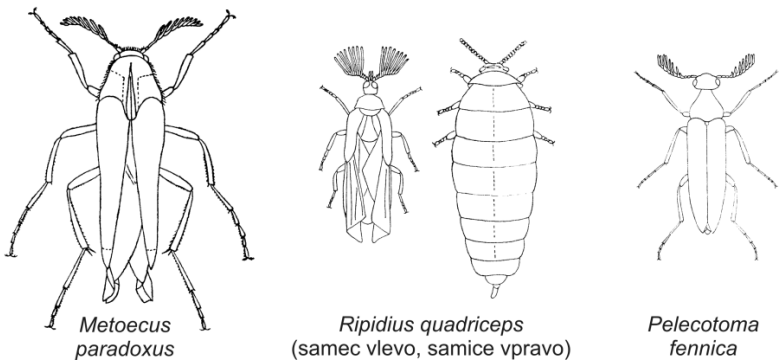
Family: **RIPIPHORIDAE** (wedge-shaped beetles)

A smallish family with approximately 400 species described, there are 3 species in the Czech Republic. Mouth parts can be atrophied, elytra frequently spread. In certain species, sexual dimorphism is very significant (females are larva-like and without wings). This family is more interesting rather than important, its representatives being parasites on other insects. During their post-embryonic development, various morphologically different types of larvae occur, and therefore their development is polymetabolous.

Metoecus paradoxus parasitizes wasps living socially in the ground. The female lays eggs into decayed wood in autumn. Eggs overwinter and in spring a larva of the 1st instar hatches. It is similar to a triungulin, but instead of having claws it is equipped with attaching pads it uses to cling to the body of a wasp collecting material for the construction of a hive and which carries it into the hive. There, it burrows into the body of the host's larva, then moults into a maggot instar, and after the chamber is closed in the wasp comb it climbs to the host's surface. It consumes its host from the outside, and finally the 6th instar pupates in the empty cell. The imago hatches in autumn and leaves the hive. The imago dies shortly after fertilization and laying of eggs.

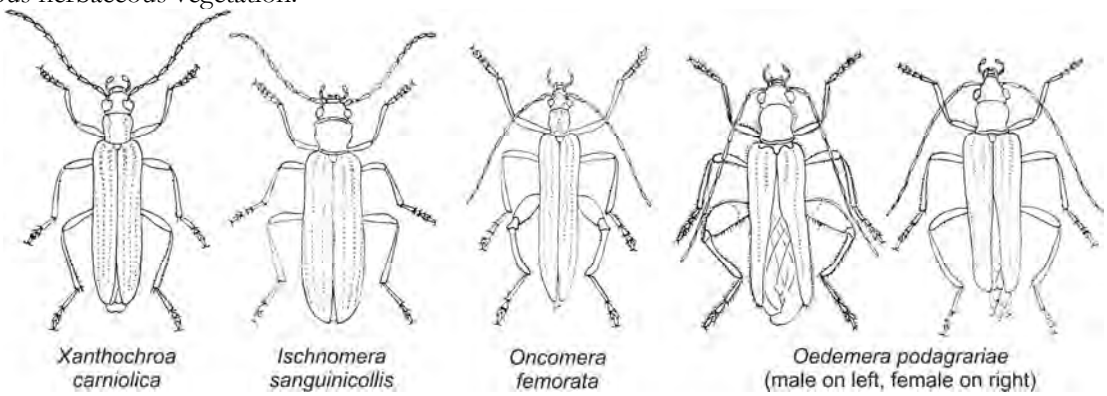
Ripidius quadriceps parasitizes cockroaches (Blattodea). The triungulate larva actively seeks its host (cockroach larvae of the genus *Ectobius*) and enters inside it. After multiple moultings it leaves the larva and pupates in the soil.

Pelecotoma fennica parasitizes woodworms of the genus *Ptilinus*. The first larval instar is not triungulate, as eggs are laid directly on trunks attacked by woodworms. The larva of the first instar seeks the host larva, invades it, then overwinters inside. In spring, it increases its volume and leaves the host. The following 4 instars live as ectoparasitoids. The final, fifth instar creates a gallery ending beneath the surface of the infested wood and there it pupates. The hatched imago crawls out.



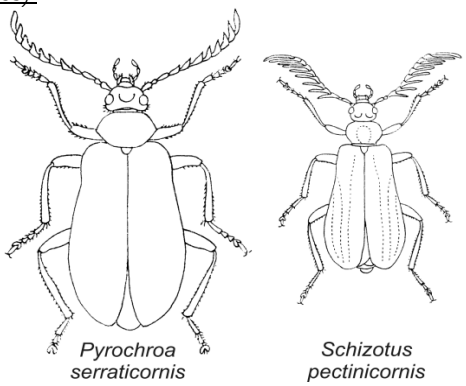
Family: **OEDEMERIDAE** (false blister beetles)

There are 26 species in the Czech Republic. Males have markedly thickened femora, but they do not jump. Adults live especially on flowers of herbaceous vegetation, bushes, and trees where they feed on pollen. Several species live on old wood. Larvae develop in rotting wood or inside dead stems and roots of various herbaceous vegetation.



Family: **PYROCHROIDAE** (fire-coloured beetles)

Only 3 species occur in the Czech Republic. Adults (8–18 mm) are marked by their bright red colour, sometimes with black head. They occur on herbaceous vegetation, leaves of bushes at the edges of glades, among other places. Up to 35 mm long larvae develop under the bark of especially deciduous trees. They are conspicuously yellow–brown, flat, rather strongly sclerotized, and the 9th movable segment carries a pair of straight or slightly bent urogomphi. Larvae are myco- and saprophagous with occasional carnivory (chiefly longhorn beetles).



Family: **MELOIDAE** (blister beetles)

With about 25 species in the Czech Republic, these are lightly sclerotized, frequently large and metallic-coloured beetles. True blister beetles have much-shortened elytra and also shortened and non-functioning wings. Imagos are generally herbivorous. When disturbed, the pores on the joints of the legs secrete hemolymph containing the alkaloid cantharidin.

Females lay large numbers of eggs (from 2,000 to 10,000, depending upon the species), depositing them on top of or shallowly into the soil. Postembryonic development is connected by a parasitic way of life with a complicated metamorphosis known as hypermetaboly.

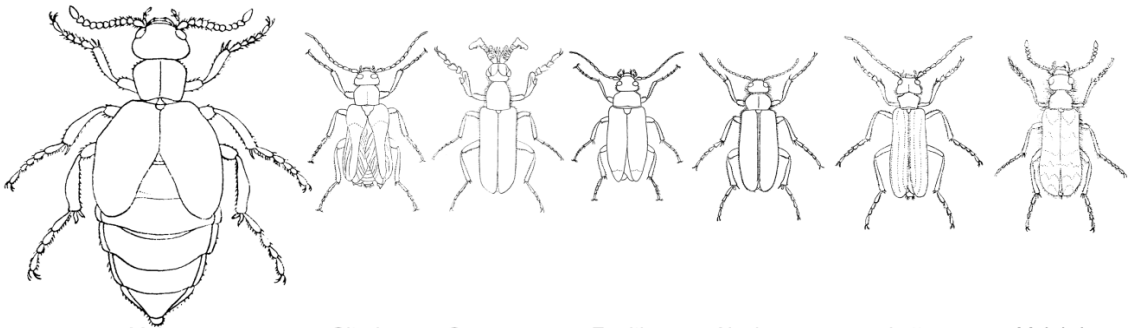
The first very mobile campodeoid instar – triungulin – is characterized by the terminal ends of the tarsal segments that carry also two strongly developed cilia in addition to the claw, so they appear as if ending in three claws. This so-called invasive larva must invade a hive of solitary bees, wasps from the family Sphecidae, or oothecae of grasshoppers, either actively (genus *Lytta*) or by waiting (especially on blossoms) and catching onto the ciliation of a host insect to be thereby transported into the hive of the host, which are bees of the genera *Anthophora* and *Andrena* (*Meloe*, *Cerocoma*).

Two to three more instars follow, mostly grublike (scarabaeoid type) (sometimes the first can also be caraboid, where the stemmata are still conserved, but mostly this form of larvae is not existent). In this form the larva leaves the host and transforms into the so-called pseudo-pupa (coarctate instar), which is an instar that remains within the skin of the previous larval instar, is immobile, does not ingest food and

overwinters. In the spring it transforms into the final (6th) instar. It is again mobile, with short limbs, but it again does not ingest food and pupates afterwards. The pupa is non-biting and free. Adults are phytophagous and frequently found on blossoms or on other parts of plants.

Triungula in the species of the genera *Epicauta* and *Mylabris* invade the egg covers of grasshoppers and feed on the host's eggs; the species of the genus *Cerocoma* consume the supplies of paralysed juvenile grasshoppers and crickets prepared as food for larvae of *Tachytes* and *Tachysphex* wasps. *Sitaris muralis* parasitizes large solitary bees of the order *Anthophora*. The genus *Meloe* parasitizes various species of bees.

Local feeding of the imagos of the Spanish fly (*Lytta vesicatoria*) on ash trees can have certain importance for forestry.



Family: **TENEBRIONIDAE** (darkling beetles)

There are approximately 60 species in the Czech Republic in the narrower meaning of this family (not counting Lagridae and Alleculidae, which currently are also included into this family). They are morphologically a very diverse family with body size of 1.3–31 mm. At the end of the abdomen, there are glands secreting a foul-smelling secretion with repulsive function.

Most species inhabit arid steppes and deserts, but they also inhabit decaying wood and tree fungi, living under dead bark of deciduous and coniferous trees, under straw but also in the nests of mammals and birds. Larvae and adults feed on dry and decomposing plant materials or fungi.

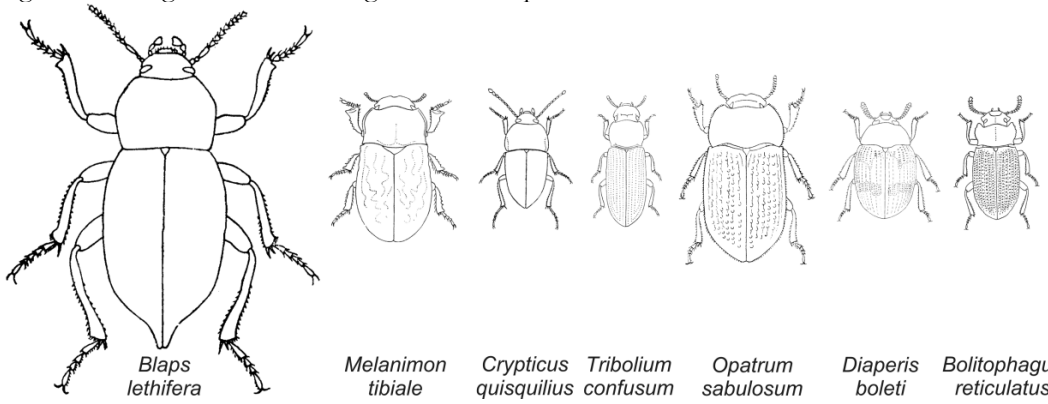
Certain species are synanthropic and can cause serious damage to stored foodstuffs. Representatives of the genus *Tribolium* cause damage in older stocks of food including various spices. *Tenebrio molitor* (mealworm) damages stored flour.

Of mycophagous species, *Bolitophagus reticulates* is common, living in bracket fungi *Fomes fomentarius* (tinder fungus), and *Diaperis boleti* on bracket fungi *Polyporus squamosus* (Dryad's saddle), *Piptoporus betulinus* (birch polypore) and *Laetiporus sulphureus* (sulphur polypore).

Species of the genus *Corticeus* live in galleries of various species of bark beetles and other ligniperdous insects. Although described as their predators, they probably live on detritus and mycelia inside their galleries.

Among the largest representatives in the Czech Republic is the synanthropic *Blaps mortisaga*, which feeds on decaying plant remains (the end of the elytra of the representatives of the *Blaps* genus terminate in a nail-like protrusion).

The darkling beetle *Opatrum sabulosum* can chew on pines buds and shoots, but it is a wide-ranging polyphage and damages a number of agricultural crops.



Superfamily: *CHRYSOMELOIDEA*

A superfamily with 4 families, all four of which are represented also in the Czech Republic.

Family: **CERAMBYCIDAE** (longhorn beetles)

There are about 190 species in the Czech Republic. The family includes small and large species. For example, *Tetrops praeusta* measures just 3–4 mm, while *Ergates faber* reaches up to 60 mm, tanner beetle (*Prionus coriarius*) up to 45 mm, and great Capricorn beetle (*Cerambyx cerdo*) up to 53 mm. Elsewhere, the titan beetle *Titanus giganteus*, has body length exceeding 16 cm and is the largest beetle of the world.

All species of longhorn beetles are phytophagous and an overwhelming majority is connected to woody plants (coniferous and deciduous), where they develop mainly under the bark in the bast fibre (exceptionally also in the bark itself) or in galleries continuing to various depths into the wood, and in some cases at the end of their development the larvae reach the surface layer of the wood in order to pupate (a vast number of the longhorn beetles). Only a small percentage develops in stalks and stems of herbaceous vegetation. In exceptional cases, the larvae live freely in the ground consuming roots (the genus *Dorcadion*). Depending on the species, development takes place in fresh, live material (and thus there may be physiological damage), in dead wood with various degrees of moisture (in this case, species invading the wood can cause technical damage to the wood), or in various stages of infestation of the wood by fungi. Of course, technical damage of wood also occurs often with species causing primarily physiological damage of wood in direct connection with invading the wood for pupation. However, the overwhelming majority of species develop in decaying or dead materials, frequently already partially damaged. Species capable of development in dried wood already incorporated in structures have considerable importance.

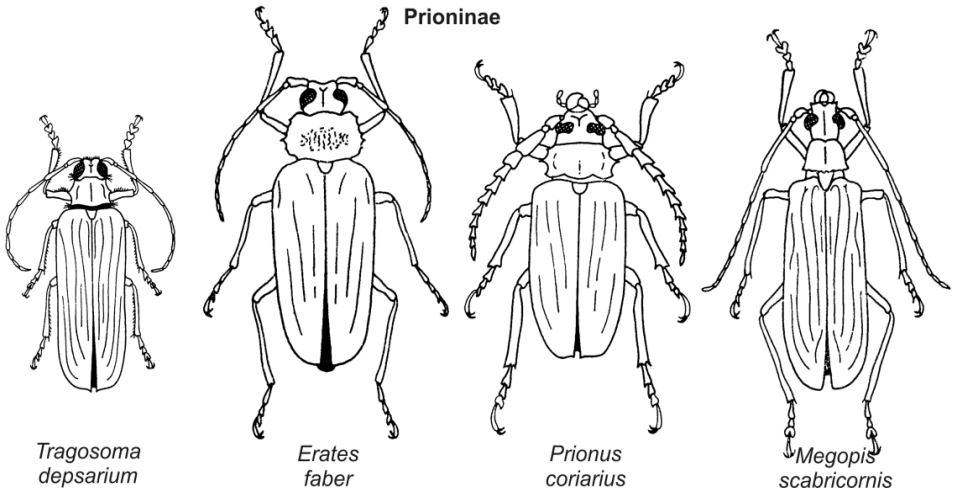
Adults typically have an elongated body and most have long antennae with 11 segments, strongly developed mandibles, and tarsi with 4 segments. Adults of many species visit blossoms where they feed on pollen and nectar or even chew on the blossoms, leaves and bark of young shoots. They are also frequently found on running sap. Adults of some species do not ingest food at all. Adults frequently stridulate (produce creaking sounds by rubbing the pronotum against the base of the elytra). They exhibit both daytime and night-time activity.

Larvae are generally similar in all species – whitish and cylindrical (species living inside stems of herbs and in wood) or flattened (living under the bark) with short thoracic legs or with none. The cranium is usually well sclerotized.

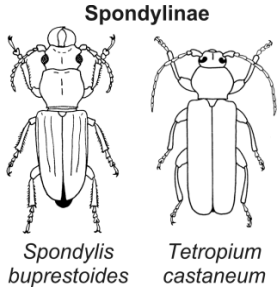
The pupa is typical for beetles – pupa exarata libera. The development of longhorn beetles most frequently lasts for 1–2 years. In certain species it depends considerably on the moisture of the wood in which they develop, and in extreme cases development can thus extend to over 10 years (e.g. *Hylotrupes bajulus*).

Representatives of 6 subfamilies occur in the Czech Republic.

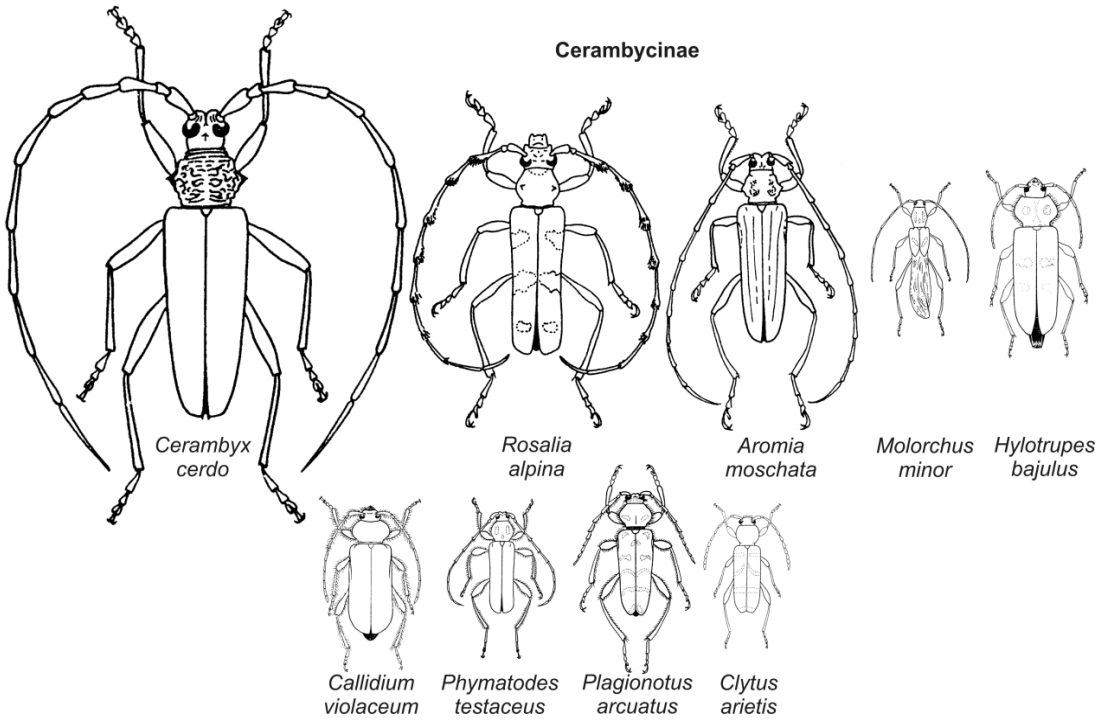
Prioninae (prionids) – only 4 species in the Czech Republic. They are the largest local species of longhorn beetles, tied to wood already damaged by fungi with increased moisture. *Ergates faber* is associated predominantly with pines at lower elevations, *Megopis scabricornis* develops in various woody plants (mainly poplars) and is tied to alluvial areas, and *Tragosoma depsarium* is one of the rarest local longhorn beetles tied to pines in mountain elevations (the species is dying out; suitable conservation management consisting in planting of pines within the area of occurrence is necessary; at present, found only rarely in the Bohemian Forest and in Nové Hrady Mountains). The most common species in the Czech Republic is *Prionus coriarius*, which develops in dead wood of the roots of various trees.



Spondylinae – 10 species in the Czech Republic. Species develop under the bark or in the bark of various, primarily coniferous trees. They include the significant forest pests *Tetropium castanum* (on spruce), *T. gabrieli* (on larch), *T. fuscum* (on spruce), and *Spondylis buprestoides* (on pine).

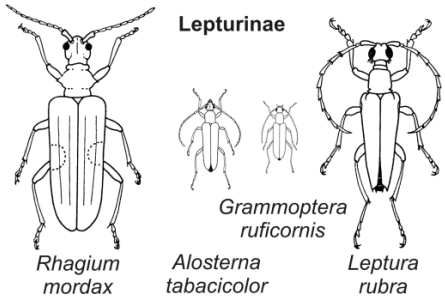


Cerambycinae – an extensive subfamily containing 62 species in the Czech Republic. All species develop in the wood of living trees and bushes through various degrees of wilting to entirely dry and even technically processed wood. This group includes, for example, *Cerambyx cerdo*, which causes significant damage to oaks in southern Europe. It is rare in Czech conditions and is tied to the remains of original stands of alluvial forests; this species warrants protection. *C. scopolii* is the second representative of this genus in the Czech Republic; it is abundant and develops in various deciduous trees and is markedly smaller than *C. cerdo*. *Rosalia alpina* is tied especially to original beech stands and is practically extinct in the Czech Republic due to forestry management. *Aromia moschata* is a conspicuously large and green species connected with goat willow (emits aromatic substances with a pleasant scent). *Molorchus minor* develops especially on spruce of weaker dimensions and has conspicuously shortened elytra. *Hylotrupes bajulus* is a very significant pest of processed wood, able to entirely destroy constructions made of pine wood. It may also develop on other conifers and is able to develop in wood entirely stripped of bark and with very low moisture level. Similar to the previous species, *Callidium violaceum* causes significant damage to processed wood, but remains of bark are necessary for invasion. It attacks diverse coniferous woody plants. *Phymatodes testaceus* attacks assorted hard broadleaves with bark and is a significant technical pest even of structural wood. *Plagionotus arcuatus* and *P. detritus* are similarly pigmented to wasps and develop on oak. *P. arcuatus* is an important technical pest, as it burrows pupal chambers up to 8 cm deep. *P. detritus* has a similar impact, but it is considerably rarer. Representatives of the genus *Clytus* are also similar to wasps in their colouring.

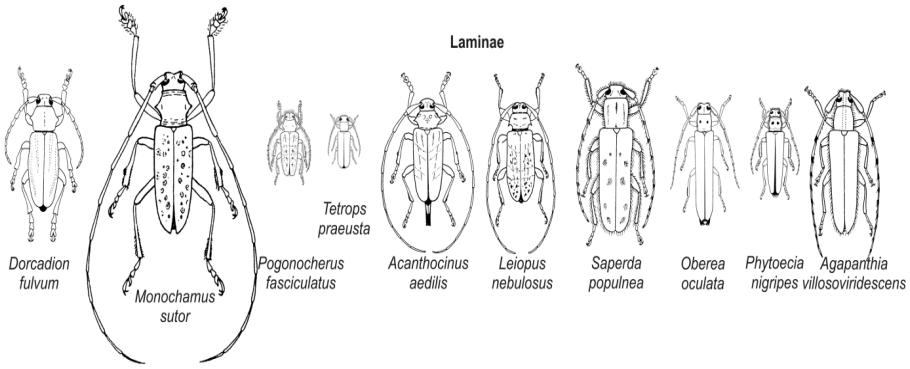


Necydalinae – there are only two rare species in the Czech Republic with strongly shortened elytra, both developing on various deciduous woody plants. *Necydalis ulmi* is connected with the most original stands with sufficient number of old trees. It is an almost extinct species requiring protection especially in the form of suitable forestry management.

Lepturinae – an extensive group including about 60 species in the Czech Republic, developing under the bark of various deciduous and coniferous trees in various stages of wilting, and exceptionally also on herbaceous plants (*Brachyta interrogationis* in the roots of wood cranesbill [*Geranium silvaticum*]). This subfamily includes the very small and locally most abundant longhorn beetles of the genera *Grammoptera* and *Alosterna* and the prominent longhorn beetles of the genus *Rhagium*, distinguished for padding their pupal chambers with rough splinters. *Corymbia rubra* is another conspicuous species. It is common in coniferous forests and develops in strong wood with sufficient humidity (tree stumps, root bases, and the like). It is visibly striking rather than harmful.



Laminae – 71 species in the Czech Republic, with strongly orthognathous to hypognathous heads. A number of species occur on coniferous and deciduous woody plants, and development on herbaceous plants is also common. Species of the genus *Dorcadion* are non-endophytic and consume roots of grasses in the soil. Important species developing on conifers include large Laminae of the genus *Monochamus* (spruce, pine) and *Acanthosinus aedilis* (pine). Species developing on broadleaves frequently live in living trees (e.g. *Compsidia [=Saperda] populnea* [aspen], *Anaerea [=Saperda] carcharias* [aspen]) or under the bark of wilting wood (*Saperda octopunctata* [linden], *S. punctata* [elm], *Exocentrus*). A very abundant polyphagous species on broadleaves is *Leiopus nebulosus*. Species of the genera *Oberea*, *Phytoecia*, *Calamobius*, *Theophilea*, and *Agapanthia* develop in stems of various grasses and herbs.



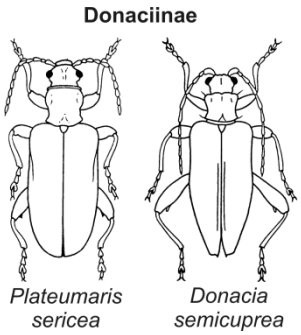
Family: **CHRYSOMELIDAE** (leaf beetles)

An extensive family with over 400 species in the Czech Republic, classified into 13 subfamilies. With certain exceptions (switch to secondary animal saprophagy in certain Clytrinae), all species are phytophagous in the larval and imaginal stages, in most cases with a strong connection to the host plant. Host plants are primarily herbaceous, and less frequently woody.

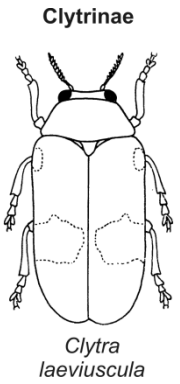
Imagos are of smaller sizes, morphologically quite varied in shape, and frequently brightly coloured. Larvae are morphologically quite different among the individual subfamilies. Larvae mostly ectophageously consume assimilative organs or are burrowers.

Leaf beetles most frequently have one-year generations, though certain species have up to 3 generations per year while others may have 4-year generations. Imagos overwinter most frequently; larvae and other stages less frequently.

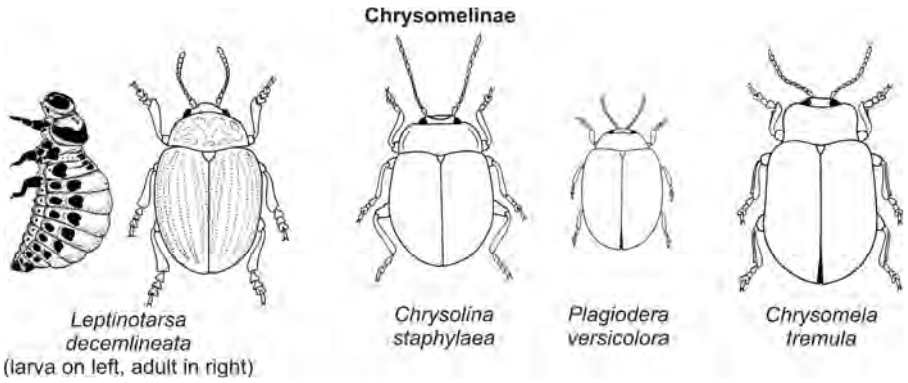
Donaciinae – more bionomically interesting than of real importance, this group of leaf beetles is morphologically similar to longhorn beetles (Cerambycidae). They lay eggs underwater on plants (especially reed, but also water lilies and pond lilies) and the larvae live on submerged plant parts. Respiration is very specific – larvae pierce the parenchyma with special strongly sclerotized thorns at the end of the abdomen and suck out oxygen using the last pair of spiracles. Pupation also takes place underwater on plants, in a cocoon filled with air. The imago is developed already in autumn, but it overwinters in a cocoon. The most abundant genera in the Czech Republic are *Plateumaris* and *Donacia*.



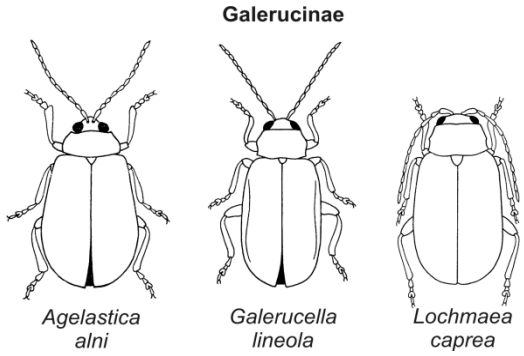
Clytrinae – *Clytra quadripunctata* is biologically interesting. Imagos are found in the vicinity of anthills of the genus *Formica*. Eggs are fitted with a cover of faeces and secretion. The 2-mm egg shell falls or is laid directly on the surface (or in the vicinity of) an anthill and the ants will transport it into the ant colony. The larva continues to build on its shell from its own faeces and develops for 2–4 years inside the anthill, feeding on organic refuse of animal origin and occasionally on ant eggs. It also pupates in the shell. Similar development is also apparent in other species of this subfamily.



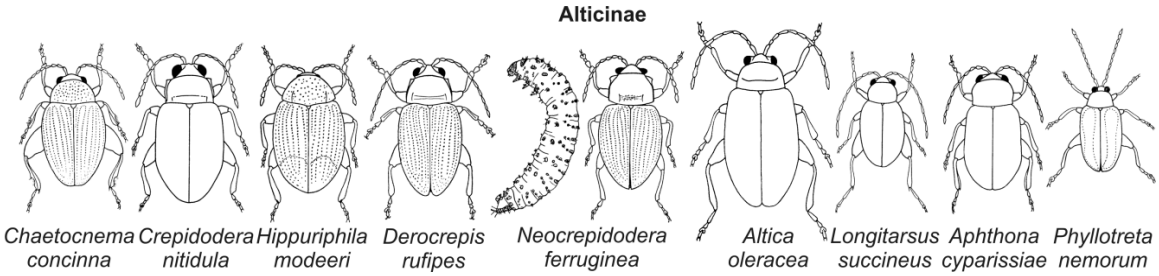
Chrysomelinae – the most common type of leaf beetles. Species are frequently brightly coloured. Larvae have a paunchy abdomen, almost hairless, most frequently living freely on the surface of plants, and pupating on plants or on the ground. This group includes, for example, the Colorado potato beetle (*Leptinotarsa decemlineata*), which damages potatoes. The most prominent species with the greatest importance to forestry include those of the genera *Plagiodera*, *Melasoma populi*, *M. tremulae*, *M. saliceti*, *Chrysomela vigintipunctata*, *Gonioctena* and *Phratora*, developing on willows and poplars.



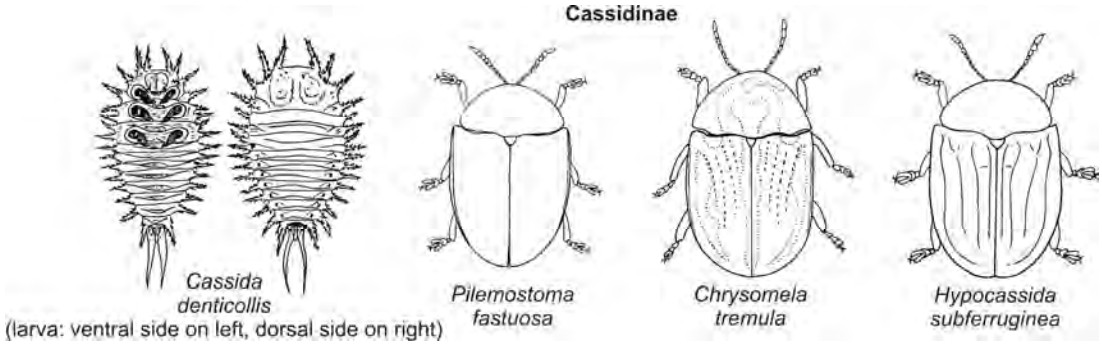
Galerucinae – larvae are eruciform, usually strongly pigmented, with tubercules bearing bundles of hairs. Pupation most frequently occurs in the ground. This subfamily includes, for example, leaf beetles of the genera *Galerucella* and *Lochmaea* (developing on willows, poplars, and alders) and *Agelastica alni* (on alder).



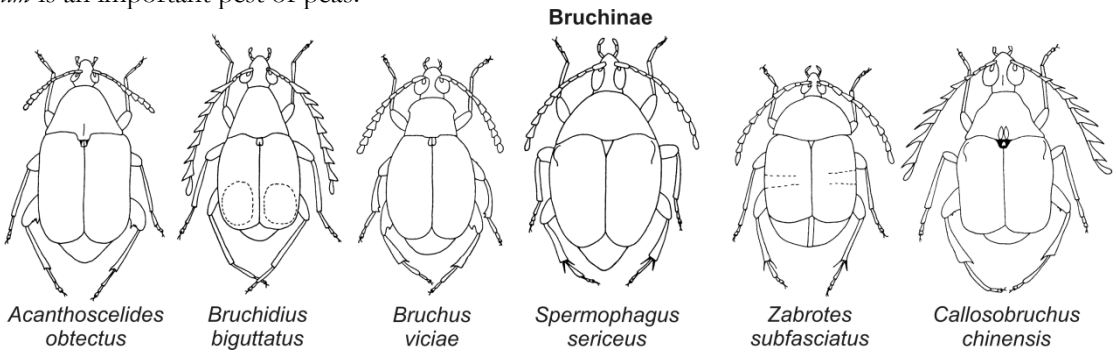
Alticinae (flea beetles) – an extensive group of jumping leaf beetles, mostly with well-developed hind saltatorial legs. Larvae are also eruciform, somewhat sclerotized (with the exception of strong sclerotization of the head, prothorax, 9th abdominal segment, and dispersed small sclerites). They develop freely in the ground on roots or burrow in leaves and stems. They pupate in the ground. This subfamily includes, for example, the genera *Altica* and *Crepidodera* (willows, poplars). The genus *Phyllotreta* frequently causes significant damage to cruciferous plants in agriculture.



Cassidinae (tortoise beetles) – strongly flattened leaf beetles living on herbaceous plants and trees. Larvae are also very flattened and equipped with protruding prickles. The moulted skins of previous instars remain at the ends of the body. Pupation takes place on the underside of leaves; the pupa is obtect. In the Czech Republic, the group is only represented by the genus *Cassida*.



Bruchinae (been weevils) – small oval beetles (2–5 mm); filiform antennae with 11 segments, in males slightly serrate. Scutum is bell-shaped, strongly narrowed at the front. Larvae are apod, white with a brownish head, similar to larvae of true weevils. Beetles occur on blossoms of various legumes; larvae develop in the seeds. *Bruchidius ater* develops in the seeds of *Robinia pseudoacacia* (Black Locust), and *Bruchus pisorum* is an important pest of peas.

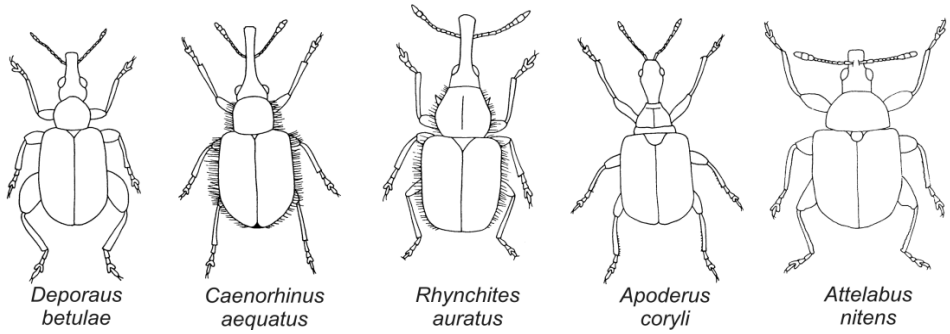


Superfamily: *CURCULIONOIDEA*

Family: **ATTELABIDAE** (leaf-rolling weevils)

There are over 30 species in the Czech Republic. Species range in size between 2 and 9.5 mm and are frequently metallic green, purple and blue-coloured, and frequently also red-black to black. As in Curculionidae (true weevils), the head is elongated into a rostrum, on the sides of which are located, in contrast with true weevils, straight (non-geniculate) antennae (with 11–12 segments). Larvae are short, wide and strongly arched, with no thoracic legs. Development most frequently occurs in stems, leaf rolls, shoots, buds, blossoms and fruits. A number of species cause damage in agriculture and forestry, but the damage is minimal.

Rhynchites bacchus develops in the young fruits of cherries, blackthorns, plums and apples, while *Caenorhinus aequatus* attacks small fruits of apples, plums, apricots, peaches and cherries. *Caenorhinus interpunctatus* develops in the petioles and middle veins of leaves of fruit trees and strawberries, and *Rhynchites caeruleus* develops in the petioles of pear and apple trees. Rolls of leaves on broadleaves are created by the polyphagous *Byctiscus betulae*, on aspen by *Byctiscus populi*, on birch and hornbeam by *Deporaus betulae*, on oak by *Attelabus nitens* and on hazel by *Apoderus coryli*.



Family: **CURCULIONIDAE** (true weevils)

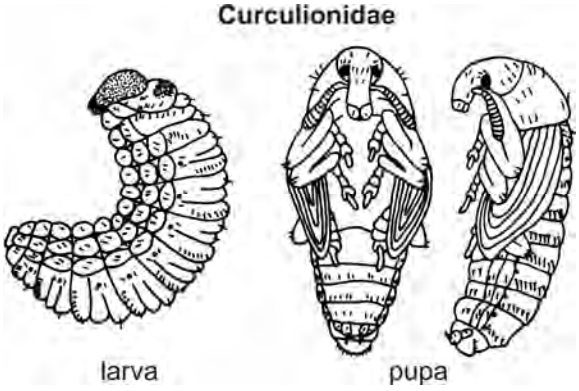
There are over 1,000 species in the Czech Republic. This family is characterized by a well-developed rostrum of various lengths and usually geniculate capitate antennae. Strong sclerotization of the overwhelming majority of species is also characteristic.

Body shape varies from elongated oval to spherical. Dark pigmentation is dominant, and the elytra are frequently decorated by multi-coloured scales. Most species are small, with body sizes of 1.2–21 mm. The largest representative in Czech fauna is *Liparus glabrirostris*, measuring up to 21 mm (in mountain altitudes on the banks of streams).

All species are phytophagous and may develop freely in soil (consuming roots of plants). Most species live inside plant tissues (seeds, stems, roots, bulbs, cones) of trees and especially herbaceous plants. Some species burrow in leaves, others feed on bast fibre, and still others even on wood. Certain species live on the surface of plant tissues. In a number of species, close ties to the host plant have developed.

The lifespan of imagos often exceeds 1 year (among species important in forestry, *Hylobius*, *Pissodes*, *Otirrhynchus*, and others).

Eggs are laid into the ground, on plants, or inside them (into chewed-out holes). Similarly to bark beetles, there are 3–5 larval instars.



Larvae are always without true thoracic legs, usually non-pigmented and white (with the exception of the always well-developed and strongly pigmented head), and effectively in one of three shapes:

- C-shaped apod larvae in species developing in the soil or plant tissues (e.g. *Hylobius*, *Pissodes*, *Otiorhynchus*, and a number of others);
- apod, but straight larvae (similar to larvae of longhorn beetles) known in species burrowing in leaves (e.g. jumping weevils of the genus *Rhynchaenus*);
- elongated larvae somewhat similar to caterpillars in species living freely on the surface of plants – they have slight rudiments of thoracic legs and small pseudopodial appendages on the abdominal segments (e.g. the *Phytonomus* genus).

They pupate either in a pupal cradle in the soil or in plant tissues. Certain species develop by thelytoky parthenogenesis (e.g. the genus *Otiorhynchus*).

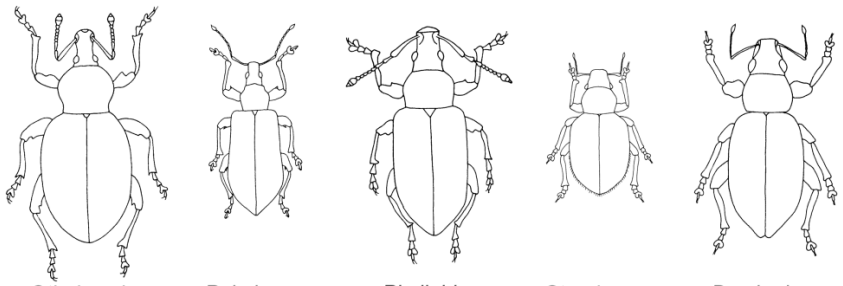
Generally 1-year generations, less frequently 2 years and more, and in certain species, on the other hand, even 2 generations per year.

Some species are also significant as forest pests. These undoubtedly include weevils of the genus *Pissodes* – dark-coloured species with elytra decorated with spots and bands of lightly-coloured scales. They develop under the bark on various conifers. Two species live on spruce (*Pissodes harzyniae* and *P. scabricollis*), four on pine (*P. piniphilus*, especially in stronger branches in the crowns of pines; *P. pini*, in the lower parts of the trunk; *P. notatus*, in the trunks of more mature seedlings; and *P. validirostris*, in pine cones), and one species on fir (*Pissodes piceae*). Imagos live and reproduce for 2–3 years. They lay eggs into holes gnawed into bark and the larvae chew more or less star-shaped, corrugated and gradually broadening galleries filled with boring dust and faeces. Larvae pupate at the ends of galleries in pupal cradles protruding to the surface of the sapwood and surrounded often by rougher splinters or by a larger mound of softer boring dust.

Weevils of the genus *Hylobius* cause damage especially through their feeding. There are 4 species in the Czech Republic, of which only *H. Abietis* is significant.

Beetles of the genus *Magdalis* develop in branches and twigs, in the bast, and inside the wood, and the imagos gnaw on the bark of that year's shoots. The most common species include *Magdalis violacea* and *M. nitida* (on spruce), *M. frontalis* (on pine), and *Magdalis armigera* (on elm).

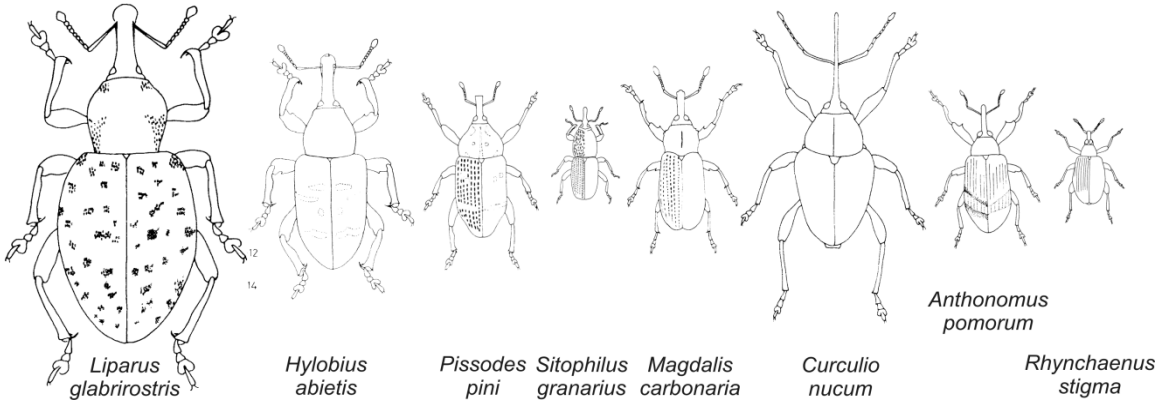
Larvae of the species *Brachyderes incanus* and of the genera *Otiorhynchus* (most frequently *O. niger*, *O. ovatus* and *O. sulcatus*), *Strophosomus* (*S. capitatus*, *S. melanographus*), *Phyllobius* and *Polydrosus* develop in the soil, gnawing on roots of various plants and thereby causing damage especially in tree nurseries and plantations. Adults cause damage by feeding on assimilative organs, soft bark, and shoots.



Among species causing direct damage inside the wood, *Cryptorhynchus lapathi* is known to damage poplars, willows (especially willow coppices) and alders.

Species of the genus *Anthonomus*, which develop in blossom buds, frequently cause damage in agriculture. Some species of the genus *Curculio* cause worminess in acorns.

Species of the genus *Sitophilus* are important pests of stored cereals, developing within their seeds.



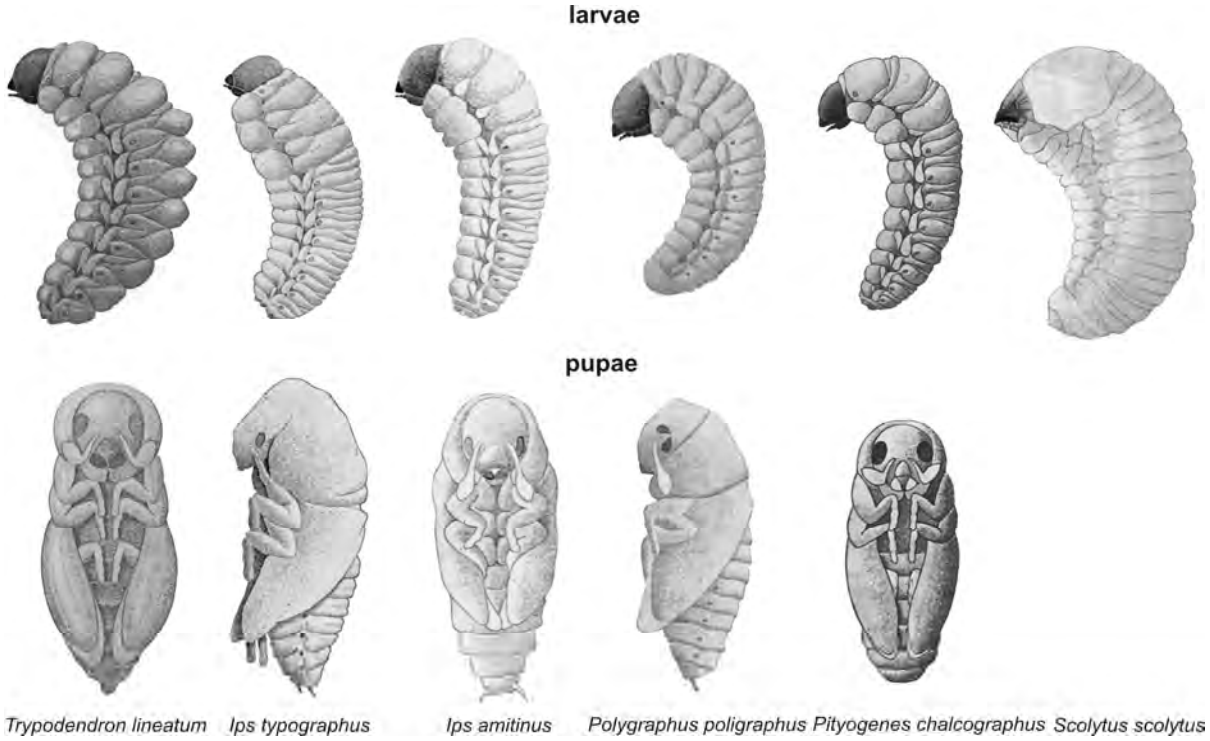
Family: **CURCULIONIDAE:** SCOLYTINAE (bark beetles)

There are over 100 species in the Czech Republic, and about 6,000 species are known throughout the world. In older works they are classified as a separate family.

Eggs are oval to ellipsoid, small and corresponding to the size of the female. In the first phases of embryonic development they are white, and later the shadow of the embryo appears on the surface.

Larvae are white (pinkish in *Hylurgops palliatus* and *Tomicus piniperda*), apod, with a well-developed, usually darker orthognathous head. They are slightly arched and generally similar to larvae of true weevils (Curculionidae). Short strong mandibles are attached to the head, as are 2-segmented maxillary and labial palps and short single-segmented antennae. The head bears numerous cilia, the number and placement of which is used to differentiate the various genera and species. The prothorax is the most developed of the body segments.

Pupa is the typical white beetle pupa exarata libera, with the limbs of the future imago being well visible. The scutum and especially the abdomen bear short cilia, and the top side of the abdomen features small hump-like protrusions. The ninth segment has a pair of strong hooks directed to the sides with which the pupa attaches to the walls of the pupal cradle.



Adults have a thin cylindrical, or in exceptional cases spherical, body. Body size of Czech species ranges from 1 mm (*Crypturgus pusillus*) to 8–9 mm (*Dendroctonus micans*). (Among the global fauna, the smallest is *Xylosandrus morigerus* from New Guinea [0.5 mm] and the largest are South-American species of the genus *Phloeoborus* [12 mm].) Coloration is usually dark brown, black-brown, or black-grey. The body surface may be shiny or matt and hairless, sparsely haired or covered with scales. Head is spherical, exceptionally elongated into a short snout (*Hylastes*, *Hylurgops*), and is mostly covered by the scutum. Antennae are short and geniculate. The flagellum has 2–7 segments, and the antennae terminate with a spherical to elliptical 1–4 segmented capitulum. Legs have 5-segmented tarsi and thickened femora and coxae. The abdomen is covered by the elytra, which are usually sloping at the end and often bearing species-specific structures (connected inter-grooves, depressions often in combination with variously shaped notches).

Membranous wings are folded under the elytra (only males of the genus *Xyleborus* have vestigial wings, and therefore remain for their entire lives in the maternal gallery).

Food – all species are phytophagous and, with certain exceptions, feed on bast fibres of the host species of woody plants or on symbiotic ambrosia fungi.

Among conifers, all native and many introduced species are hosts (introduced spruces, pines, cedars, but also species of the genus *Thuja* and cypresses). Among broadleaves, elms, oaks, beech, hornbeam, ash, lindens, poplars, willows, birches, fruit trees, hazel, alder, and even maple (as well as certain introduced species) are hosts.

Some species develop on undesirable plants or vines. For example, *Kissophagus hederae* on common ivy (*Hedera helix*), *Xylocleptes bispinus* on old man's beard (*Clematis vitalba*), and *Liparthrum bartschti* on common mistletoe (*Viscum album*).

Other groups develop in stems of herbaceous plants. For example, *Hylastinus obscurus* develops in stems of *Trifolium pratense*, *Ulex europaeus*, *Ononis natrix*, *Medicago* spp., *Sarothamnus scoparius*, and *Cytisus* spp. (in Western Europe it is a serious pest of clovers and alfalfa). *Phloeophthorus rhododactylus* is found on *Sarothamnus scoparius*, and *Thamnurgus varipes* in stems of wood spurge (*Euphorbia amygdaloides*).

Coccotrypes dactyliperda is often introduced to the Czech Republic along with dates, in the pits of which it develops. It therefore belongs to the group of granivorous species.

The group of mycophagous species also develop endophytically (especially in wood, where they burrow galleries the walls of which are covered by symbiotic fungi on which they feed). They are often, therefore, referred to as false xylophages. The species of the genus *Xyloterus* (=*Trypodendron*) feed on the fungus *Leptographium lundberbii* which requires high humidity, and thus recently dead material is targeted. The genus *Xyleborus* develops similarly, feeding on the fungus *Monilia candida*. Species of the genus *Lymantor*, on the other hand, develop in entirely dead branches of various deciduous woody plants, feeding on symbiotic fungi of the genera *Diaporthe* and *Massaria*.

The overwhelming majority of bark beetles therefore develop in woody plants (trees and bushes), and a smaller proportion in herbaceous plants. Only woody plants are attacked in the north, while in the Mediterranean region the number of species feeding on herbs and bushes increases. While Hylesininae develop on conifers, broadleaves and herbs, Scolytinae in the Czech Republic develop exclusively on broadleaves and Ipinae on conifers and broadleaves.

This family includes a number of species damaging forest stands. In Czech conditions, however, they are normally always secondary pests (attacking weak and dying plants, or those already excluded from competition). The only exceptions are species damaging agricultural crops (e.g. *Hylastinus obscurus*, which in Czech territory is practically of no importance). The primary pests are generally species developing on herbaceous plants. However, bark beetles do not pose a serious threat for all species of woody plants.

Bionomy of bark beetles is rather interesting, as care for offspring is considerably developed in all species. Adults seek a suitable species of host plant with optimal wilting stage (in exceptional cases, fully healthy plants) for founding a new generation and there they start constructing their galleries.

This entire process starts with **swarming**. It is a mass event, with spring swarming usually occurring in the afternoon and summer swarming most pronounced right around sunset. Beetles seek suitable plants (weakened, ailing, felled and not debarked or broken trees and bushes; in some cases, apparently healthy or fully healthy herbaceous plants). While in the first stage of invasion the bark beetles distinguish a spectrum of volatile substances (essences, alcohols and many other substances) secreted by the tree (so-called primary attractants), in the subsequent phase orientation according to so-called aggregation pheromones prevails (though many species do not use aggregation pheromones).

Reproduction occurs with fertilized eggs. Some species of bark beetles are monogamous (1 ♂ + 1 ♀), others polygamous (1 ♂ + multiple ♀♀), forming the basis of the following bionomy:

- In monogamous species, the female bores into the bark first, chewing out the start of the gallery with an extension at the beginning (nuptial chamber). The male then flies to the female and mates with her in the extended part of the corridor or at its edge (e.g. *Xyleborus*).
- In polygamous species, the male burrows into the bark first and constructs a spatial nuptial chamber. It then attracts the females with a pheromone, mating with them in the nuptial chamber (e.g. *Ips*, *Pityogenes*).

Males die shortly after copulation, while females live much longer due to the need to lay the eggs.

Gallery – from the nuptial chamber, the females then start constructing maternal corridors. The number of maternal corridors in the gallery is equal to the number of fertilized females.

A maternal corridor is created according to the following scheme:

1. The female extends the maternal corridor by chewing using its mandibles in a direction away from the nuptial chamber.
2. It gnaws an incision into the side wall, then retracts into the nuptial chamber where it pushes out the chippings (the male then pushes the chippings out of the gallery).
3. In the nuptial chamber, it turns around, backs into the maternal corridor to the end, and lays a fertilized egg into the gnawed incision.
4. It then runs head-first into the nuptial chamber, turns around, and again runs head-first runs to the end of the maternal corridor, which it again extends, gnaws an incision, and the entire process is repeated.

The eggs laid in the incisions of the maternal corridor start developing immediately, and the hatched larvae begin gnawing larval corridors. In this way, a species-specific gallery is formed.

In species living in wood, eggs are only deposited on the periphery of the corridor (genus *Xyleborus*) or into incisions (genus *Xyloterus*). In some cases the eggs are deposited in shallow incisions in groups (*Cryphalus* and *Dendroctonus*), and in others they are deposited in groups in various places within the maternal corridor (*Hylurgops glabratus*). Regularity and spacing, as with the orientation of the maternal corridor, are characteristic of the given species. Longer maternal corridors are equipped with respiratory openings (*Scolytus ratzeburgi* on birch).

Species developing in wood have no nuptial chambers. In this case, females are fertilized near the sinkhole (*Xyloterus*) or directly where they hatched (*Xyleborus*).

Types of galleries – galleries may be divided according to various criteria.

According to the position of the gallery:

- Galleries formed under the bark or in the top layer of the bast (most bark beetles).
- Galleries formed in the wood (with variations of ladder-like galleries, branched galleries in a single level, and branched galleries in multiple levels).

According to the number of maternal corridors (a):

- Simple galleries – with only a single maternal corridor.
- Complex galleries – with at least 2 maternal corridors (with variations of vertical, horizontal, clip-like, and forked galleries).

According to the number of maternal corridors (b):

- Single-branched galleries.
- Two-branched, three-branched, etc.

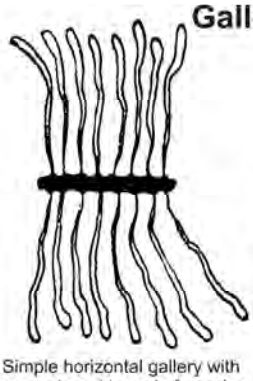
According to the direction of the course of maternal corridors:

- Vertical galleries – maternal corridors follow the main direction of the conductive tissues in the bast.
- Horizontal galleries – maternal corridors cut perpendicularly across the conductive tissues in the bast.

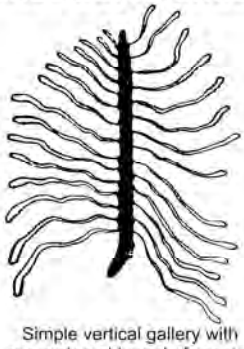
Other types of galleries:

- Star-shaped galleries – maternal corridors radiate outward from the nuptial chamber.
- Irregular galleries – occur in species where the female lays multiple eggs at a single place in the maternal corridor (with variations of areal, areal–branched, fascicled, etc.)

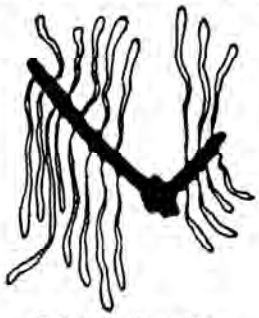
Galleries bored under bark in higher layer of phloem



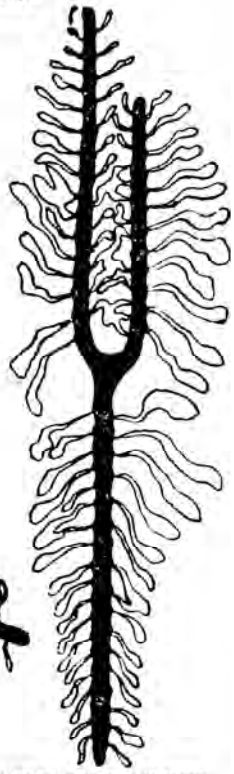
Simple horizontal gallery with one maternal tunnel of species *Scolytus intricatus*.



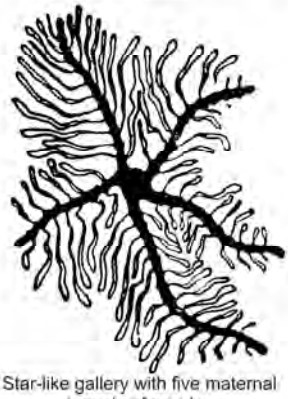
Simple vertical gallery with one maternal tunnel of species *Scolytus ratzeburgi*.



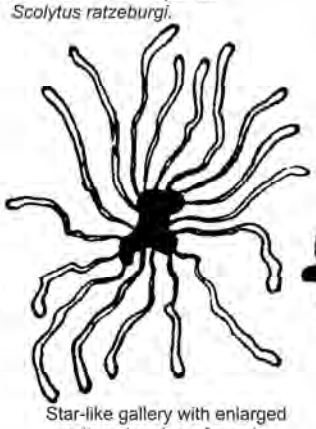
Fork-like gallery with two maternal tunnels of species *Phthorophloeus spinulosus*.



Vertical gallery with three maternal tunnels of species *Ips typographus*.

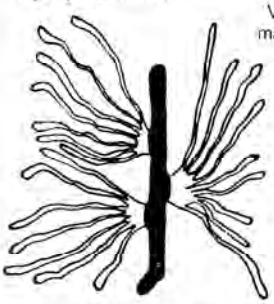


Star-like gallery with five maternal tunnels of species *Pityogenes quadridens*.



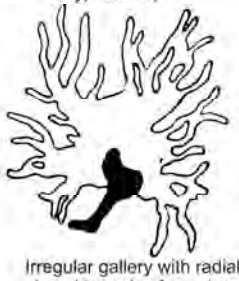
Star-like gallery with enlarged mating chamber of species *Cryphalus* sp.

Horizontal gallery with two maternal tunnels of species *Myelophilus minor*.



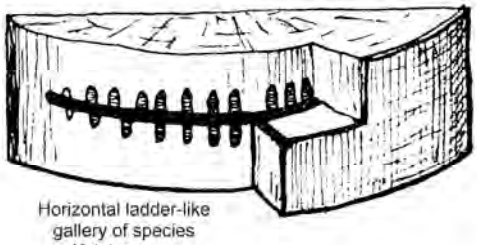
Irregular gallery with sheaf-like larval tunnels of species *Hylurgops glabratus*.

Irregular, communal, planar gallery of species *Dendroctonus micans*.

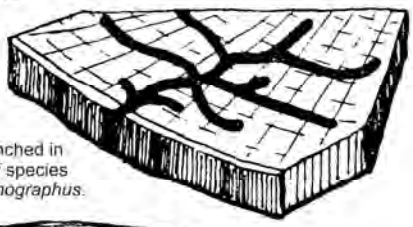


Irregular gallery with radial larval tunnels of species *Orthotomicus laricis*.

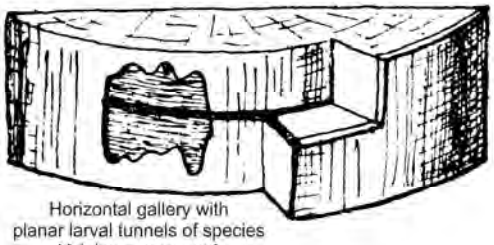
Galleries bored in wood



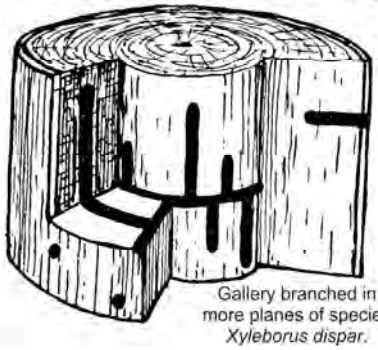
Horizontal ladder-like gallery of species *Xyloterus* sp.



Gallery branched in one plane of species *Xyleborus monographus*.



Horizontal gallery with planar larval tunnels of species *Xyleborus saxeseni*.



Gallery branched in more planes of species *Xyleborus dispar*.

Sister generations – female bark beetles complete egg-laying in their maternal corridor. They then continue regenerative feeding in the same corridor (this section is always without incisions for eggs). After regenerative feeding, they establish a separate, always simple (even in polygamous species) maternal corridor, thereby founding a so-called sister generation (e.g. in *Ips typographus* about 25% of females establish sister generations).

Development of larvae – several days after the eggs are laid, the bark beetles complete their embryonic development and the larvae hatch and begin feeding on bast or on ambrosia fungi.

Pupation occurs at the end of the larval corridor at the place of feeding. Certain species found under bark penetrate very slightly into sapwood before pupation (*Tomicus minor* and *Pityocteines*).

Hatching of beetles – after a short period, the pupa cracks on the dorsal seam and a whitish beetle with dark eyes emerges. The sex ratio at the time of hatching is usually 1:1 (♂:♀). Reproduction, however, proceeds at a different ratio. For example, *Ips typographus* at a ratio of 1:3 (♂:♀) and *Pityogenes chalcographus* at 1:6 (♂:♀), as a large number of these polygamous males are encased in resin when constructing the nuptial chamber.

For several days the hatched beetle remains in place, relatively motionless (during which time the skin hardens and changes colour), and then slowly begins maturation feeding.

Maturation feeding – this feeding is necessary for normal metabolism and especially for the sexual maturation of the individual. It may be performed in various ways:

- Species living in wood and feeding on ambrosia fungi (*Xyloterus*, *Xyleborus*) feed on the remains of ambrosia fungi. The maturation period can last up to several months, after which time they leave the gallery through the opening gnawed by the parents.
- Species living under bark either may feed on remains of the bast left by larvae at the place of hatching (*Ips*, *Pityogenes*, *Pityophthorus*, *Dryocoetes* and others, as well as *Lymantor* [in which case, material with certain fungi])
- or soon after hatching may fly out and burrow into the healthy organs of other woody plants (*Tomicus* in July into that year's shoots; similarly, species of the genus *Scolytus* mature while feeding on twigs; *Ips cembrae* on larch; *Phloeosinus* on juniper; *Hylesinus fraxini* burrows under the bark of young ash trees; *Pteleobius* on elm; *Dendroctonus* spp. and *Hylesinus crenatus* carry out their maturation feeding in the bark without damaging the tree).

Generation ratios and overwintering – bark beetles can overwinter in the larval, pupal or adult stage. Adults of certain species may also overwinter in litter (in *Ips typographus*, only about 3–5% of hatched individuals).

- Certain species have two and more generations per year (e.g. *Scolytus pygmaeus*).
- Another group of species are those with a single generation per year and
    - overwintering as beetles during maturation feeding (e.g. *Hylexinus fraxini*, *H. orni*, *Myelophilus minor*, *M. piniperda*, *Trypodendron lineatum* and *Ips duplicatus*) or
    - overwintering in the larval stage (e.g. *S. ratzeburgi*, *S. carpini* and *Hylesinus oleiperda*).
- The most common group is comprised of species that have two generations at lower elevations (and in southern Europe), but only one generation at higher elevations (and in northern Europe) (e.g. *Scolytus scolytus*, *S. multistriatus*, *S. laevis*, *S. mali*, *S. rugulosus*, *Plygraphus polygraphus*, *Cryphalus abietis*, *Pitiogenes chalcographus*, *Pityokteines curvidens*, *Ips sexdentatus*, *I. typographus*, *I. amitinus*, *I. cembrae* and *I. acuminatus*).
- Two-year development is rather exceptional, with the larva overwintering first and the beetle during maturation feeding for the second time (e.g. *Dendroctonus micans*, *Hylesinus crenatus*).

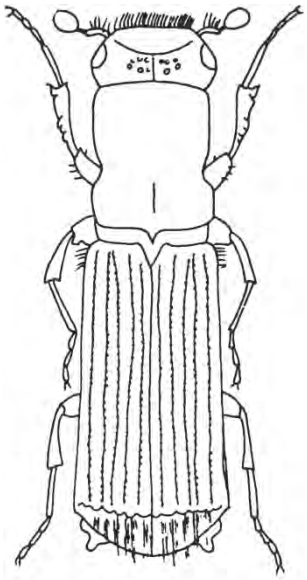
Certain bark beetles (Curculionidae: Scolytinae) and their host plants

Bark beetles on conifers	Bark beetles on broadleaves
Norway spruce (*Picea abies*) *Dendroctonus micans* *Dryocoetes autographus* *Hylastes cunicularius* *Ips amitinus* *Ips duplicatus* *Ips typographus* *Pityogenes chalcographus* *Pityographus pityographus* *Polygraphus poligraphus* **Scots pine (*Pinus sylvestris*)** *Hylastes ater* *Hylurgus ligniperda* *Ips acuminatus* *Ips sexdentatus* *Orthotomicus proximus* *Orthotomicus suturalis* *Pityogenes bidentatus* *Pityogenes quadridens* *Tomicus minor* *Tomicus piniperda* **Silver fir (*Abies alba*)** *Pityokteines curvidens* *Pityokteines spinidens* *Pityokteines vorontzovi* **European larch (*Larix decidua*)** *Ips cembrae* **Junipers (*Juniperus* spp.)** *Phloeosinus aubei* *Phloeosinus serrifer* *Phloeosinus thujae* **Thujas (*Thuja* sp.)** *Phloeosinus aubei* **Cypresses (*Cupressus* spp.)** *Phloeosinus aubei* *Phloeosinus serrifer*	**Oaks (*Quercus* spp.)** *Scolytus intricatus* *Xyleborus dispar* *Xyleborus monographus* **Elms (*Ulmus* spp.)** *Pteleobius kraatzi* *Pteleobius vittatus* *Scolytus laevis* *Scolytus multistriatus* *Scolytus pygmaeus* *Scolytus scolytus* **Ashes (*Fraxinus* spp.)** *Hylesinus crenatus* *Hylesinus fraxini* *Hylesinus toranio* *Hylesinus orni* **Hornbeam (*Carpinus betulus*)** *Scolytus carpini* **Birch (*Betula* spp.)** *Scolytus ratzeburgi* **Fruit trees** *Scolytus mali* *Scolytus rugulosus* **Linden (*Tilia* spp.)** *Ernopocerus caucasicus* *Ernoporus tiliae* **European beech (*Fagus sylvatica*)** *Ernopocerus fagi* *Taphrorychus bicolor* **Common aspen (*Populus tremula*)** *Trypophloeus asperatus* **Common ivy (*Hedera helix*)** *Kissophagus hederae* **European Mistletoe (*Viscum album*)** *Liparthrum bartschti*

Family: **CURCULIONIDAE:** PLATYPODINAE (ambrosia beetles)

There is only one species in the Czech Republic. Only one genus with two species is represented in Central Europe. Platypodinae is an especially tropical subfamily, very close to bark beetles (Curculionidae: Scolytinae). In older works, it is classified as a separate family.

It includes smaller species (4.7–5.8 mm) with an elongated cylindrical body and a free head (not retracted under the scutum). Antennae are similar to the antennae of bark beetles, although the capitulum of the antenna is never segmented, with a constant number of 4 flagellum segments. The scutum is long and cylindrical, with a curving of the side parts apparent from above – placement of the fore femora. Legs have 5 tarsal segments and a visibly long first tarsal segment (longer than the rest of the tibia combined). Sexual dimorphism is evident in the shape of the end of the abdomen (in males, cut off and with dents).



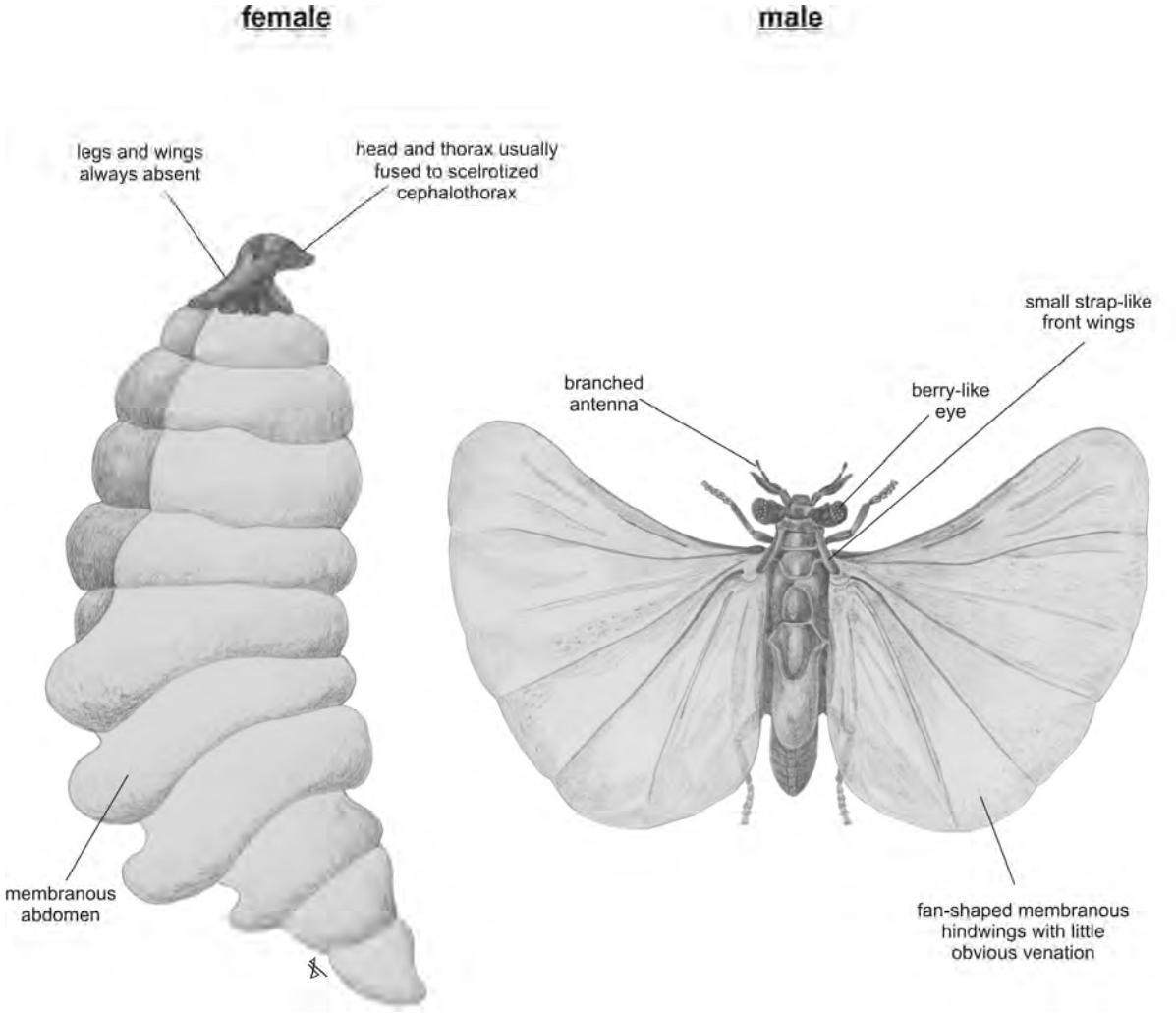
Platypus cylindrus

Larvae are similar to those of Scolytidae, but they are not curved; first thoracic segment cylindrically enlarged and body segments on the sides with strong bristles; in contrast to bark beetles, very mobile. Larvae feed on mycelium of the ambrosia fungus, the spores of which adults carry in the ciliation of the body and in specialized organs (so-called mycangia) on the top side of the thorax.

Only *Platypus cylindrus* (oak pinhole borer) is found in the Czech Republic. It develops on oak and many other hardwood broadleaves, but also on linden trees (the wood always must have sufficient humidity necessary for development of the ambrosia fungus). It is a serious technical pest, especially of oak.

The second central European species is *Platypus oxyurus*, which develops on firs (nearest occurrence, for example, in neighbouring Slovakia, but an overall rare species).

Order: **STREPSIPTERA** (twisted-wing parasites)		
derivation of the order's name streptos (Greek) = twisted, pteron (Latin) = wing	number of known species in the world 560	number of known species in the Czech Republic 30
Metamorphosis: **holometaboly: polymetaboly**		



Systematics

Order with worldwide distribution; only representatives of suborder Stylopidia found in the Czech Republic.

- Suborder: **Mengenillidia** – more primitive suborder, nearest representation in Southern Europe. Females still have visible separation of the body into the three parts (head, thorax, abdomen) and developed legs, eyes and antennae, and they leave the body of the host. They parasitize Zygentoma.
- Suborder: **Stylopidia** – only one family (Stylopidae) among Czech fauna. Females have the head and thorax merged into a cephalothorax; they lack legs, antennae and eyes; and for their entire lives they remain in the host's body.

General characteristics and body description of an adult

This order is morphologically and biologically exceptionally interesting, exhibiting extreme sexual dimorphism. Average size is ca 5 mm, with a maximum just over 20 mm. Many species, however, are much smaller (around 1 mm; e.g. central European *Elenchus*, parasitizing Membracoidea).

Male – head is hypognathous, bearing relatively large arched eyes. Individual ommatidia (20–70) are separated by bands of cuticle. Ocelli are not developed. They are also characterized by the 4–7 segmented branched antennae, at least one segment of which is laterally extended. Mouthparts are either entirely reduced or (in Mengenillidia) reduced labrum and labium are retained. The male therefore does not ingest food at all, which is also reflected by the strongly simplified structure of internal organs.

Prothorax is strongly reduced; mesothorax also reduced but bears the first pair of wings, which are reduced and transformed into relatively long organs erected perpendicular to the mesothorax (similar to halteres in Diptera). Metathorax is strongly developed and bears the second pair of wings, which are used for flight. They are large, mebranous, folded longitudinally at rest, with strongly reduced venation. Thorax is generally conspicuously long, usually the same length as the abdomen.

The first and second pair of legs have long coxae, with no trochanters. Males of Mengenillidia have tarsi with 5 segments, and the praetarsus is equipped with claws; males of Stylopidia have tarsi with 2–4 segments, and the praetarsus has no claws.

Abdomen has 10 segments. Phallus in Mengenillidia is straight (copulation normal); in Stylopidia mostly curved (female endoparasitic).

Females of Mengenillidia – head, thorax, and abdomen visibly separated (not merged); bearing limbs, eyes, and head appendages; always apterous; freely living outside the host's body.

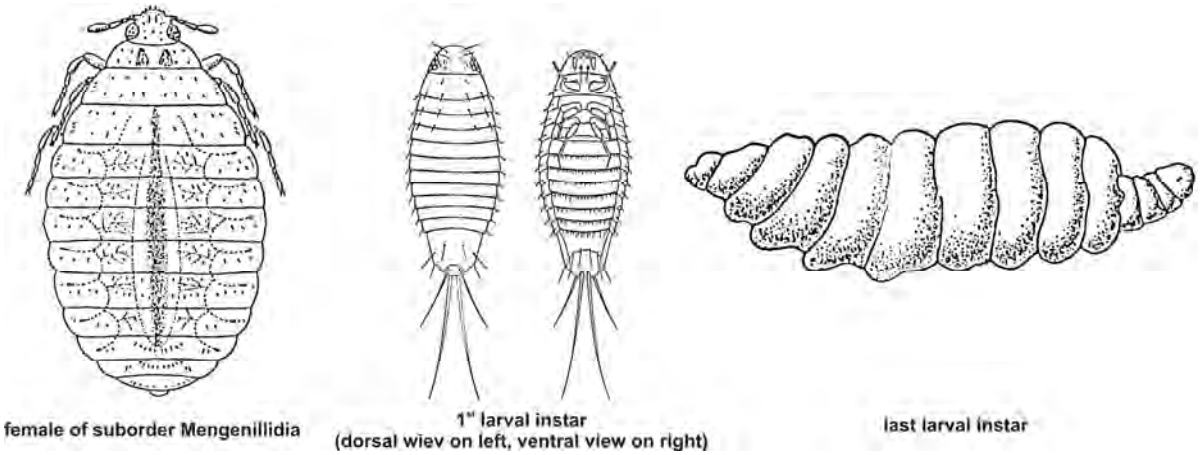
Females of Stylopidia spend their entire lives inside the hosts' body and have an essentially larval shape. The female is in the pharate stage for its entire life, in a puparium formed by the cuticle of the last larval stage and pupa. Head is merged with the thoracic segments in a sort of unsegmented cephalothorax, which is the only segment (or in combination with the first abdominal segment) projecting outside the host's body. The cephalothorax is strongly sclerotized and markedly darker than the light abdomen inside the host's body. Segmentation of the abdomen is more or less maintained.

In relation to reproduction, a special formation occurs (in Stylopidea) – so-called embryonal area, on the ventral side between the wall of the puparium and the cuticle of the female body, into which open 1–5 non-paired secondary reproductive openings (so-called brood canals), which are sometimes doubled or tripled. The embryonal area opens with a slit in the area of the cephalothorax, which is closed by a thin membrane until the larvae emerge.

The internal organs are also strongly altered and reduced. In contrast with normal structure, only a simple respiratory system (opening through a single pair of pores on the cephalothorax), simple nervous system, and heart with closed ostia are preserved in the abdomen. The digestive system is strongly degenerated, and eggs and oviducts are entirely missing. Eggs are distributed throughout the abdomen. The so-called Nasonov glands also open on the cephalothorax and secrete a pheromone attracting males.

Larva

The first invasive instar is mobile, campodeoid without antennae or mandibles, with size ranging from 0.1–0.4 mm. The body is segmented and the head bears 3–5 large, mutually separated stemmata. The thorax features well-developed legs with tarsi terminating in fastening pads (forelegs always, middle legs sometimes) or claws (hind pair of legs). At the end of the body are 2–4 relatively long bristles with which the larvae of certain species can leap over distances of up to 50 times their own size. Their body shape is similar to that of the first larval instar of blister beetles (Meloidae), and thus they are referred to as triungulinoform, even though the most characteristic sign of the triungulins (3 claws on tarsi) is missing.



Other instars are maggot-like and are legless or at most have bases of legs.

Pupa

Pupal structure is adectica exarata. In females of Stylopidia, this stage is "suppressed".

Reproduction

Besides sexual reproduction, parthenogenesis has also been proven (in various Mengenillidae). In the large family of Stylopidae, parthenogenetic reproduction is only presumed, as in a number of species almost exclusively females are found. Both sexes develop from unfertilized eggs (amphitoky). Polyembryony has also been proven (in the genus *Haltictoxenos* parasitizing *Halictus*), where the egg breaks down into over 40 parts, from which the same number of embryos develop.

Mengenillidia	**Stylopidia**

Fertilization is extravulvar.

Copulation occurs on a surface outside the body of the host, wherein the male pierces the body wall of the female abdomen at any place with its strongly sclerotized straight aedeagus.	Copulation always occurs on the host, wherein the female's body wall is pierced in the embryonal area on the ventral side of the cephalothorax.

Sperm is therefore deposited directly into the body cavity where the dispersed eggs are fertilized. The entire embryonic development takes place in said body cavity. The hatched larvae assemble near the brood canals, from where they are expelled peristaltically:

through the reproductive opening on the 7th abdominal segment out of the body.	into the embryonal area from where, after perforating the closing membrane on the slit on the cephalothorax, they leave the body (reproductive opening is not developed).

The number of expelled larvae ranges from 50 to 6,000, depending on the species. These mobile, so-called invasive larvae attack hosts. Those parasitizing silverfish, firebrats, cockroaches, mantids, orthoptera or true bugs attack the host in the nymphal stage. They pierce its skin using enzymes and enter inside its body within about 2 hours. Those that parasitize Hymenoptera attach to a host on a flower, let themselves be carried into the nest, and then invade the host larva. After several days, they change into a second type of larva which migrates around the host's body, feeding on substances from its body cavity. They grow fast, and in the closing stage of development they gather in the abdomen. The development continues as follows:

The last instar of both future males and females has well-developed hind legs. It pierces the host's skin, exits the host, and once outside pupates in a puparium of the last larval exuviae. A female hatches shortly thereafter and either leaves the puparium or simply opens it and remains inside for its entire life.	The last instar tears open the intersegmental membrane of the host (in most cases in the abdomen) using its spreading mandibles and pushes out only the front part of the body. Both sexes pupate in a puparium inside the host's body. The female atypically moults once more in the pupal stage, but the exuviae is not discarded. The female remains inside the host for its entire life. The male may also moult several times (up to 4 times) and may go through even two pupal stages. The male hatches from the puparium and leaves the host.

The hatched males must very quickly find a female to fertilize (the longest recorded male lifespan was 8 hours), and the cycle repeats.

Hatching of imagos is conditioned by light and climatic conditions and is adapted to the development of the host species. Adults frequently hatch from already dead bees and wasps.

Food

Imagos of both sexes do not ingest food.

Ecology

Twisted-wing parasites parasitize, or stylopize, species of the orders Blattodea, Mantodea, Orthoptera, and Hemiptera. Representatives of Hymenoptera are also frequent hosts (in the Czech Republic, the genera *Polistes*, *Andrena*, *Halictus*, and *Ammophila*; in the tropics, Mutilidae and ants [Formicidae]).

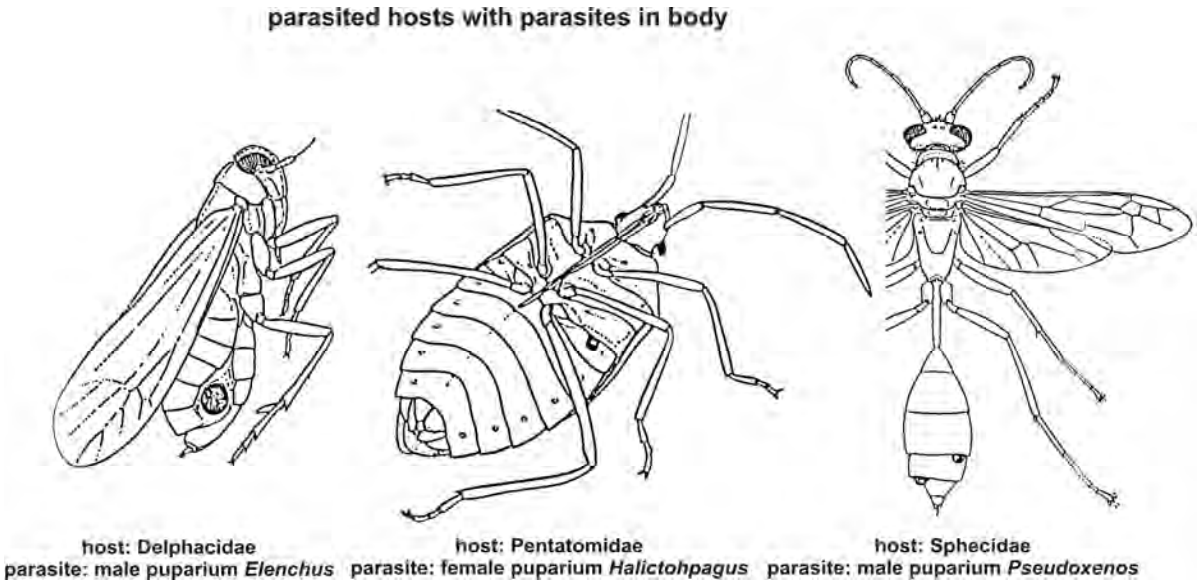
Representatives of Mengenillidia develop in myrmecophilous silverfish and firebrats (Zygentoma: Lepismatidae). Hosts are most frequently attacked as nymphs, in places where the primary larvae hatched.

The number of Strepsiptera larvae that can hatch inside a single host varies. In Mengenillidia, only 1–2 larvae may hatch in a single host; in Stylopidae, 3–5 (max. 15) larvae may hatch in a single host.

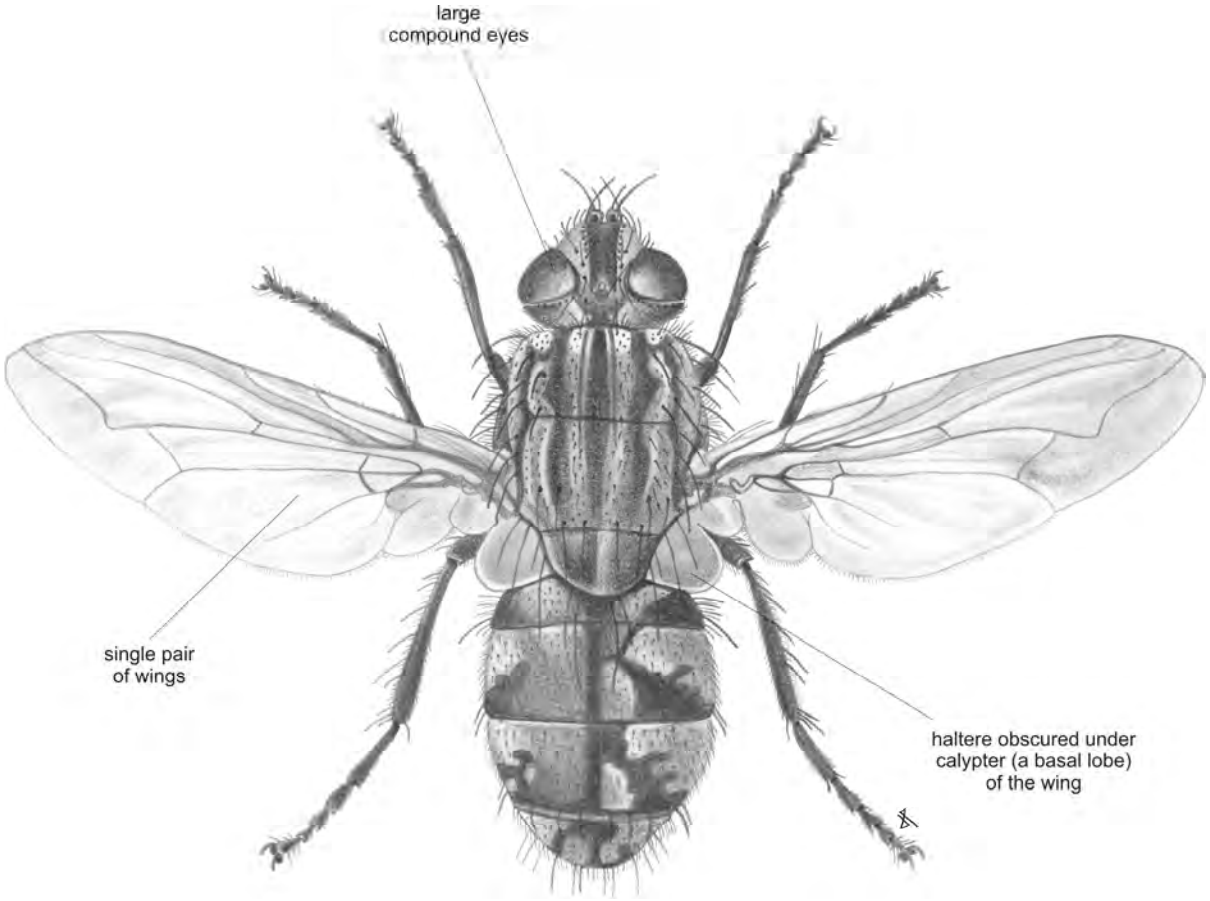
Consequences for the host

The host develops entirely normally up to the imaginal stage. Stylopized individuals frequently live even longer than non-stylopized individuals. The host remains fully viable, perhaps with the exception of Auchenorrhyncha, which usually die shortly after the development of the twisted-wing parasites concludes.

The minimum consequence for the host is its sterilization.



Order: **DIPTERA** (true flies)		
derivation of the order's name di (Greek) = two, pteron (Latin) = wing	number of known species in the world 122,000	number of known species in the Czech Republic over 6,000
Metamorphosis: **typical holometaboly or modified holometaboly: polymetaboly and, in the exotic family Termitoxeniidae, cryptometaboly**		



Systematics

They apparently separated approximately 280 million years ago (i.e. in the Permian). Along with scorpionflies (Mecoptera) and fleas (Siphonaptera), they form a monophyletic group.

It is a numerous order divided in the classical view into 2 main suborders: Nematocera, which is more original and therefore more primitive, and Brachycera, formerly divided into 2 groups – Orthorrhapha and Cyclorrhapha (circular-seamed flies).

Orthorrhapha have antennae positioned relatively high on the forehead, above the prefrontal suture, and the lunula or ptilinal suture is not developed. Larvae are hemicephalous, mandibles move in the vertical plane, and the pupa is obtect.

Cyclorrhapha have antennae positioned low on the forehead, below the prefrontal suture, and the lunula or ptilinal suture is developed. Larvae are acephalous, equipped only with mouth hooks that form part of the cephalpharyngeal skeleton; pupae are placed in puparia, in the upper part of which a "lid" is formed, lined by a fine circular seam, by which the puparium opens under the pressure of an eversible sac on the imago's forehead.

This division certainly contains a number of paraphyletic groups. Phylogenetic relations are better described by the following system:

- Suborder: Nematocera – antennae of imago with more than 6 more or less equivalent segments, larva is eucephalous, mandibles located in usual horizontal position, and pupae are obtect.
  - Infraorder: Axymyiomorpha
  - Infraorder: Culicomorpha
  - Infraorder: Blephariceromorpha
  - Infraorder: Bibionomorpha
  - Infraorder: Psychodomorpha
  - Infraorder: Ptychopteromorpha
  - Infraorder: Tipulomorpha
- Suborder: Brachycera – antennae of imago have less than 6 segments, and the segments are markedly varied (heteronomous).
  - Infraorder: Asilomorpha
  - Infraorder: Muscomorpha
  - Infraorder: Stratiomyomorpha
  - Infraorder: Tabanomorpha
  - Infraorder: Vermileonomorpha
  - Infraorder: Xylophagomorpha

General characteristics and body description of an adult

The order contains species of various sizes, from 0.5 mm (certain biting midges [Ceratopogonidae]) to 30–32 mm (certain horse-flies [Tabanidae] and crane flies [Tipulidae]). The body is often weakly sclerotized; sclerotization of the body and thorax is stronger and that of the abdomen sometimes weaker. Coloration is varied, frequently bright, including metallic-coloured tints. Adults ingest liquid food of various natures, and larvae are variously saprophagous, secondarily phytophagous, predators, parasites or parasitoids.

Head is freely mobile (with the exception of bat flies [Nycteribiidae] and louse flies [Hippoboscidae], for which it apparently closely fuses with the prothorax), originally rather prognathous (e.g. crane flies [Tipulidae]) and in higher forms orthognathous.

Eyes are frequently large, on the top of the head (especially in males), frequently almost joined (holooptic eyes), usually larger in males than in females. In good fliers, the facets also frequently differ in size and/or colour (the facets are usually larger on the upper side of the eye and smaller on the bottom). Less frequently the eyes are small, consisting only of several facets (e.g. louse flies [Hippoboscidae] and gall midges [Cecidomyiidae]). In rare cases, they are entirely absent (certain bat flies [Nycteribiidae]).

Ocelli are developed (usually 3), but may be absent in certain groups (e.g. mosquitoes [Culicidae], non-biting midges [Chironomidae], black flies [Simuliidae], certain gall midges [Cecidomyiidae], and certain horse-flies [Tabanidae]). Ocelli are also absent in groups with absent or strongly reduced compound eyes (see above; frequently in connection with parasitic lifestyle and other related characteristics, such as reduction of wings). In exceptional cases, two ocelli are developed (fungus gnats [Mycetophilidae]).

Antennae have various structures and various numbers of segments depending on suborder and family classification. In Nematocera, antennae have a large number (more than 6) of relatively equivalent segments, most frequently filiform to moniliform, with the number of segments of the flagellum ranging most frequently between 7 and 14, but in some cases much more. In Brachycera, antennae are short (less than 6 segments), with a visible apical, but more frequently subapical bristle (so-called arista) developed on the compact 3rd antennal segment. In addition to serving as olfactory organs, the antennae in a number of species are also organs of hearing (so-called Johnston's organ located in the second antennal segment).

Mouthparts are originally of the piercing-sucking type, but in more developmentally advanced groups they change to lapping-sucking, which in certain groups are again secondarily transformed to piercing-sucking. The basic types can be deemed to include the piercing-sucking mouthparts of the more primitive Nematocera and the lapping-sucking mouthparts of the more developed Brachycera. Other types of the piercing-sucking mouthparts are only modifications of either type, or a combination of both types.

- Piercing-sucking mouthparts of Nematocera: visible elongation of almost all parts of the mouth – labrum, hypopharynx, mandibles, maxillae, and labium. The labrum, hypopharynx, mandibles, and galeae of maxillae change into piercing bristle-like formations that are also used to supply saliva (through a channel in the hypopharynx) and for sucking in food. The extended labium forms a sheath and, similarly to other species with piercing-sucking mouthparts, does not penetrate into the wound. It is characteristic of bloodsucking Nematocera (e.g. Culicidae).
- Lapping-sucking mouthparts of Brachycera: the second basic type of mouthparts of Diptera is the lapping-sucking type with markedly developed haustellum. A "proboscis-like" enlarged labium (which is foldable to the back) comprises the largest of the external mouthparts. The hypopharynx and labrum are located in its grooved frontal part and together with the neighbouring part of the labium thus form a sucking tube ensuring the supply of saliva and sucking up of liquid food. The enlarged labial palps form pad-like structures (so-called labella) veined with capillaries which distribute and cover food with saliva and then are used for sucking up the food transformed into liquid form. Other parts of the mouth are reduced or absent; only the maxillary palps remain preserved.
    - The piercing-sucking mouthparts of certain higher bloodsucking Diptera are derived from this type (e.g. stable fly [*Stomoxys calcitrans*], genus *Glossina*, and family Hippoboscidae). In principle, it is identical to the previous type, with the only difference being that the entire haustellum is very strongly narrowed and the labella are small, strongly sclerotized and fitted with teeth. All mouthparts enter the host's tissue (including the labium), i.e. the entire proboscis.

Mouthparts of predatory and bloodsucking Brachycera (typically in horse-flies [Tabanidae], robber flies [Asilidae], and certain others) are a combination of the two basic types. The incision is made by the stylet-like labrum, hypopharynx, and paired mandibles and maxillae; the haustellum, terminating in two labella, forms a sheath covering the piercing parts and does not penetrate into the wound.

The length of the mouthparts varies considerably. In bee-flies (*Bombylius* [Bombyliidae]), the length may even exceed that of the body. In exceptional cases, mouthparts may be vestigial (for example, in bot flies [Oestridae]).

Thorax is characterized by a strongly developed mesothorax, while the two remaining segments are very small. Chaetotaxy of the thorax plays a very important role in identifying the individual taxa within this group.

Legs also have various forms, from the long delicate legs of some families of the suborder Brachycera (e.g. mosquitoes [Culicidae] and crane flies [Tipulidae]), through the specialized, strongly bristled legs adapted for hunting of the robber flies (Asilidae) and legs equipped with unusually strong claws and grabbing pads (louse flies [Hippoboscidae] and bat flies [Nycteribiidae]), to the usually formed legs of most other families. The number of tarsal segments is 5, and in exceptional cases less (3–4).

The forewings are usually well-developed, while the hind wings are transformed into halteres, operating especially as organs of balance. Species with vestigial wings and entirely wingless species are the exception. In certain families, aptery is the typical characteristic for the entire family (bee lice [Braulidae]). In other cases, the wings break off after the host has been reached (Hippoboscidae). At rest, the forewings are most frequently folded flatly over the abdomen, often slightly triangularly spread, and less frequently folded over each other (mosquitoes [Culicidae]) or horizontally spread (crane flies [Tipulidae]). Venation is not very rich (especially a minimal number of cross-veins). The posterior margin of the forewing has a special, separate formation (alula). Diptera are among the best fliers among insects. The wing membrane may be entirely smooth or variously covered by bristles or scales.

Abdomen is separated from the thorax by a visible narrowing, with the exception of parasitic and wingless species. Sterna are relatively small, but terga are large. In females, the terminal abdominal segments form a telescopic false ovipositor, which is mostly retracted into previous abdominal segments at rest, but exceptionally may be non-retractable (e.g. certain bot flies [Oestridae]).

The nervous system in Nematocera has a complete nerve cord (in imagos and larvae). In Brachycera, there is a significant tendency toward concentration of ganglia in the thorax (even the subesophageal ganglion may merge with the ganglia concentrated in the thorax). The concentration of ganglia may be even more significant in larvae than in adults, such that the large and relatively uniform complex of ganglia in the thorax may also incorporate the supraesophageal ganglion shifted to the back.

The tracheal system is strongly developed, and air sacs are also frequent (especially in good fliers). The respiratory system is externally open via two pairs of spiracles on the thorax and varying numbers of spiracles on the abdomen.

Egg

Eggs are mostly white to dark and oval to elongated oval.

Larva

Larvae are apod almost without exceptions, and only exceptionally with pseudopodial appendages (e.g. in non-biting midges [Chironomidae] and shore flies [Ephydridae]).

Within the order, there is a clear tendency toward reduction of the head capsule, and thus it is possible to encounter also eucephalous, hemicephalous and acephalous larvae in all possible transitional forms.

- Lower Diptera still have a developed head with the typical chewing mouthparts (eucephalous). This state is common in most Nematocera, typically in species developing in water and consuming small organisms (e.g. mosquitoes [Culicidae] and non-biting midges [Chironomidae]).
- Hemicephalous species exhibit a gradual weakening of sclerotization of the hind part of the cranium and retraction of this part into the first thoracic segment. Mandibles may still be developed in the typical form (e.g. in larvae of crane flies [Tipulidae]) or a slightly altered form. Larvae of this type are common in many Nematocera, but especially among members of the suborder Brachycera.
- The head capsule is absent, however, among a considerable portion of Diptera (acephalous) and of the entire skeleton of the cranium only the more strongly sclerotized cephalopharyngeal complex remains, located in the front and terminating in hook-shaped teeth which only move vertically.

The full number of spiracles is preserved in the soil larvae of march flies (Bibionidae). In all other cases, larvae have developed fore or rear spiracles or all spiracles are closed and the larvae respire through their entire body surface. In species developing in water, the spiracles are located on various protrusions, sometimes of considerable length.

Larvae generally go through 4 instars (in some cases more), though in certain Brachycera (for example, Cyclorrhapha) there are only 3 instars. In certain parasitic species (e.g. tachina flies [Tachinidae] and bee flies [Bombyliidae]), larvae of the first instar (invasive) tend to be morphologically different from subsequent instars (i.e. polymetaboly).

Pupa

Pupa is always non-biting (pupa adectica), essentially of two types:

- **Pupa obtecta** – usually immobile, with relatively well-visible sheaths of legs, wings and head appendages. The very mobile pupae of mosquitoes (Culicidae) and the less mobile pupae of robber flies (Asilidae), bee flies (Bombyliidae) and horse-flies (Tabanidae) are exceptions, wherein their abdomens are equipped with prickles used to reach the surface of the soil. This pupa is typical for all Nematocera and some Brachycera.
- **Pupa exarata coarctata** – pupa is in a puparium with a "lid" formed in its upper part, lined by a fine circular seam (from which this group gets its name, "circular-seamed flies" [Cyclorrhapha]), by which the puparium opens under the pressure of an eversible sac on the imago's forehead. The puparium is formed from the hardened skin of the last larval instar. This pupa is typical of certain Brachycera (a group called Cyclorrhapha, or circular-seamed flies).

Ecology

Diptera are distributed across all continents, including Antarctica. They may be found in deserts and in water, from lowlands to mountains. They are vastly abundant.

Adults feed on liquid food of various natures, while larvae are saprophagous, secondarily phytophagous, predators, parasites or parasitoids.

Reproduction is, with minor exceptions, sexual. In various families, however, less common methods of reproduction, such as typical hermaphroditism (myrmecophilous Termitoxenia), parthenogenesis (in certain gall midges [Cecidomyiidae] even with heterogony connected with paedogenesis in the larval stage) or paedogenesis in the pupal stage (in certain non-biting midges [Chironomidae]), may be encountered.

Eggs are usually laid in environments with relatively higher humidity, either individually or more frequently in group batches that may have a very characteristic look. Embryonic development is usually short, and eggs are only seldom overwintering or diapausing. The number of eggs laid ranges from only a few to several thousand. For example, certain ectoparasites of mammals deposit only several larvae, while some entomophagous species lay several thousand eggs.

In addition to ovipary, ovovivipary is also relatively common (e.g. certain tachina flies [Tachinidae] and flesh flies [Sarcophagidae]), as is vivipary in certain species (louse flies [Hippoboscidae], bat flies [Nycteribiidae], certain pedogenetic gall flies [Cecidomyiidae], and certain bot flies [Oestridae]).

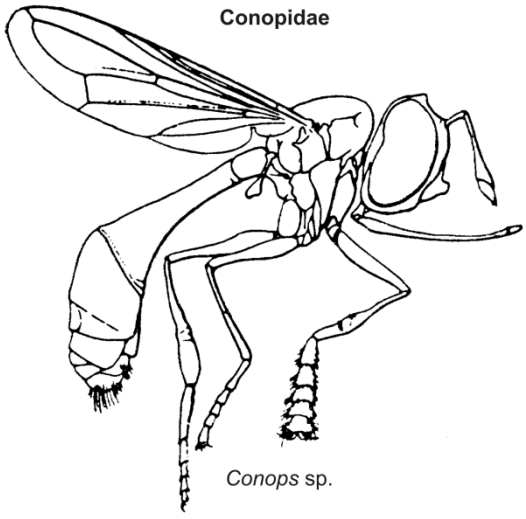
Food

Adults feed on liquid food the source of which may be

- animal (fresh) – species predatory in the imago stage include, among others, robber flies (Asilidae) and dagger flies (Empididae), which feed on invertebrates, and louse flies (Hippoboscidae), bat flies (Nycteribiidae), mosquitoes (Culicidae), biting midges (Ceratopogonidae), black flies (Simuliidae), and horse-flies (Tabanidae), which feed on the blood of vertebrates;
- plant:
  - fresh (especially on blossoms) – a number of families,
  - from decaying plant matter – a number of families;
- dead material – consisting of plant or animal matter and mixtures thereof – a number of families.

Larval feeding varies greatly, from original saprophagy to pronounced parasitism. They live in various conditions both on dry land and in water, and certain species are even adapted to such extreme conditions as hot springs, salt water, and cold waters of rapids.

- Saprophages – in various decomposing substances of plant and animal origin or, in some cases, in foodstuffs and products (fruit flies, cheese flies, house flies, flesh flies); most families.
- Phytophages – in various plant tissues; certain Cecidomyiidae (gall midges), Chloropidae (frit flies), Tephritidae (tephritid fruit flies), and Anthomyiidae.
- Mycophages – in live and dead fungi (Mycetophilidae [fungus gnats]).
- Endoparasites of various invertebrates and especially insects – Tachinidae (tachina flies) and Conopidae (thick-headed flies).
- Endoparasites of vertebrates – bot flies (Oestridae), exceptionally also representatives of other families.
- Predators – for example, certain Cecidomyiidae (gall midges) and Syrphidae (hoverflies).



Conops sp.

Importance for humans

- Negative:
  - Great hygienic and epidemiological importance – undoubtedly the most important insect vectors of diseases.
  - Pests in agriculture, food processing industry, and partially also forestry.

- Positive:
  - Parasitoids or predators of insect pests.
  - Due to vast abundance, saprophagous species are important in the circulation of substances.
  - Due to their large numbers, they also form a wide food base for other organisms (especially birds, insectivores, and, in the case of aquatic species, fish).
  - Important pollinators of plants (this positive aspect is highly undervalued).
  - Breeding of fruit flies has served humanity as valuable material for genetic studies.

Suborder: NEMATOCERA

Mostly thin, delicate species with long body appendages, though not all species share this body structure. They have characteristic many-segmented (6–65) antennae with more or less equivalent segments. The maxillary palp has 3 to 5 segments.

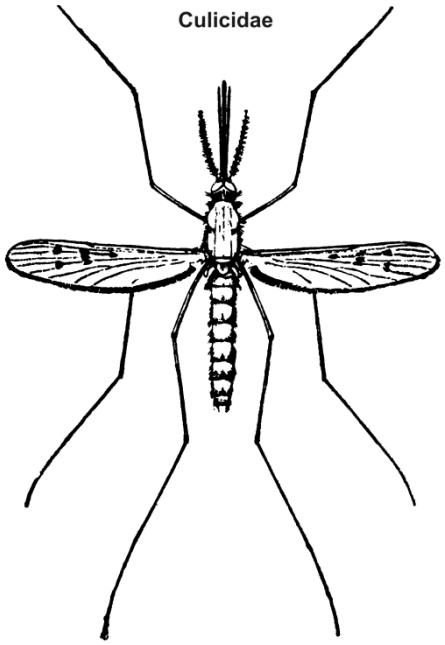
Larvae have various degrees of development of the head capsule (eucephalous to hemicephalous forms) and chewing mouthparts, where the mandibles move in the usual manner in the horizontal plane.

Pupae are obtect. Certain representatives of gall midges (Cecidomyiidae) that pupate in the last larval exuviae are an exception.

Infraorder: CULICOMORPHA

Family: **CULICIDAE** (mosquitoes)

Fine, thin, 3–15 mm long, with conspicuously long legs; thin wings with scales on the veins; antennae have 15 segments and in males are long and plumose; piercing-sucking mouthparts. They are important ectoparasites on vertebrates (not only warm-blooded, ca 15% of species feed on amphibians and reptiles); females are bloodsucking (though not of all species) and males feed on flower nectar.



Anopheles maculipennis

Larvae are eucephalous with long antennae, swim freely in water, breathe atmospheric oxygen with the last pair of spiracles, and filter detritus and small organisms (algae and single-cell animals) from the water.

Pupa obtecta is very characteristic. Head and thorax form a solid whole, but the abdomen is very mobile, so they are able to move quickly, although apparently directionally uncoordinated. The number of generations varies, and apart from the pupa all stages can overwinter.

The most well-known species the females of which suck blood are in the genera *Anopheles*, *Aedes*, and *Culex*. Representatives of these genera are not difficult to distinguish from one another based on morphology as well as biological traits.

- Imagos at rest:

- *Culex* and *Aedes* –abdomen parallel with the surface, and
- *Anopheles* – raised abdomen.

- Larvae also offer an opportunity to distinguish representatives of the individual genera:
  - *Culex* and *Aedes* are positioned more or less vertically, while
  - *Anopheles* larvae lie in the water horizontally.
- Eggs in species of the genera
  - *Culex* are deposited in mass batches and remain on the water surface as so-called "rafts", floating on a cushion of air contained in funnel-shaped recesses on one pole of each egg.
  - *Aedes* are darkly coloured with net-like sculpture, do not float, and are usually affixed to vegetation. Larvae also develop in dry conditions, but in that case they only hatch once they get into an aquatic environment.
  - *Anopheles* are deposited individually on the water surface where they remain due to air-filled chambers inside the egg cover.

The hungry imago moves very rapidly and individual senses only manifest themselves at a short distance from a host. Presence of the host is revealed to the female by scent molecules that the animals release into their surroundings. Great attractants are, for example, CO_2, lactic acid, carbonic acid, and ammonia. Digestion of the blood takes between 3–5 days.

Perception of sound is also strongly developed and serves primarily for seeking the opposite sex. The Johnston's organ positioned in the second antennal segment serves for this purpose. Sound is produced especially by the frequency of wing movement (e.g. *Culex* has around 300 and *Aedes* around 600 Hz [wing oscillations/second]). The female is attracted and enters the swarm of males.

Mosquitoes have considerable epidemiological importance. The greatest trouble is caused by Culicidae in the tropics and sub-tropics, as well as in the north (e.g. Greenland, Lapland, Siberia). In the tropics, they are also the main vectors of a number of highly dangerous diseases.

Common species in the Czech Republic include the common house mosquito (*Culex pipiens*) and *Culiseta annulata*. Both species are strongly connected to humans. They develop in any water regardless of its quality, and they have even been discovered in the contents of latrines. Females overwinter (males die very soon after copulation), usually in human constructions, most frequently in cellars, sewers, and the like. In Czech conditions, they usually leave their overwintering sites in May. Under favourable conditions, up to 4 generations may develop during the year. They suck on all warm-blooded organisms, but preferentially attack birds. Species of the genus *Aedes* are, in contrast, common in nature, in meadows and forests.

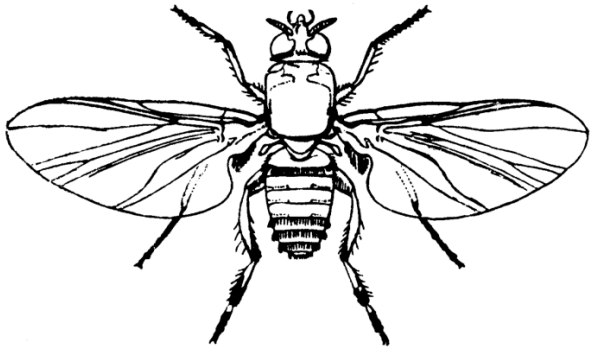
The species *Aedes vexans* and *A. caspius* are characteristic for wet meadows. A number of other species live in forests.

Simuliidae

Family: **SIMULIIDAE**

(black flies)

Small, 2–5 mm long, grey to black-coloured species, rather resembling brachyceran flies in terms of habit. Antennae are short, but have 9–11 segments. Eyes, as in a number of other Diptera, are separated in females while in males they touch, and in the upper part they consist of larger facets and in the lower part of smaller ones. The thorax is strongly arched, short wings, and the veins of the



Simulium ornatum

wings are concentrated towards the front edge.

Simuliidae are exclusively diurnal. The female's food consists of the blood of vertebrates (however, they also visit flowers along with the males), and they attack practically all mammals including humans, and to some extent also birds. With their strong proboscis they inflict a wound which bleeds for a long time, as substances limiting blood coagulation get into the wound along with a strong haemolytic venom that causes the formation of bruises. They carry agents of various diseases and therefore have immense epidemiological significance. A number of species, however, only feed on plant juices, as do males of all species.

Species feeding on plant food lay eggs immediately after copulation, while species of which the females suck blood only lay eggs after first feeding. Eggs are laid on aquatic vegetation or other objects in the water in clutches of usually 50–200 eggs (exceptionally up to 1,200) over the course of the following 3–4 weeks.

Larvae develop exclusively in flowing, clean, and oxygen-rich waters. Grown larvae reach sizes of up to 15 mm and are characterized by fan-like cilia on the labrum with which they hunt (filter) food. They feed on algae, bacteria, and other plankton organisms. In species that move, these fan-like organs are absent. In the front part of the larval bodies, there are strongly developed spinning glands, forming a tissue on which the larvae move similarly to inchworm caterpillars. They have short pseudopods developed on the thorax and the last abdominal segment is also equipped with a certain type of pygopod. Young larvae respire through the entire body surface; older larvae have a well-developed tracheal system connected to rectal gills. Moulting occurs 6–8 times.

Shortly before pupation, the larva spins some sort of funnel-shaped cocoon open in the front, from which the fan-like tube-form tracheal gills protrude. Shortly before emergence of the imago, the pupa fills with air that envelopes the imago and with the help of which it swims completely dry to the water surface.

They overwinter as eggs, larvae, or pupae. They have multiple generations per year.

Family: **CERATOPOGONIDAE** (biting midges)

Very small, 0.5–3 (and up to 8) mm long, thickset, darkly coloured species with well-developed piercing-sucking mouthparts. Antennae have 13–15 segments; wings are relatively wide and frequently spotted.

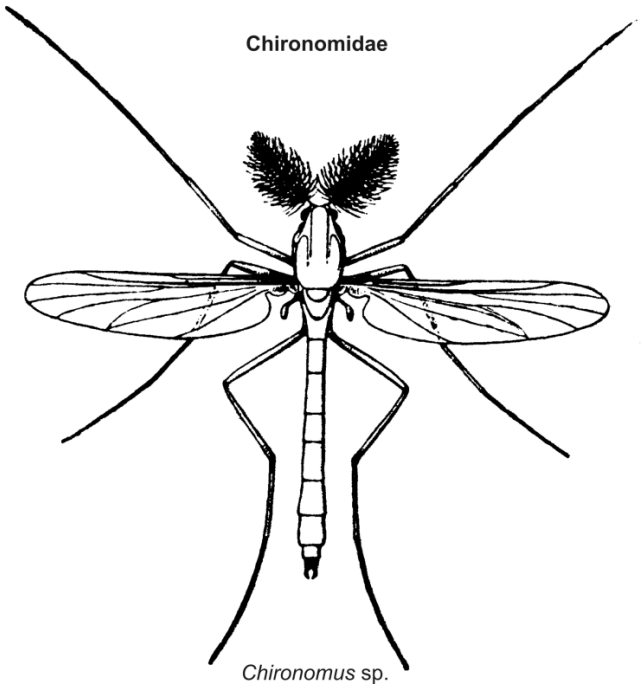
Females of a number of species bite very severely and suck the blood of warm-blooded vertebrates, including humans. Other species similarly attack cold-blooded vertebrates and other animals. Attacking species in the Czech Republic are, for example, bloodsucking gnats. This family also includes species where both sexes feed on plant juices.

Apart from painful punctures and the ensuing severe itchiness, a common and strong reaction in humans are large blisters up to 2 cm filled with serous fluid. Humans are attacked only by representatives of the genera *Culicoides*, *Forcipomyia*, and *Leptoconops*.

Larvae are morphologically very similar to the larvae of Chironomidae (non-biting midges). Larvae may develop in water or may be terrestrial, living under bark, in decaying plant substrate, in soil, and even in anthills. Larvae feed on small animals or dead plant substances.

Family: **CHIRONOMIDAE** (non-biting midges)

Visually very similar to mosquitoes (Culicidae) (for which they are often mistaken), but their mouthparts are vestigial (and thus they do not bite) and wings are scaleless. Larvae develop mainly in water, less frequently in mud, compost, manure, etc.



Infraorder: BLEPHARICEROMORPHA

Family: **BLEPHARICERIDAE** (net-winged midges)

Imagos with long legs, slim bodies, and thin wings resembling small crane flies. They have characteristic eyes divided into the upper part with larger facets and bottom part with smaller facets by a cross-slat.

Adults hunt insects in flight (mostly non-biting midges) and suck on them.

Development of larvae is similar to Simuliidae (black flies), but it occurs in extremely fast-flowing waters and some species are even capable of developing in waterfalls.

Larvae are characteristic, very strongly flattened, and divided into 6 segments pronounced by constriction. (Segmentation largely does not reflect the true segmentation of the insect body. For example, the first apparent segment includes the head, thorax, and the first abdominal segment.) There are 6 suckers on the ventral side of the body; their effectiveness is also supplemented by a secreted adhesive. The larvae live essentially sedentarily on the undersides of rocks, and only move to places with richer food that form algae coatings covering the stones. As in the previous group, the young larvae respire through their body surface and in following instars through tracheal gills positioned like appendages on the underside of body segments.

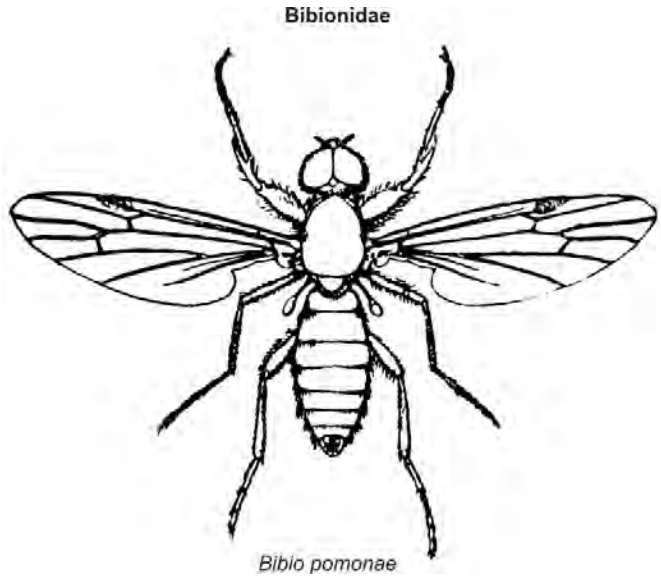
Pupa is formed similarly to Simuliidae, including the fan-like tracheal gills.

Infraorder: BIBIONOMORPHA

Family: BIBIONIDAE

Medium-sized (4–13 mm), black, red-brown to yellow, intensely hairy species. Sexual dimorphism is reflected very prominently in size and hairiness of eyes. In males, the eyes are hairy, large, mutually touching, and with larger facets in the upper part than in the lower; in females, they are bare, small, and separate from each other. Antennae are short, with 8–16 segments; wings with reinforced veins on the front edge. Tibiae of females are equipped with fossorial prickles on the end.

They occur as early as spring, when during warm days they fly clumsily, slowly, and frequently in swarms. Hind legs conspicuously hang down in flight.



Bibio pomonae

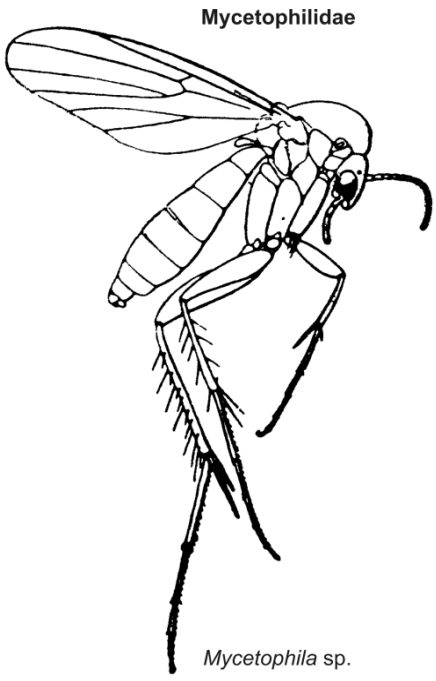
Bibionidae are also among species abundant in cities. Imagos feed on plant juices and honeydew.

Eggs are laid into humus soil in larger groups. The clutch of a single female ranges around 150–200 eggs, and in total up to 3,000 eggs may be laid.

Larvae develop in the upper layers of soil and as saprophages they are quite important in creating humus. During overpopulation and shortage of dead organic matter, however, they can cause considerable damage by gnawing on plant roots, as pests both in agriculture and forest management (especially in nurseries).

The damage is often attributed to freezing, but the presence of larvae can be judged by the presence of small mounds of earth and ca 1.5 mm large openings in the soil. The more mature larvae are covered by dense, variously shaped prickly projections (young larvae have long hairs). There is usually 1 generation per year.

In Central Europe, *Bibio hortulanus* (black male, brown-red female) and the St Mark's fly (*Bibio marci* [both sexes black]) are among the most important species.



Mycetophila sp.

Family: MYCETOPHILIDAE

(fungus gnats)

Small species with a conspicuously arched thorax. Legs are very strong, coxae long and protruding, with prickly tibiae.

Larvae of the predominant majority of species develop in the fruiting bodies of mushrooms (causing worminess). Some species, however, have been recorded on liverworts and mosses. Larvae of certain species tied to mushrooms are at least occasional predators.

Family: **SCIARIDAE** (dark-winged fungus gnats)

Small, 0.6–8 mm long, grey-brown to black species. Eyes are large and touch at the base of the antennae, which have 16 segments. Females may be brachypterous to apterous.

Larvae live in various decaying materials, such as forest litter, fungi, compost, rotting plants, under dead bark, and on plant roots. They also live in the substrate of house plants, and frequently damage field mushroom cultures.

Family: **CECIDOMYIIDAE** (gall midges)

Very small, 1–4 (max. 10) mm long, softly sclerotized, inconspicuously coloured species. Antennae are filiform, finely ciliated, with 6–30 segments (most frequently 14–16 segments); the individual segments on both sides are wick-like and constricted. Mouthparts are entirely vestigial. Legs are long and break easily. Wings are relatively wide with reduced venation; cross-veins are entirely absent. The abdomen has 9 segments; in females it ends with a false telescopic abdomen (enabling the depositing of eggs into tissue).

Larvae are white, but frequently yellow, orange to reddish in colour. The head is strongly reduced, with stylet-like mouthparts, adapted for suctorial feeding. On the abdominal side of the prothorax there is often longitudinal sclerotized rod- or fork-shaped skin, of which the front part is not grown to the skin and freely protrudes forward.

Pupae are obtect, yellowish to reddish with a darkened head and wing bases. Sometimes there are sclerotized formations on the pupa's head, with which the pupa punctures flight openings before the adult hatches, and through which the pupa partially pushes itself out.

Besides sexual reproduction, paedogenesis (reproduction of larvae) also occurs in certain genera. Even in these species, however, both sexes appear from time to time and paedogenesis is shortly replaced by normal sexual reproduction (heterogony).

Gall midges develop in all plant parts with the exception of roots. Formation of galls is characteristic for a considerable number of species. The formation of galls is apparently contributed to by secretions of the larvae and mechanic stimulation by their movement. Galls are characteristic of individual species, so it is frequently easier to determine the originator based on galls rather than on the basis of the morphological characteristics of the imago.

Certain species live in galls of the gall-forming species of Cecidomyiidae (but also gall wasps) as inquilines and therefore do not form the gall themselves. Other species live in plants without creating galls (e.g. species living in seeds or cones); others feed on detritus and decomposing organic matter (decaying wood, under bark). There are, however, also predatory species, more precisely parasitic ones. They attack especially other species of gall midges and also certain true bugs (Hemiptera: Sternorrhyncha), such as species of the genera *Endaphis* and *Endopsylla*.

Many species are of considerable economic importance, especially in agriculture, and a number of species also cause damage in forestry, although the economic damage is for the most part in no way noticeable.

For example, the pear psylla (*Cacopsylla pyricola*) is agriculturally important, causing deformation of pear fruits that later rot. The hessian fly (*Mayetiola destructor*) attacks culm of cereals near the nodule, causing the stems to break. The saddle gall midge (*Haplodiplosis marginata*) causes similar damage. The

yellow blossom wheat midge (*Contarinia tritici*) causes damage to cereal ears, and the wheat midge (*Sitodiplosis mosellana*) causes reduction in the weight of seeds. *Dasineura papaveris* sucks forming poppy seeds, and later the inside of the poppyheads are infected by moulds. The brassica pod midge (*Dasineura brassicae*) causes deformation and premature opening of rapeseed siliques, and the Swede midge (*Contarinia nasturtii*) attacks the leaves and petioles of Brassicaceae plants which then grow thick, stunt in growth, and rot. *Dasineura medicaginis* and *Contarinia medicaginis* convert buds and blossoms to galls, significantly decreasing the yields of alfalfa seed stands. The blackberry stem gall midge (*Lasioptera rubi*) produces galls on stems of blackberry bushes, causing the stems to break or dry out.

In forestry, *Resseliella piceae* has importance, for example, as it damages seeds of firs. *Plemeliella abietina* (spruce seed gall midge) causes identical damage on spruce, sucking on scales of spruce and pine cones, and *Kaltenbachiola strobi* (spruce-cone gall midge) decreases the germination capacity and weight of seeds. *Dasineura kellneri* prevents the development of larch buds, and *Thecodiplosis brachyntera* (needle-shortening pine gall) causes stunted growth of pine needles. The sucking of *Contarinia fagi* on beech trees leads to drying out of buds or disfigured development of leaves. *Hartigiola annulipes* (beech leaf gall midge) and *Mikiola fagi* (beech gall midge) cause relatively harmless leaf galls on beech trees. *Rabdophaga rosaria* (European rosette willow gall midge) makes prominent galls from the buds of willows (that are then similar to roses), *Rabdophaga saliciperda* (willow shot-hole midge) makes up to 50 cm large galls on willow branches, and *Rabdophaga salicis* (willow cabbage gall) forms about 3 cm long galls under the bark on new willow shoots of the given year. Sucking of the species *Dasineura marginemtorquens* causes twisting of the edges of willow leaves.

Infraorder: PSYCHODOMORPHA

Family: **PSYCHODIDAE** (moth flies)

Small, 1–4 mm long, densely long-haired species with long antennae.

Larvae develop in water rich in organic matter with low oxygen content or are semi-terrestrial.

Females of certain species suck blood, and humans are one potential host. When feeding, they transmit serious diseases.

Infraorder: TIPULOMORPHA

Family: **TIPULIDAE** (crane flies)

Small to large species (10–32 mm); ocelli not developed; serrate, setaceous, or pectinate antennae, mostly with 13 segments (rarely 15–19 segments). Conspicuously long legs, easily broken off. Wings are thin, long, frequently with a marking. A V-shaped seam has developed on the thorax. Sexual dimorphism is apparent especially at the end of the abdomen, which in males is thickened, while in females it converges to a point.

The female lays eggs into soil, mud, decomposing wood, etc. They are dropped or, with the help of a secretion, placed on rocks or aquatic vegetation. The number of laid eggs is high, from several

hundred to over 1,000. Typical biotopes for development are meadows, forests, and in the vicinity of water.

Larvae are hemicephalous; the last abdominal segment has 6 horn-like lobes. Aquatic larvae respire through the body surface and additionally also through appendages (tracheal gills) or rectal gills. Terrestrial species breathe through two pairs of spiracles located on the last body segment. Larvae have a soft body cover and only exceptionally are equipped with hairs or other formations. In species living on peat mosses, fork-like structures are developed on the end of the abdomen; in species living in soil, pseudopodial appendages are present. Pupae are capable of limited movement.

They usually have 1 generation per year, with pupation most often occurring in April to June. Probably only females ingest food (nectar from blossoms).

Common species include *Nephrotoma crocata* (heath banded tiger), *N. appendiculata* (spotted crane fly), *N. pratensis*, *Tipula paludosa* (European crane fly), *T. scripta*, *T. pabulina*, and *T. oleracea* (marsh crane fly).

Family: **LIMONIIDAE**

Small to medium-sized species; wings are transparent, with decoration, or absent (*Chionea*).

Larvae are similar to those of Tipulidae. On the apex of the abdomen there are at most 5 lobes (in crane flies, 6); hemicephalous.

Development takes place in water or is semiaquatic. Most species live as saprophages, but some are phytophagous, mycetophagous, or even predatory.

Suborder: BRACHYCERA

Habitus of the imago is usually more compact (versus Nematocera). Imagos have antennae with less than 6 heteronomous segments, positioned above the prefrontal seam. The first segment of the flagellum has a different shape than the remaining segments; maxillary palp is short (max. 2 segments).

Larvae are hemicephalous to acephalous, and mandibles move in the vertical plane.

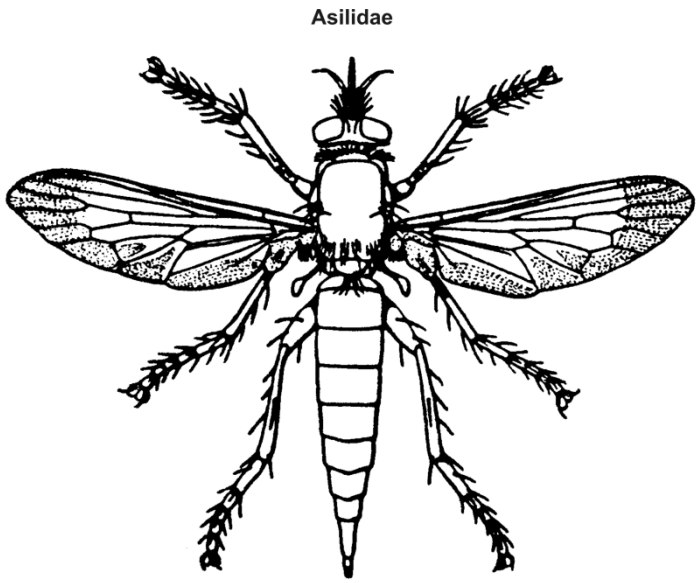
Pupa may be obtecta or exarata coarctata.

Infraorder: ASILOMORPHA

Family: **ASILIDAE** (robber flies)

Medium-sized to large, often intensely hairy species. There is an obvious "brush" on the facial section composed of setae. Eyes are large, dichoptic (not touching on the top of the head), and between the eyes the peak is conspicuously recessed. Antennae face forward. Piercing-sucking mouthparts consisting of a strong proboscis. The proboscis is formed by the hypopharynx and maxillae, creating a closed tube surrounded by the labium. The mandibles and labellum are practically absent. The proboscis is very robust. Legs are also robust, capable of a strong grip.

Imagos are predatory and their food is comprised mainly of Diptera and Hymenoptera, although they also frequently hunt beetles and Hemiptera. They mostly sit on trunks, stones, or other elevated places from which they attack their prey, which they seize with their legs, pierce, and suck. They return to the starting position with the prey. Due to the strong proboscis, they have no problems in overpowering even species with stingers, dragonflies, and strongly sclerotized beetles. Individual species are specialized to a certain degree on certain types of prey. For example, *Dioctria* spp. hunt mostly Hymenoptera (especially ichneumon wasps), and *Molobratia teutonus* hunt bees.



Asilus barbarus

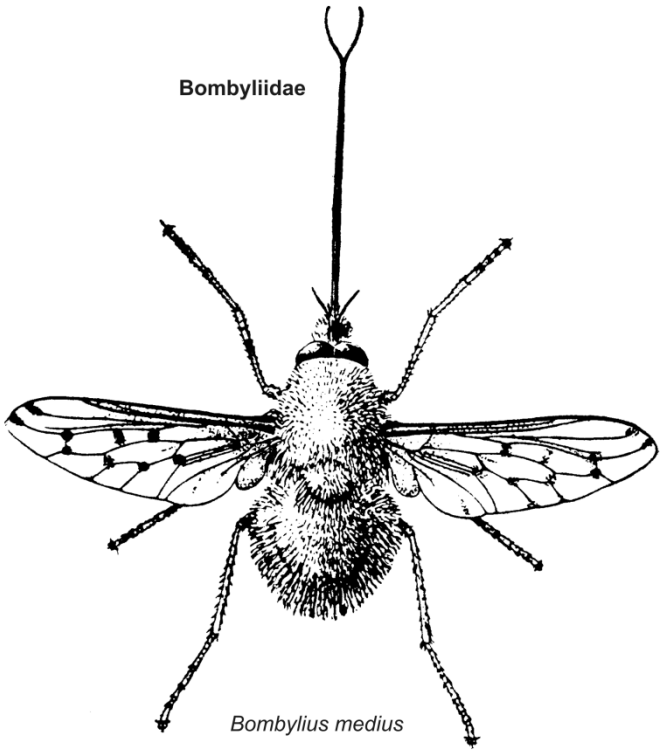
Laying of eggs varies greatly, from simple dropping of the egg to the ground (e.g. the genera *Dioctria* and *Leptogaster*) to direct laying into the ground, affixation to plants, or depositing into cracks and crevices in wood.

Larvae are long and cylindrical. They feed on decomposing parts of plants. Certain species, however, are predatory. *Laphria* spp., for example, live under bark and hunt beetle larvae.

Pupa is obtect.

Family: **BOMBYLIIDAE** (bee flies)

Small to medium-sized (2–16 mm), thickset, and mostly intensely hairy species. They have a conspicuous long, forward-facing proboscis (and their overall shape and, in particular, their intensely hairy bodies strongly resemble bees or bumblebees). Wings mostly have dark markings, and the position of their legs in flight is characteristic – fore and middle legs protrude forward, while the hind legs direct backwards with the tarsi bent up.



Bombylius medius

Imagos feed by sucking nectar from blossoms while in flight.

Larvae develop in egg clutches of grasshoppers and hives of solitary bees and wasps, in caterpillars and pupae of moths, and in larvae of beetles and other insects. In species developing in batches of

grasshopper clutches, the eggs are deposited in their immediate vicinity or directly on them. Species parasitizing bees flick the eggs into the entrance holes. Some of these species may also be encountered on the ground. Here they fill the internal parts of the end of the abdomen with fine sand grains that pile onto the sticky surface of the laid egg and thus protect it to a certain degree. Thin larvae hatch from the eggs and invade the nests. First they feed on the food prepared for the bee larvae, and then they change into a much stockier type of larva that also consumes the larvae of the host species.

Among other Hymenoptera, the larvae of ichneumon wasps are attacked, and thus hyperparasitism occurs. Hyperparasitism is also known in *Hemipenthes morio*, which attacks caterpillars already infested by tachina flies (Diptera: Tachinidae).

More abundant species of the Czech fauna also include the large bee fly (*Bombylius major*), parasitizing bees (especially of the order *Andrena*).

Family: **DOLICHOPODIDAE** (long-legged flies)

Small species (1–7 mm) of metallic green, metallic blue or yellow colour. Antennae set "high" on the head; long yellow legs.

Adults are predators of small organisms.

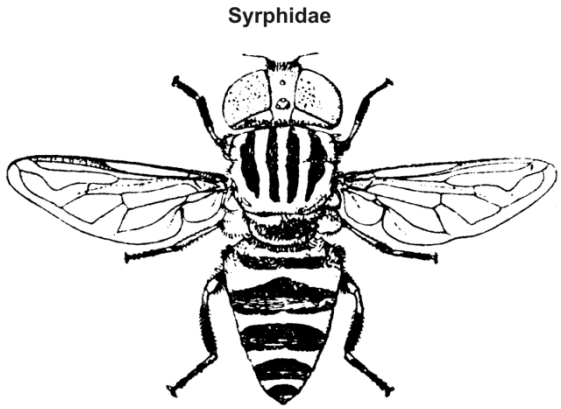
Larvae are mostly predatory, terrestrial and aquatic.

Species of the genus *Medetera* are important in forestry, developing as predators of bark beetles (Curculionidae: Scolytinae). Mortality caused by species of the genus *Medetera* can vary significantly. It depends on the density of infection of the trunk by bark beetles. In case of low infection, their influence is minimal. With a density of 10 bark beetle larvae per 100 cm² of bark, they can cause mortality of 70–90%.

Infraorder: **MUSCOMORPHA**

Family: **SYRPHIDAE** (hoverflies)

Medium-sized to large species. A varied group in shape and coloration. A number of species are brightly coloured, mimicking bees, wasps, or bumblebees (in coloration and body hair).



Eristalinus quinquelineatus

Records from ancient Chinese literature which state that bees use urine to produce honey testify to the fact that this mimetism is perfect. This was undoubtedly due to confusion with the European hoverfly (*Eristalis tenax*), which occurs from early spring to autumn and is distributed throughout the world. Larvae develop in excrement inside toilet sewage reservoirs, dunghills, and the like. Adult hoverflies occur in the same places as bees.

Imagos have a conspicuous manner of flying. Due to the high frequency and suitable positioning of the wings they can practically "hover" in place. They frequently visit blossoms from which they suck

the nectar. Some species only frequent blossoms of certain plant species, and therefore are indisputably also good pollinators of these species. Particularly for plants growing in humid and shady places, hoverflies have immense importance as pollinators and therefore can be seen as second only to bees.

Larvae of individual species may be saprophagous, phytophagous and predatory, with their shape corresponding accordingly:

- Species living in mud, sewage pits, and in hollow trees with decomposing muddy matter are frequently equipped with a very long telescopic breathing tube ending in a spiracle. This tube may reach even several times the length of the body, and thus it limits the depth to which the larva can move. Larval development is usually completed in several weeks. The tube is then retracted, two openings form on the front side of the larva, and the skin changes into a thick puparium. Puparia then accumulate at the edges of water bodies.
- Species developing in humus, compost, manure and the like have much shorter breathing tubes.
- Larvae of *Temnostoma vespiforme* develop in decaying birch wood and are equipped with two chitinous plates in the front part, used to scratch off wood, grind it, and prepare it for consumption.
- Species of the genus *Eumerus* develop in flower bulbs. Larvae are equipped on the surface with prickles which damage the bulb tissues, causing juices to run off on which larvae then feed. A certain number of species also burrow in tissues (leaves and stems) of living plants.
- Larvae of the members of Microdontinae develop in anthills (myrmecophily) and have lost segmentation, thus resembling molluscs. They apparently only feed on dead material (saprophagy).
- The last group are larvae of predatory aphidophagous hoverflies. These larvae are frequently quite brightly coloured and can be found in aphid colonies. Smaller larvae of the first instars feed on eggs, while the more advanced instars feed on larvae. They become active in the evening and morning hours. They use their stylet-like mouthparts to pierce and lift an aphid and then quickly (in about 1 minute) suck out the aphid. The losses on aphids are relatively considerable. A single larva of the third instar consumes 80–100 aphids per day. This group includes members of the genera *Syrphus*, *Epistrophe*, *Scaeva*, *Sphaerophoria*, as well as members of other genera (this group includes about 100 species in Europe). Some species prefer a certain species of aphid, but they are not strictly monophagous and if suitable prey is insufficient they also attack other species of aphids and even scale insects, caterpillars of suitable size, and leaf beetle larvae. Using these aphidophages as a biological control has not been successful, as hoverflies have not been made to copulate in laboratory conditions.

  A long diapause in the larval stage takes place in a number of species.

Pupae are usually drop-shaped or pear-shaped. The head lacks the cross-seam above the antennae, and thus the puparium opens under pressure of the entire head.

Family: **LONCHAEIDAE** (lance flies)

Small species (2–5 mm) with black, blue or green colour; females have long ovipositors.

Larvae are mostly phytophagous but may also be saprophagous or predatory.

Certain species of the genus *Lonchaea* eat eggs, larvae and adults of bark beetles.

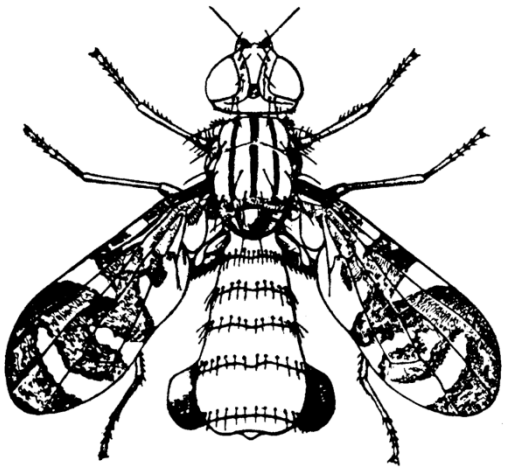
Family: **TEPHRITIDAE** (tephritid fruit flies)

Small to medium-sized species (2–8 mm); wings and body frequently have characteristic coloration; females have a cone-like long ovipositor (sometimes even longer than the body).

Larvae develop in plant tissues, and some form galls.

For example, cherry fruit fly (*Rhagoletis cerasi*) causes worminess of cherries, and celery fly (*Euleia heraclei*) burrows in the leaves of the carrot family, especially celery.

Tephritidae



Platyparea poeciloptera

Family: **AGROMYZIDAE** (leaf-miner flies)

Small species (1–5 mm), predominantly black in colour, conspicuous thorax and wide abdomen. Females have a serrate ovipositor.

Females lay eggs into plant tissues.

Larvae mine in leaves, bast, cambium, stalks, or seeds and fruits. Certain species of the genus *Phytobia* burrow in the cambium of woody plants, causing brown blotch of the wood. Leaves of cereals are mined by *Agromyza megalopsis* and skins of onions and garlic by *Phytomyza gymnostoma.*

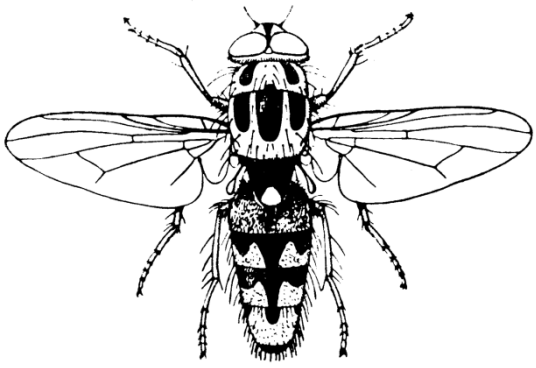
Family: **ANTHOMYIIDAE**

Small to medium-sized species (3–11 mm), mostly dark coloured, rarely yellowish (often with longitudinal stripes on the thorax).

Larvae are saprophagous, coprophagous, phytophagous or predatory. A number of species cause damage by burrowing, and some are pests of agricultural and horticultural plants.

For example, the onion fly (*Delia antiqua*) causes rotting of onions, the wheat bulb fly (*Delia coarctata*) damages wheat bulbs, the beet leafminer (*Pegomya*

Anthomyiidae

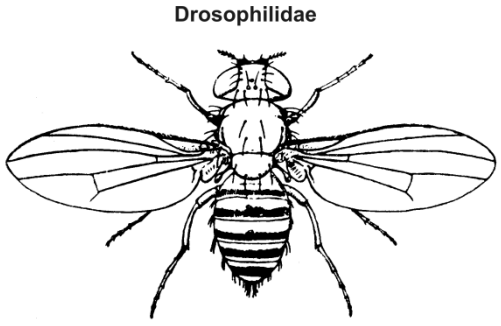


Anthomyia pluvialis

hyoscyami) burrows in beet leaves, and the bean seed fly (*Delia platura*) burrows on the cotyledons and vegetative tips of tomatoes, radishes, beans, peas, lettuce, and other plants.

Family: **DROSOPHILIDAE** (fruit flies)

Small species (1.5–5 mm); yellow-brown body or brown body with darker markings or even uniformly dark. Drosophilidae are most known for being the classic subject of genetic studies (they have only 4 pairs of chromosomes, are prone to mutations, are easy to breed, and have high breeding capacity).



Drosophila funebris

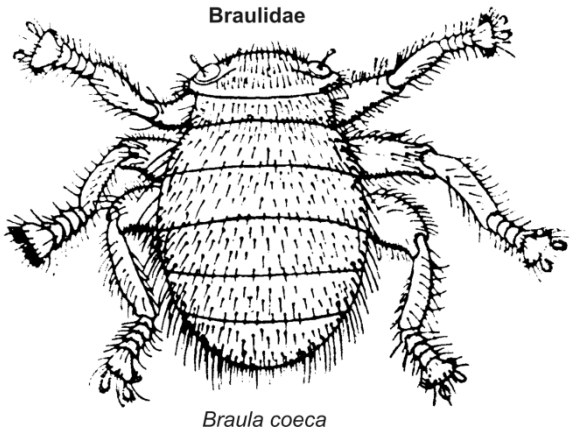
Larvae develop

- in fermenting plant juices (vast majority of species);
- in fungi, faeces, and the like (certain species);
- in living plant tissues as borers (certain species);
- as predators and parasites (exceptionally, for example, *Cacoxenus indigator* in hives of bees and wasps).

The most well-known species is the common fruit fly (*Drosophila melanogaster*). The number of eggs laid by this species ranges between 400 and 500. The entire development may take place within 10 days. Thus, after 30 days the progeny of a single fertilized female can reach an unbelievable 16 million individuals. Similar ratios may also be found in other species of this family.

Family: **BRAULIDAE** (bee lice)

Species of minute size, apterous, halters absent. Body is generally wide and flat. Eyes significantly reduced; legs strongly developed.



Braula coeca

Imagos live attached by comb-like claws to the hairs of bees and steal food intended for the queen and larvae. Females are oviparous; eggs are laid on the walls of cells, especially the surface of lids.

Larvae tunnel through the walls of the hive and feed on the wax. Symbiotic organisms contribute to the digestion of wax (similar to the greater wax moth [Lepidoptera: *Galleria mellonella*] and other species with an atypical single-sided diet).

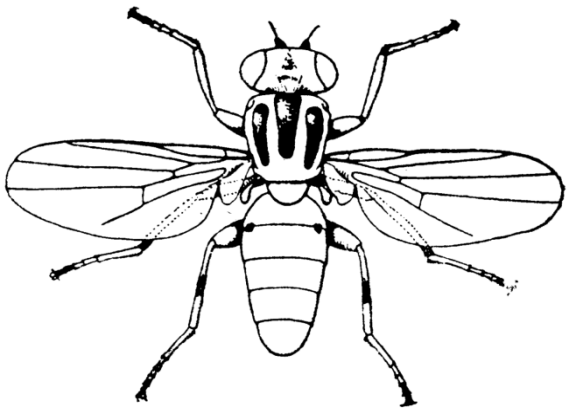
Pupa is white, soft, translucent, in the form of a flattened pear.

Family: **CHLOROPIDAE** (frit flies)

Small species with a conspicuous forehead and yellow, green or black coloured.

Larvae develop in plant tissues (especially grasses). Certain species are important pests of cereals (for example, the barley gout fly [*Chlorops pumilionis*)]).

Chloropidae



Chlorops hypostigma

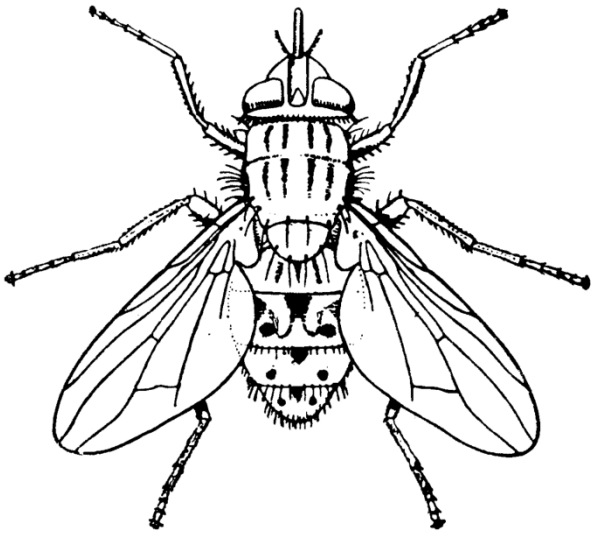
Family: **MUSCIDAE**

Medium-sized species, more or less all resembling the common house fly (*Musca domestica*). Lapping mouthparts. Antennae have 3 segments, basal segment is smooth, and apical is plumose.

Adults may be predatory, haematophagous, saprophagous, or sucking on various plant and animal secretions. Certain species are synanthropic (though certainly not all). Adults, especially of synanthropic species, have hygienic importance as passive vectors of pathogens and diseases.

Larvae are white, acephalous maggots. They develop in rotting plants, dry and wet soil, insect hives, bird nests, in water, on carrion, and in manure.

Muscidae



Stomoxys calcitrans

Most synanthropic species develop in faeces, and the larvae are coprophagous in the first stages and become predatory in subsequent stages. This phenomenon is relatively common frequent also in a number of other Muscidae. Larvae of certain species (e.g. *Hydrotaea* and *Muscina*) are used in forensic entomology to determine a victim's time of death.

The most common species include:

Musca domestica (common house fly) – a cosmopolitan, synanthropic species occurring even in considerably extreme climatic conditions. Males have enlarged, almost touching eyes. At rest, the proboscis is folded on the underside of the head. Imagos ingest liquid food. The common house fly has

great hygienic importance. Some specimens have been determined to contain several million bacteria causing a number of dangerous diseases such as typhus, paratyphus, and dysentery.

After World War II and the discovery of effective insecticides, especially DDT, a large campaign was commenced against this species and a number of others. These measures failed, however, especially due to the selection of resistant forms. It was demonstrated that the 20th generation already exhibited sensitivity to DDT 1,000th that of the first generation.

The largest hatching grounds are dung heaps and places with decomposing plant matter (up to 8,000 individuals can develop in 1 kg of horse manure, 15,000 in the same amount of pig manure). The number of eggs laid by one female can reach up to 2,000.

Between the range of local latitudes, development takes about 2–3 weeks, so about 8 generations develop per year. The result, therefore, is theoretically 20^{24} individuals as the progeny of a single fertilized female. With an average weight of 12 mg/imago, such number of fly bodies is equivalent to 20 concrete cubes with sides of 10 km.

Musca autumnalis (face fly) – settles in large numbers especially on the head and wounds of cattle. Imagos suck secretions in these areas.

Stomoxys calcitrans (stable fly) – similar to the common house fly, but may be easily discerned according to the position of the wings, which are more outspread in resting individuals, and according to the forward-protruding proboscis. Individuals resting on vertical walls are also easily recognizable, as they sit with their head upwards. Larvae of the stable fly develop in dung heaps. Adults attack especially cattle, just like the two European species *Haematobia irritans* (horn fly) and *Haematobosca stimulans*.

The Muscidae also include the feared African species of the genus *Glossina* (also known as the tsetse), vectors of both human sleeping sickness and nagana (a dangerous cattle disease). However, the development of these species is interesting. Larvae develop inside the female body and are laid as fully matured larvae which immediately pupate. Nutrition of the larvae inside the female body is provided by so-called milk glands. The problem of sleeping sickness has essentially been solved through medical treatment, but the problem of nagana remains. Thus, on an area of ca 10 million square kilometres, intensive cattle raising cannot be performed, presenting an immense burden for the national economies of African countries.

Family: **FANNIIDAE**

Adults are generally similar to house flies (Muscidae) and were even previously classified as such.

Larvae also develop in decomposing organic matter, but they have a different appearance: flattened and with numerous leaf-shaped protrusions pointing back.

The most common species is the synanthropic lesser house fly (*Fannia canicularis*), known for its persistent circling around hanging lights.

Infraorder: **STRATIOMYOMORPHA**

Family: **STRATIOMYIDAE** (soldier flies)

Rather small to large species, most brightly coloured, frequently with metallic shine. Abdomen is wide and flat, thorn-like protrusions on the thorax, wings folded over one another at rest.

Adults feed on nectar and pollen.

Larvae are eucephalous, have a conspicuously flattened fusiform body tapering at the back, strongly sclerotized (cuticle reinforced with calcium carbonate). They develop as saprophages,

phytophages, coprophages and predators in humid habitats and water and respire thorough a breathing siphon.

Infraorder: TABANOMORPHA

Family: **TABANIDAE** (horse-flies)

Medium-sized to large (7–30 mm) species. Mouthparts are piercing-sucking, forming a stylet-like labrum, hypopharynx and paired maxillae and mandibles. The cover of the piercing parts is formed by the labium terminating with two labella. Only females are haematophagous (some species, however, suck plant juices), while males are floricolous (much smaller proboscis). Females are generally larger and dichoptic, males smaller and holoptic.

Adults attack warm-blooded vertebrates, including humans. Various species, however, prefer different host species. Humans are attacked primarily by smaller species of the genera *Chrysops* and *Haematopota*, cattle and horses by species of the genus *Tabanus*.

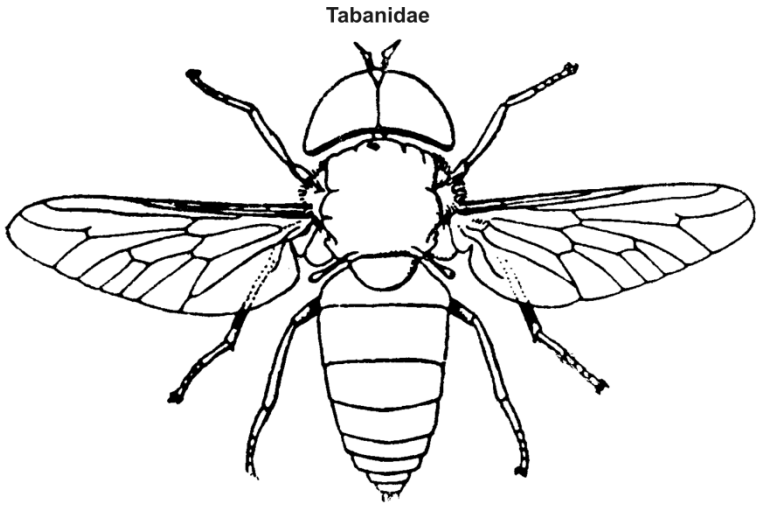
Given the relatively large diameter of the female proboscis, nerves are often damaged by the bite, which is therefore considerably painful. In areas with high incidence of horse flies, animals can lose up to 100 ml of blood per day, which can lead to weight loss and losses in milk production.

They display highest activity in sultry summer days, though some species are not prevented from finding food even in weak rain (e.g. *Haematopota*). Species of the genus *Haematopota* also fly practically without sound and thus landing typically goes unnoticed.

Eggs are spindle-shaped, most frequently dark-coloured. They are laid by the hundreds on plants and soil in the vicinity of water in several layers.

Larvae are hemicephalous (can be drawn inside the thorax), cylindrical, elongated, whitish, tapering at both ends with swelled humps on the ends of the individual body segments (allowing movement in soil and in water). Larvae are mostly terrestrial, but some species also develop in shallow edges of water bodies. They are predatory, feeding on insect larvae, molluscs, worms as well as larvae of its own kind.

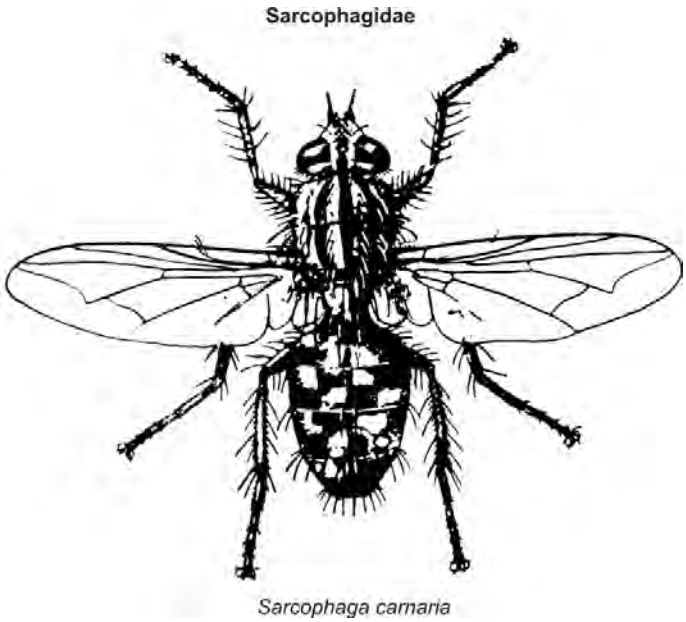
In Africa, horse-flies (species of the genus *Chrysops*) have great hygienic importance as vectors of filariasis (causing the disease called elephantiasis).



Dasystypia fulva

Family: **SARCOPHAGIDAE** (flesh-flies)

Small to large species (3–20 mm), grey-black colouring (frequently checkered) with silvery shine on the abdomen.



Sarcophaga carnaria

Larvae are acephalous, saprophagous (developing on carrion, in manure and in other decaying materials). Certain species lay eggs into open wounds of mammals and other vertebrates. Other species parasitize various invertebrates (earthworms, molluscs, and larvae of grasshoppers, beetles and butterflies).

The frequently occurring common flesh fly (*Sarcophaga carnaria*) develops mainly in earthworms. *Wohlfahrtia meigeni* develops in open wounds of frogs (especially toads), or in festering wounds on the ears and nose of cattle and humans.

Sarcophaga schuetzei parasitize caterpillars of black arches, gypsy moth, and other butterfly species.

Family: **CALLIPHORIDAE** (blow-flies)

Medium-sized to large species, mostly metallic coloured (mostly blue and green), lapping mouthparts.

Larvae are acephalous, mostly saprophagous. They develop in rotting meat, faeces and rotting plants. Some species have adapted to parasitism.

The common species *Calliphora vicina* (urban bluebottle) and *Lucilia caesar* (common greenbottle) develop on carrion, rotting meet, faeces, neglected wounds, ulcers, etc. Larvae of the common cluster fly (*Pollenia rudis*) parasitize earthworms, while those of the toadfly (*Lucilia bufonivora*) parasitize and gradually eat out the nasal mucous membranes of frogs.

Family: **OESTRIDAE** (bot flies)

The entire group develops endoparasitically on mammals, including humans. This family is represented in the Czech Republic by three subfamilies with relatively well-distinguished biologies:

- Gasterophilinae – stomach bot flies,
- Hypodermatinae – hypodermic bot flies, and
- Oestrinae – nose bot flies.

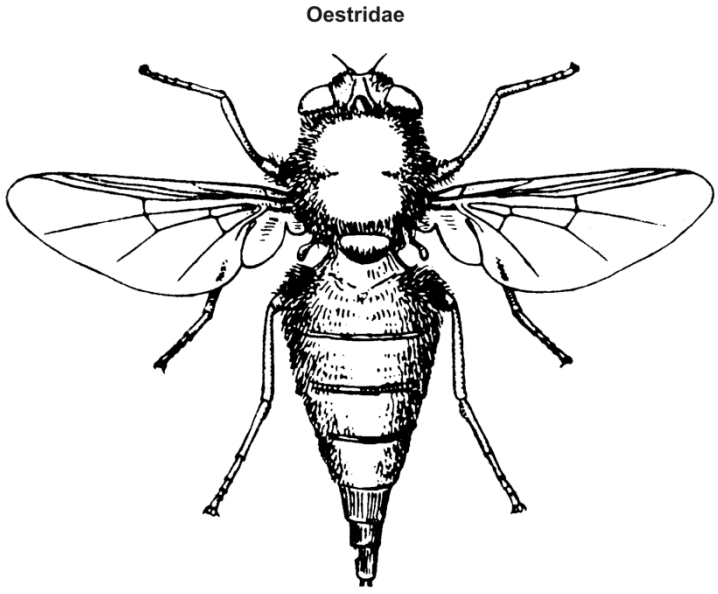
Scientific and popular educational publications assess botflies as excellent fliers. Flight speed is cited to range between 960 and 1,316 km/h (i.e. supersonic speed). Even the Guinness Book of Records stated for a long time that representatives of the subcutaneous bot flies (Hypodermatidae) are the fastest species of flying insects. These entirely unreal estimates are from a 1926 field research study of insect communities in the Mexican mountains during which British entomologist C. H. T. Townsend "measured" this speed. This information was widely cited for decades without anyone verifying it. Surprisingly, and not until many years later, it was discovered that bot flies fly at speeds of only 19–40 km/h (which is still fast for insects, but incomparable with the aforementioned speeds).

If such a small flier were truly to fly at such high speed, it would have to consume 1.5 times its own body weight per second to provide the energy for such movement. Moreover, the air resistance would kill the bot fly immediately at such speed. At supersonic speed, it would be invisible to the naked eye and would have to produce a sonic bang upon reaching the sound barrier. The collision of a bot fly with a human or animal would have a similar effect to the impact of a bullet shot from a low-calibre weapon.

Gasterophilinae

Medium-sized species (9–16 mm), visually similar to the European honeybee. Mouthparts are vestigial. Females have long ovipositors bent under the abdomen.

There are 3 species in the Czech Republic, all from the genus *Gasterophilus* with development in the digestive tract of vertebrates. Hosts are horses, donkeys and zebras (species of the genus *Gasterophilus*), as well as rhinos and elephants. Species of the genus *Gasterophilus* originally ranged only in the Palearctic and Afrotropic ecozones, but with the transport of horses they achieved an essentially worldwide range.



Gasterophilus intestinalis

Eggs are laid in the summer in a number of several hundred on the front part of the host body. Larvae usually enter the mouth cavity via the host's licking and burrow inside the mucous membranes of the lips, cheeks, and tongue. Through the mucous membranes they reach the pharynx where they leave the mucosae and migrate to the stomach or to the large intestine, where they mature. They exit with faeces and pupate in the ground. Highly infested animals lose a certain portion of nutrients, but the development of young larvae in the mucous membranes is of greater importance from a veterinary perspective. Infected mucosae bleed, are frequently holed, and cancerous tumours occur on them.

Hypodermatinae

Medium-sized species (10–15 mm), similar to bumblebees, thick-haired body, mouthparts vestigial. Females of most species have a long telescopic ovipositor.

Larvae develop under the skin of even-toed ungulates and rodents (in exceptional cases, humans), and the female lays eggs onto the host body. Larvae are stubby, with very thick perpendicular rows of small thick teeth on the body segments. Pupation occurs inside a puparium in the ground. They have one generation per year.

The most significant species evidently are:

Hypoderma bovis (cattle warble fly) – females lay eggs on fur, most frequently on limbs or belly. The number of eggs laid by a single female can reach up to 500–600. The cattle instinctively senses the danger of the buzzing parasite and tries to escape by panic fleeing. After 3–8 days the larvae hatch and dig into

the host body. Over the course of about 7 months, the larvae travel along the peripheral nerves under the skin to the back of the infected animal. There, they project their hind part equipped with spiracles on the surface of the skin. The host organism tries to encapsulate the parasite, and thus lumps the size of up to pigeon eggs occur in those places. During the next 3 months the larvae mature, and finally the ca 3 cm long larvae leave the host's skin and pupate in the ground. After 4 weeks, an adult hatches from the pupa.

Hypoderma lineatum – females lay eggs practically without the host noticing and the eggs get inside the host's body via licking. They then spend ca 7 months in the tissues of the pharynx and then go through the intercostal muscles to reach the skin of the host's back.

Hypoderma diana lives similarly on roe deer and red deer.

Hypoderma actaeon lays eggs on the fur of deer. They get into the rumen via licking and from there they migrate by biting under the skin along the spine. Swellings reach sizes up to those of chicken eggs.

Damage caused by bot flies includes decreased overall fitness of the animal, which is connected to higher sensitivity to infections and parasites, as well as decreased production of meat, milk, and degradation of the hide. *Hypoderma tarandi* causes similar damage in the north in reindeer herds.

Species developing in rodents have a distinct biology. Larvae usually get under the skin in the immediate vicinity of the laid egg, do not travel through the host body, and leave it after about 1 month.

Oestrinae

Medium-sized but robust (10–18 mm), often strongly haired or bald species, vestigial mouthparts.

Development occurs in the nasal cavity, sinuses and pharynx. They primarily infect ungulates, and only exceptionally other hosts. Several exotic species develop in rodents and leporids, and kangaroos and elephant are each hosts of one species.

Swarms of imagos can be seen in the afternoon hours of sunny summer days around towers and tops of hills, where copulation also occurs. Females only live for about 2–3 weeks and are viviparous. A single female produces up to 500 larvae which are injected during flight into the host's nasal opening. The larvae live until the next spring in the mucosae of the nose without growing much. Further development rakes place in the nostrils, pharynx, and areas at the base of the tongue to which the 2nd and 3rd instars penetrate. As adults, they reach sizes of up to 4 cm. Adult larvae are coughed out and pupate in the ground. The new imagos emerge after a 3–5-week pupal period.

They cause respiratory problems and troubles in swallowing food, resulting in lower weight gain and decreased fitness connected with higher susceptibility to infections. A known symptom is hearing impairment.

Important species include:

Oestrus ovis (sheep bot fly) – parasitizes in sinuses of sheep, causes so-called false gid and pneumonia. The disease has a rough progression, often terminating with the death of the animal.

Cephenemyia auribarbis (stagworm) – parasitizes deer.

Cephenemyia stimulator – parasitizes roe deer; several tens of larvae may even cause death by asphyxiation.

Pharyngomyia picta – larvae parasitize in the nostrils of deer (especially red deer, less frequently fallow deer, roe deer, but also elk and reindeer).

Rhinoestrus purpureus – infects horses and donkeys.

Family: **TACHINIDAE** (tachinids)

Small to medium-sized species, postscutellum (back part of the scutum) bulged, conspicuously long prominent setaceous setae on the thorax and especially the abdomen (similarity with flesh flies [Sarcophagidae]), arista on the antennae usually hairless. Taxonomically one of the most difficult families of Diptera.

Larvae are endoparasites of insects. They mostly develop in butterfly caterpillars, although certain species also develop in larvae of beetles, Hymenoptera, adults of beetles and typical bugs, and even in crane fly larvae, earwigs, Orthoptera, and ants. As parasitoids of many important pests, they are of great importance in regulating their numbers.

Adults are active especially in warm sunny days. On cold days and in the morning cold, they like sunbathing. In low air humidity (usually around midday), they hide under leaves and in other hiding places (e.g. close to the ground covered with vegetation). Females are oviparous, but may also be ovoviviparous. This also relates to laying of eggs. Tachinids may be divided accordingly into several groups:

- Certain species attempt to place eggs on the host's body. The surface of such eggs is covered with a sticky secretion that facilitates the egg's sticking onto the host's body even despite defensive movement. The usual number of eggs laid by a single female is relatively small, ranging between 50 and 200.
    - In oviparous species there is considerable danger that the larva will moult and the tachinid egg will also be cast off with it. Approximately around 30–40% of eggs die this way.
    - In this respect, ovoviviparous species have much better chances, as the larva hatches shortly after the egg is laid.
    - In certain species the ovipositor is even adapted to enable placing the egg inside the host's body (e.g. *Compsilura* spp.).
    - A very specific method of laying is found in *Rondania dimidiata*, which parasitizes adults of true weevils (also the large pine weevil [*Hylobius abietis*]). Small eggs are laid directly inside the beetle's mouth cavity.
- The second group of tachinids lays eggs in the vicinity of the host or on the food the host consumes. As the probability that the hatched larva will encounter a suitable host is small, these species hatch enormously high numbers of eggs, and thus the batch number may exceed even 5,000 eggs. Despite this drawback, such strategy also has its advantages. For example, parasitization can also occur in hosts with nocturnal activity (when adult tachinids are not active), or on such hosts that are unavailable for laying on the body.
    - In oviparous species of this group, the eggs must be consumed by the host within 2–3 weeks.
    - Larvae of ovoviviparous species either wait until they come in contact with the host and actively attach to it (e.g. *Ernestia rudis*, a very abundant parasite of the pine beauty), and in certain species they even actively seek the host.

Larvae of various species of tachinids also act in various ways once in contact with the host:

- Some immediately invade deep inside the host body and in the first and/or second instar they make do with the oxygen from the host's body fluids. In subsequent instars, however, they either stick spiracles out of the host body or connect to its tracheal system.
- Another group of larvae remain burrowed such that the abdominal spiracles are on the surface of the host. The infected host tries to isolate the parasite and separates it from the tissues of its own body

with a kind of membrane. The membrane is permeable enough, however, to allow the development of the first larval instars. More mature larvae pierce this membrane and infect deeper positioned organs.

As the victim must stay alive until the development of the tachinid larvae has finished, initially only parts "expendable" for the life of the host are consumed. These are mainly the haemolymph and the fat body. Only the last instar also consumes critical organs and generally also causes the death of the host.

Most frequently, a single egg is deposited on the host (so-called solitary parasitoids), though in some species several eggs are deposited (mass parasitoids). The relation between the parasitoid larvae also develops depending on the number of parasitoids and the amount of available food. In such conditions, very often only a single larva survives.

Certain species are monophagous (e.g. *Cyzenis albicans*, parasitizing winter moth), but they are mostly oligo- to polyphagous. In which case, there can be dozens of hosts.

In the overwhelming majority of species, the mature larva abandons its host, burrows several centimetres into the ground, and pupates. Only a very small number of species pupate in the host's body.

Tachinids are among species very important for controlling populations of significant pests in forests and elsewhere. When monitoring and predicting the further development of a calamity, it is therefore always necessary to consider parasitization by tachinids. This generally includes inspecting the litter in infected stands and of course also checking their health, as even tachinids are infected by a number of natural enemies (mainly parasitoids from the order Hymenoptera).

Family: **HIPPOBOSCIDAE** (louse flies)

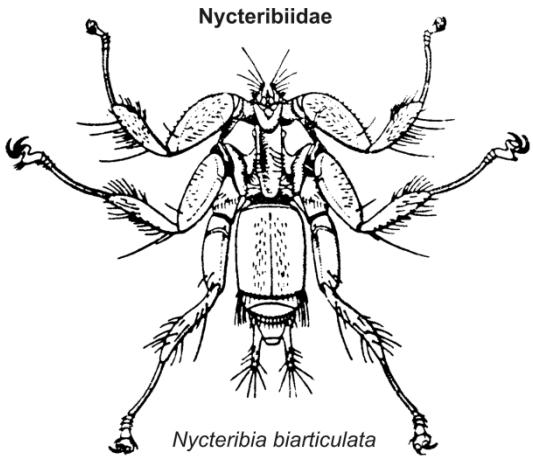
Species of smaller size (3–8 mm); flat bodies, strongly sclerotized with leather-like abdomen. Head has very limited movement, almost firmly connected to the thorax, mouthparts piercing-sucking and rigid. Legs are long, spread to the sides, adapted for movement in hairs and feathers (they move with equal dexterity forward, to the sides and backward); both winged and apterous species, with smooth transitions. For example, deer ked (*Lipoptena cervi*) is a fully winged species, but the wings break off shortly after a host is found. In *Ornithomya biloba*, there are apparent signs of wing reduction, although the imago is able to fly from nest to nest. Further reduction can be seen in the swift louse fly (*Crataerina pallida*), which is only capable of gliding flight. Some species are entirely wingless (e.g. sheep ked [*Melophagus ovinus*]), but the wings are based in the embryum. In connection with the parasitic lifestyle and flight capabilities, eyes are also reduced to various degrees. These are normally developed in species with fully developed wings, while in species with reduced wings the eyes are also reduced.

Imagos live as ectoparasites on mammals and birds, feeding off blood – both sexes. All species give birth to mature larvae that pupate immediately (larvae are nourished inside the female body by so-called milk glands). In a number of species, the surface is sticky, thereby allowing them to keep on the host or in its vicinity.

Symbiotic bacteria are present in the body of adults, compensating for the one-sided blood diet. These are also passed on to the progeny during larval development.

Humans may also sometimes be attacked, occasionally in the autumn by the deer ked (*Lipoptena cervi*) or forest fly (*Hippobosca equina*), but by far most frequently by the swift louse fly (*Crataerina pallida*) in the spring, in the period before its natural host (the swift) returns from overwintering.

Family: **NYCTERIBIIDAE** (bat flies)



Small-sized species (2–4 mm), flat and strongly sclerotized body, yellow-brown to dark brown coloration. Head is arched back to the dorsum of the thorax, eyes are strongly reduced to absent, long legs spread to the sides, ventral ctenidium (comb of thickened setae), adaptation for movement in fur, species are apterous, halters developed.

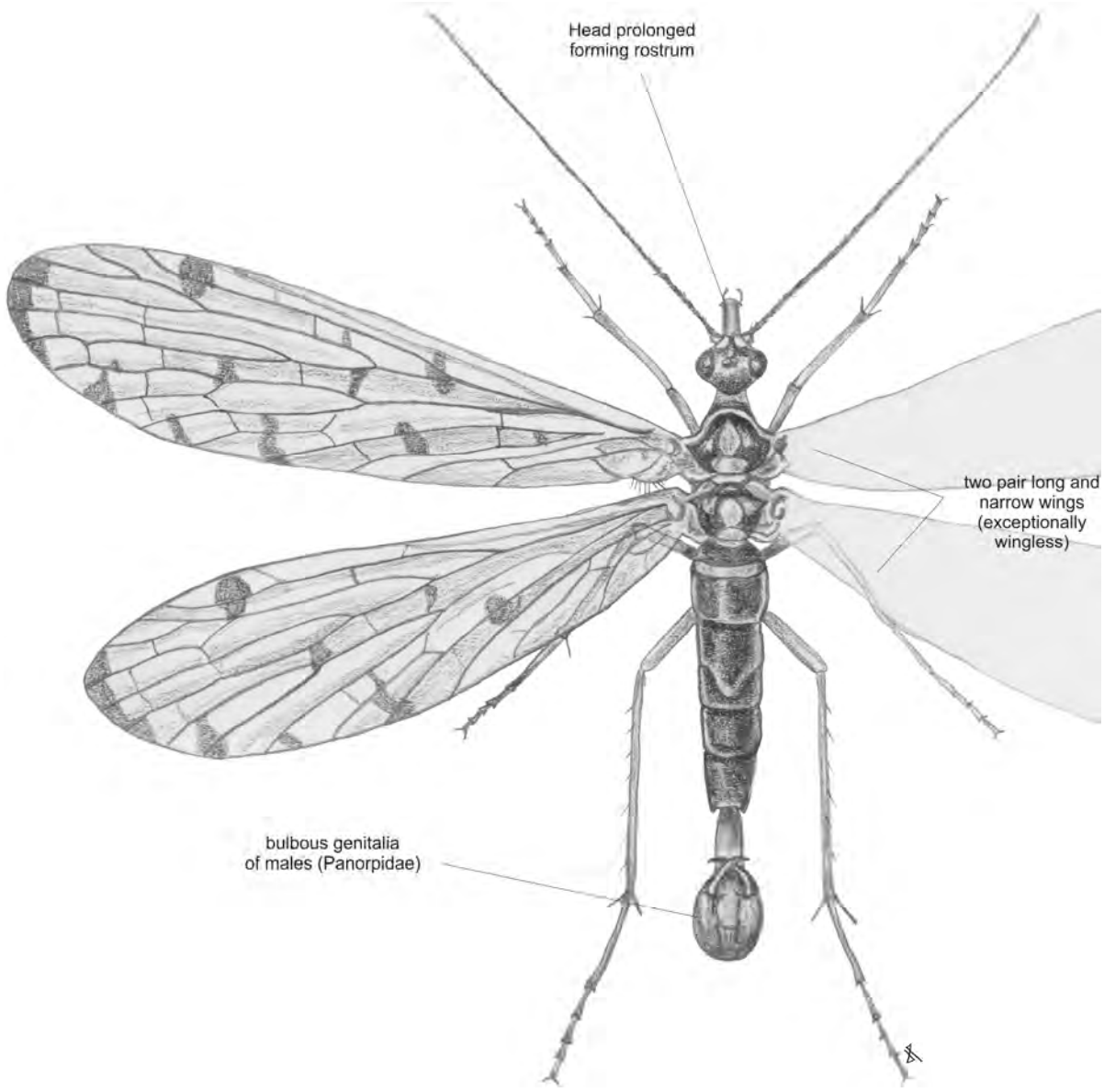
Exclusive parasites of bats (similar species of the family Streblidae also parasitize bats, but they are thermophilic species not represented among Czech fauna). Due to a similar lifestyle, their development is almost identical to Hippoboscidae (louse flies), including the mechanisms for keeping larvae on the host, nourishment of larvae inside the females' body, etc.

Infraorder: VERMILEONOMORPHA

Family: **VERMILEONIDAE**

Small to medium-sized species. Adults feed on nectar; larvae are predatory. They hunt other insects, especially in sandy soil where the larvae form funnel-shaped traps, just as do certain antlions (Neuroptera: Myrmeleontidae).

Order: **MECOPTERA** (scorpionflies)		
derivation of the order's name meco (Greek) = long, pteron (Latin) = wing	number of known species in the world 550	number of known species in the Czech Republic 8
Metamorphosis: **holometaboly**		



Systematics

An ancient group of insects (known from findings from the Permian, therefore one of the oldest Holometabola). It systematically divides into 2 suborders:

- Suborder: **Eumecoptera** (the families Panorpidae and Bittacidae from the fauna of the Czech Republic), and
- Suborder: **Neomecoptera** (family Boreidae).

General characteristics and body description of the adult

Size 2–35 mm. All species inhabit moist, shady biotopes.

Head is elongated into a snout. The snout is formed by an extended clypeus and basal parts of maxillae (stipites) and labia (submentum). Actual chewing mouthparts are at the end of the snout. Eyes are relatively large, oval, or kidney-shaped. Ocelli are developed (however, only rudimentarily in the family Boreidae). Antennae are long, filiform, and consist of 15–55 segments.

Thorax bears two pairs of thin, elongated oval wings with well-developed pterostigma. At rest, the wings are folded askew over the abdomen. In flight, both pairs of wings move at the same time and are connected on the bases with bristles; however, flight is fluttery and clumsy. In Boreidae (and certain Bittacidae), the wings are reduced and used as an auxiliary organ in copulation. The prothorax is small, movably connected to the massive mesothorax.

Legs are long, of more or less identical shape (Boreidae are able to jump). Tarsi have 5 segments, and the terminal segment is equipped with two claws. Only in Bittacidae are the legs very long (thus the imago resembles a crane fly) and equipped with only a single claw (the last segment moves against the preceding one like a pocket knife [raptorial legs]). In other groups, the legs are gressorial.

Abdomen has 10 visible segments, the first segment is reduced and partially fused with the metathorax and there is a pair of 2–3-segmented cerci on the end. In Boreidae, an elongated ovipositor is formed. In males, a pair of 2-segmented gonopods is always formed. The end of the abdomen is prominently formed in males of the family Panorpidae, where it is narrowed and then conspicuously widened. The widened part bears pincers.

Larva

Larvae are eruciform (caterpillar-like), i.e. polypod eucephalous. The head is well-developed, strongly sclerotized, with chewing mouthparts and compound eyes developed. From the thorax, only the prothorax is markedly sclerotized. There are unsegmented pseudopods on the first abdominal segments.

Pupa

Pupa is capable of biting (pupa dectica).

Food

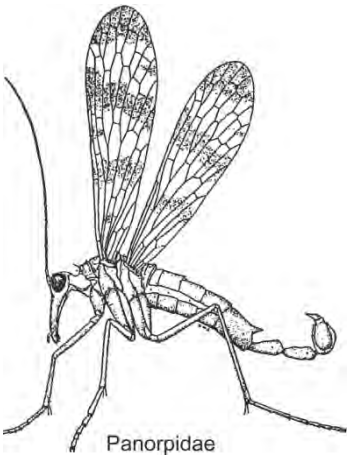
Adults feed mostly on dead animal or plant food (Panorpidae) or suck on soft parts of mosses (Boreidae). Bittacidae are predators, hunting small arthropods.

Larvae feed on dead plant and animal matter.

Suborder: EUMECOPTERA

Family: **PANORPIDAE** (common scorpionflies)

Imago feeds on dead arthropods or dead plant and animal substances. Food, however, is not chewed, but decomposed by a secretion before consumption and then sucked in.


Panorpidae

In males, salivary glands mature in a period of 8–10 days and are a requirement for mating. Before copulation, a drop of the salivary gland secretion is discharged, which the female consumes during copulation (or is supplied by another). Mating occurs several times over the course of ca 3 weeks. Approximately 4 days after mating, the female lays eggs into the ground in stacks of around 25–75 eggs connected by a secretion. This is always repeated after subsequent mating ca 3 times. In total, a female lays about 150 eggs.

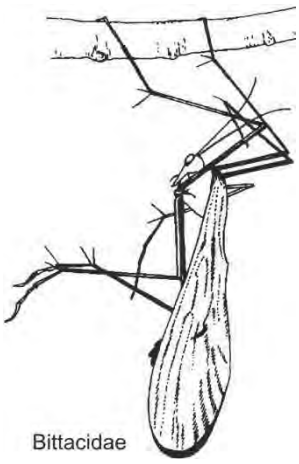
Embryonic development lasts for about 1 week. **Larvae** are of the caterpillar type, and on the first 8 abdominal segments they have 8 pairs of unsegmented pseudopods. On the end of the body, a prehensile apparatus is developed as a rectal diverticulum from 4 lobate appendages bearing hooks. This apparatus is used for inchworm-like movement, but it can also be used for standing perpendicularly to a surface. The head is strongly sclerotized and bears chewing mouthparts.

The larva lives in a tunnel only a small depth beneath the surface of the soil, goes through 4 instars, and feeds on dead animal and plant matter. Development in *Panorpa communis* lasts ca 30–40 days. The adult larva reaches lengths of around 18 cm, and the pupal stage lasts 11–13 days. The pupa is capable of biting, is free, and is situated in a pupal cradle 3–5 cm underneath the surface. The pharate imago works its way to the surface before hatching in the pupal stage.

The generation is usually double or single. The larva of the first or second generation overwinters. Imagos emerge from May and live only slightly longer than a month.

Family: **BITTACIDAE** (hangingflies)

Strikingly similar to crane flies (long legs). In contrast to all other Mecoptera, it has tarsi ending in only a single claw that closes like a knife against the previous one and serves for hunting small insects.


Bittacidae

Imagos are predators that suck their prey dry. They hunt either during clumsy flight or wait hanging by their forelegs for prey to approach. They occur from the end of July to autumn. They fly especially during dusk and also hunt at night. There is only one species in the Czech Republic, *Bittacus tipularius*.

After catching prey, the male hangs and by bending the abdomen everts the skin between the 6th and 8th abdominal segments while simultaneously secreting a liquid that attracts females.

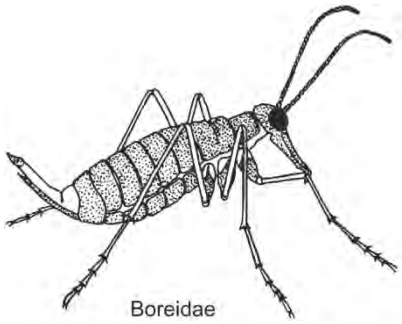
After copulation, during which the male frequently offers the prey to the female, the female lets the eggs fall to the ground. The eggs have a conspicuous cube shape and overwinter.

Larvae are equipped with tubercules on their dorsal side with finger-like branches and also bear setae. These structures capture detritus particles, so the larvae are well masked. As in scorpionflies (Panorpidae), they have a developed clinging apparatus (rectal diverticulum). They move on the surface of the soil, feeding primarily on dead arthropods. The larva reaches lengths of around 15 mm and pupates in the ground similarly to Panorpidae. The pupal stage also lasts briefly (up to 14 days) and an imago hatches. One generation per year.

Suborder: NEOMECOPTERA

Family: **BOREIDAE** (snow scorpionflies)

A family known only from the Holarctic region. It is also the only family in the fauna of the Czech Republic belonging to the Neomecoptera suborder. Only 2 out of the 25 known species occur in the Czech Republic. They are most frequently found in sparse beech or pine forests. They can be easily distinguished from other scorpionflies by the long ovipositor of the females and shortened wings of both sexes. Saltatorial movement is also prominent.

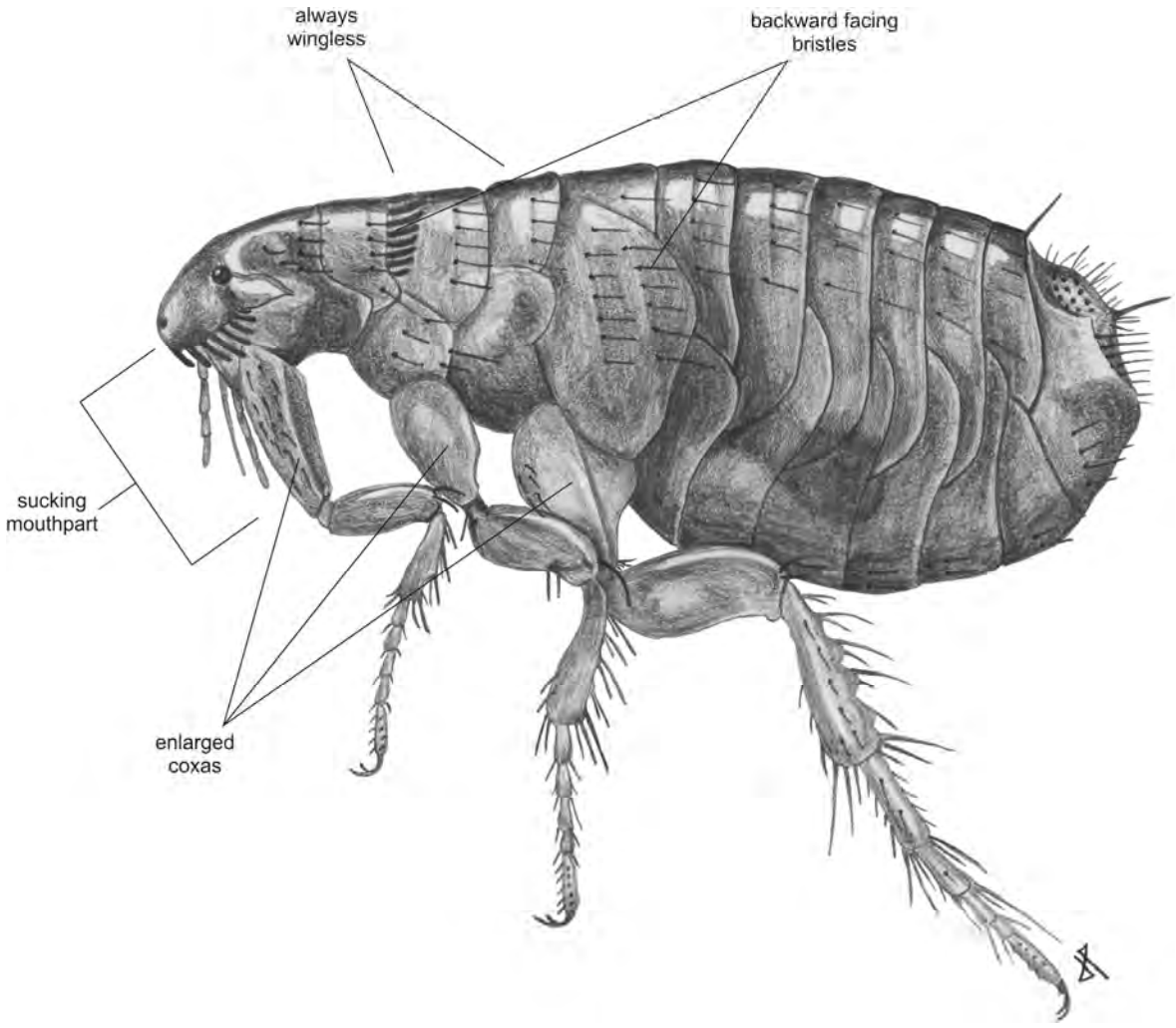

Boreidae

Imagos hatch in the autumn, usually at the end of October, and mate in the same year (copulation lasts very long, sometimes even several days, and the male carries the female on its back). Under favourable conditions, imagos are also active in winter, but particularly in early spring (until March). Thus they may be encountered also on snow, especially during a thaw. They prefer temperatures of around 10°C. The imago feeds on dead insects and thalli of mosses, on which they suck the soft parts.

The female lays eggs individually or in small piles of ca 10 eggs into the ground on the bases of moss pads.

In April, the **larvae** hatch, which have developed only thoracic limbs and entirely lack limbs on the abdominal segments, as well as structures on the dorsal side of the body. The larvae develop in the upper layer of the soil in the area of moss roots and overwinter. They feed on detritus, plant substrate, and mosses. In the second year they barely ingest food. In August, they make a pupal cradle lined with thread (sparse cocoon) and after 40 days of the pupal stage, the imago hatches. The imago lives for about 6 months.

Order: **SIPHONAPTERA** (fleas)		
derivation of the order's name siphon (Greek) = siphon, aptera (Latin) = wingless	number of known species in the world 2,500	number of known species in the Czech Republic 85
Metamorphosis: **holometaboly**		



Systematics

Fleas are an ancient group dating back to as early as the Mesozoic, parasitizing small mammals of that era. Phylogenetically, scorpionflies (Mecoptera) are the most closely related group. They systematically divide into 4 superfamilies.

General characteristics and body description of the adult

Fleas are yellowish, rusty, brown to black. Coloration, however, depends on the age of the flea, ecological conditions (for example, open spaces vs. dark burrows), and on the filling of the intestine with blood. Body size of 0.75–8 mm. Females of the genus *Vermipsylla*, in which the abdomen is considerably extended during the maturation of eggs, can reach sizes of up to 15 mm.

Imagos are always secondarily wingless, laterally flattened, straw-yellow to dark brown. The body is covered with backwards-facing prickles and combs.

Head bears piercing-sucking mouthparts. Stylets are formed by both laciniae of the maxillae and a non-paired epipharynx. The labial palp then forms the sheath of the stylets. The entire mouth is considerably endocephalic. The 4-segmented maxillary palp is a prominent component of the mouth. Eyes are developed or may also be absent. They are likely to be laterally placed ocelli, not compound eyes. Antennae are essentially 3-segmented, while the last segment (so-called capitulum) may be secondarily divided into as many as 9 segments.

Thorax bears 3 pairs of relatively long legs. Coxae are robust and protrude away from the body. The legs enable relatively long jumps, while the ability to jump is at the same time considerably dependent on the host species and its life conditions. Tarsi have 5 segments and the last tarsal segment has 2 claws.

Abdomen has 10 segments, and the last segments are often significantly modified (especially in males). No ovipositor is developed, while the male has an intricately-shaped phallus.

Egg

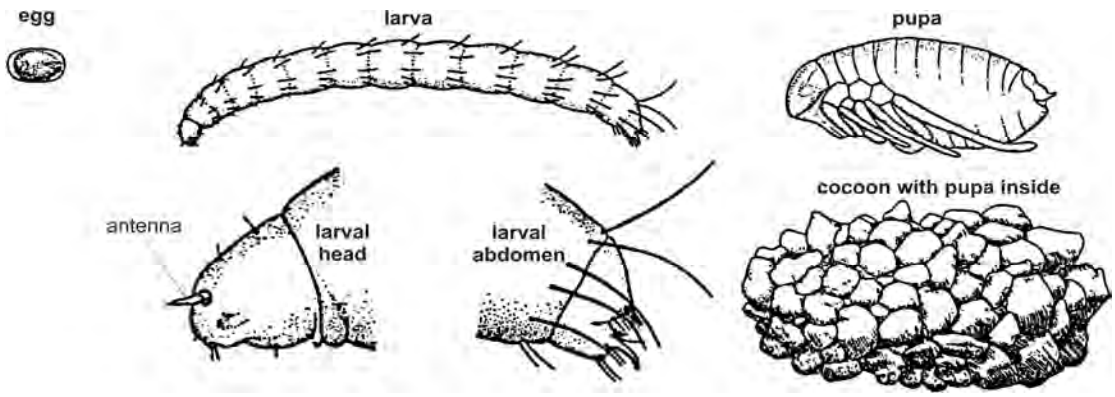
Eggs are oval and whitish.

Larva

An apod, eucephalous, vermiform larva with a well-developed head capsule hatches from the egg. It breaks free from the egg casing with a strong thorn-like egg tooth on the head. Chewing mouthparts with serrated mandibles. Antennae have a single segment. The last abdominal segment features 2 spurs. Chaetotaxy (hair arrangement and number) is important for distinguishing larvae.

Pupa

Pupa is not capable of biting and is free (pupa adectica exarata libera), enclosed in a cocoon.



Ecology

Exclusive ectoparasites of mammals and birds. Most fleas are not strictly tied to a single host. Some species live on hosts their entire lives, while others are found on hosts only when ingesting food and otherwise live in their tunnels, nests, and the like. The same applies for mating, which for some species occurs on the hosts and for others outside. In certain species, sucking of blood must occur before mating; while in others (e.g. in fleas living on birds) mating occurs immediately after hatching.

Depending on the species, the female lays **eggs** on the host or in the den/nest, in several clutches with several eggs each. The total number of eggs laid by a single female is relatively high (400–500). Upon completion of embryonic development (usually 1–2 weeks), the larva hatches with the help of the egg tooth.

Larvae go through a total of 3 instars and then pupate in a cocoon spun from the secretions of the salivary glands. The cocoon is outwardly masked by detritus. An imago hatches from the pupa in 3 weeks, but only leaves the cocoon under favourable conditions, usually on the basis of mechanical impulses from the host (sometimes after several months).

Food

The imago feeds on blood. Sucking is so intensive that even undigested blood is shortly excreted. The larva is not parasitic, feeding on detritus, organic remains, or droplets of undigested blood excreted by the imago, outside the host's body. In exceptional cases (only in exotic species), larvae may live permanently on the host (e.g. in the flea *Haplopsyllus glacialis* parasitizing European hare, which does not have a permanent den, and in *Uropsylla tasmanica* living in Australia and Tasmania in the skin of marsupials).

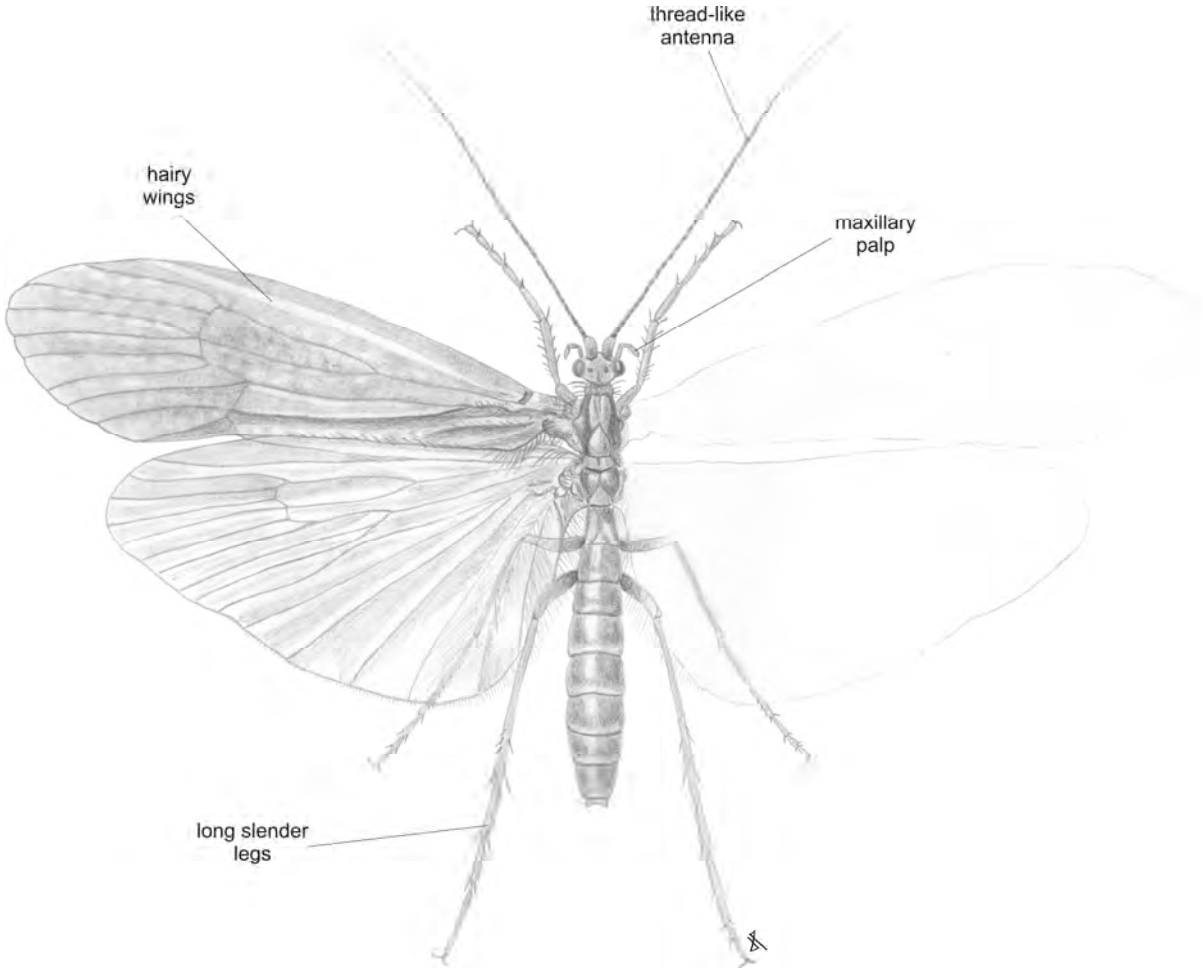
Importance for humans

Fleas are dangerous carriers of diseases such as plague (*Yersinia pestis*) and murine typhus (*Rickettsia mooseri*).

List of certain host species and their typical fleas

Host	Species of flea
Oryctolagus cuniculus (European rabbit)	*Spilopsyllus cuniculi*
Lepus europaeus (European hare)	*Spilopsyllus cuniculi*
Marmota marmota (Alpine marmot)	*Oropsylla silantiewi*
Ondatra zibethicus (Muskrat)	*Ctenophthalmus assimilis*
Felis domestica (Domestic cat)	*Ctenocephalides felis*, *C. canis*, and *Pulex irritans*
Canis lupus familiaris (Domestic dog)	*Ctenocephalides canis*, *C. felis*, and *Pulex irritans*
Vulpes vulpes (Red fox)	*Chaetopsylla globiceps*, *Ch. trichosa*, *Paraceras melis*, *Pulex irritans*, *Ctenocephalides canis*, and randomly also a number of others
Martes martes (European pine marten)	*Monopsyllus sciurorum*
Mustela erminea (Stoat)	*Ctenophthalmus agyrtes*, *C. assimilis*, *Megabothris turbidus*, *Palaeopsylla soricis*, and *P. similis*
Mustela nivalis (Least weasel)	*Ctenophthalmus agyrtes*, *Megabothris turbidus*, *Ctenophthalmus assimilis*, and *C. solutus*
Meles meles (European badger)	*Paraceras melis*, *Chaetopsylla trichosa*, *Ch. Globiceps*, and *Pulex irritans*
Homo sapiens (Human)	*Pulex irritans*, also *Ctenocephalides canis*, and *C. felis*; *Ceratophyllus columbae*, *C. gallinae*, *C. hirundinis*, and *C. agyrtes* were also recorded

Order: **TRICHOPTERA** (caddisflies)		
derivation of the order's name trichos (Greek) = hair, pteron (Latin) = wing	number of known species in the world 7,000	number of known species in the Czech Republic 240
Metamorphosis: **holometaboly**		



Systematics

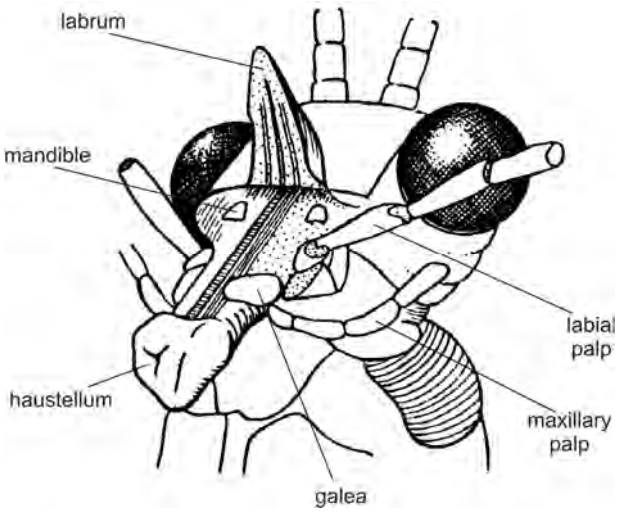
A group closely related to butterflies (Lepidoptera), as indicated also by wing venation. They systematically divide into 3 suborders, primarily based on the morphology of the maxillary palp of imagos:

- Suborder: **Spicipalpia** – the last segment of the maxillary palp is not annulate (secondarily segmented on the surface); more complex wing venation;
- Suborder: **Annulipalpia** – the last segment of the maxillary palp is annulate and also mostly pointed at the apex; wings are frequently without scales, only setae; and
- Suborder: **Integripalpia** – the last segment of the maxillary palp is not annulate, not pointed to the apex, and wings have scales and setae.

Caddisflies have worldwide distribution but are found mostly in the temperate zone of the Northern Hemisphere. They range not only far to the north, but also in mountains. In European mountain ranges, they may be encountered even at elevations of around 3,000 m a.s.l.

General characteristics and body description of the adult

Size from 5 to 30 mm. Imagos are very similar to one another, do not move far from water, and are mostly nocturnal; aquatic larvae.



Head is usually small, densely haired. Antennae are long, many-segmented, and are held at rest in front of the body. Eyes are well-developed, medium-sized, strongly bulging, 3 ocelli (exceptionally 2) or absent. Chewing mouthparts, but strongly modified for lapping or sucking. Mandibles are rudimentary, galea of the maxillae is small to reduced, 5-segmented maxillary palp, labium transformed into a haustellum (a kind of proboscis) enabling the intake of plant juices, 3-segmented labial palps.

Thorax – small prothorax, strong mesothorax, normally-developed metathorax.

Legs are gressorial, strong, and long. Tarsi have 5 segments with 2 claws and an arolium. Tibiae are frequently prickly (in many species, the mid-tibia and tarsi are widened into natatorial legs); long coxae. They enable quick and nimble movement.

Wings are developed in 2 pairs (aptery is rare, especially in females). The front pair is more leathery, the hind membranous. Hind wings are shorter but wider than the forewings. Both pairs are ciliate, and if scales are present then they are along the veins (even so, they have a different structure than in butterflies). Venation is predominantly longitudinal, with a minimum of cross-veins. Both pairs of wings are connected to each other; movement is simultaneous; flight capabilities are quite good. Wings are folded roof-like at rest.

Abdomen has 9 segments in males and 10 segments in females. The 10th segment of females often has small cerci. In certain families, a longer ovipositor is developed.

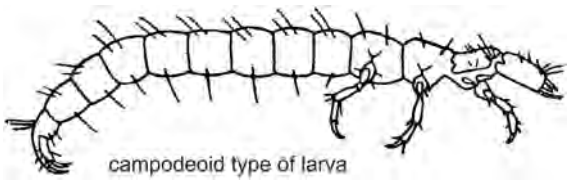
Egg

Eggs are small, mutually connected by secretion.

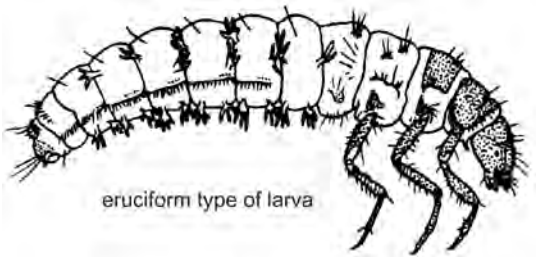
Larva

There are essentially two types of larvae (with transitional forms occurring):

- **campodeoid** – prognathous head, slightly dorsoventrally flattened; long and segmented pseudopods on the apex of the abdomen; tracheal gills developed or respiration through the entire body surface; thick setae not developed; usually lack protective capsules (living freely or constructing funnel-shaped nets);



- **eruciform** – orthognathous head; cylindrical body; they stabilize themselves inside the capsule via hooks on the end of the abdomen; always with filiform tracheal gills and long, fine setae on the 3rd–8th abdominal segments; mostly with protective capsules.


eruciform type of larva

The head capsule is well-developed; chewing mouthparts; antennae are very short and single-segmented; 6 larval eyes (stemmata); labial spinning glands developed.

The prothorax is strongly sclerotized, the mesothorax less so, and the metathorax is very softly sclerotized (similarly to the abdomen).

Forelegs are always the shortest but the strongest (holding prey and the structure of the capsule). The other 2 pairs are used for movement.

The abdomen has 9 segments. In eruciform larvae, 1–3 eversible humps (1 dorsal and 2 lateral) fixing the larva inside the capsule and enabling water to circulate around the body are located on the first segment. The last abdominal segment bears a pair of conical pygopods that terminate in strong claws (in eruciform larvae, keeping inside the capsule; in campodeoid, movement in nets). In eruciform larvae, the pygopods are merged and create the impression of a seeming 10th abdominal segment. The abdomen of most species is equipped with tracheal gills. Their development depends on the oxygen content of the water in which the species lives. Species inhabiting cold swiftly flowing mountain water have less-developed or missing gills, while species of still waters have more developed gills (exceptionally, tracheal gills are also on the thoracic segments).

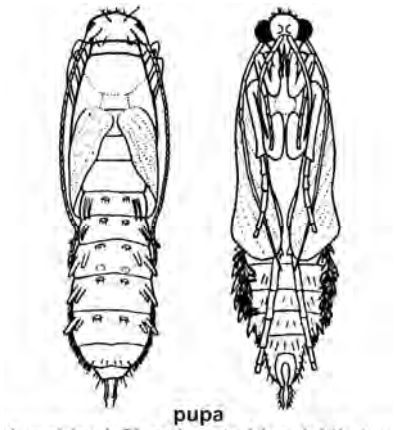
Depending on the species, the number of larval instars is 5–7, while tracheal gills occur only from the 2nd instar. The rectal retractable gills are used as auxiliary respiratory organs.

Larval capsules

The capsule is based on a case spun from the products of the spinning glands. Exceptionally, this concludes the construction of the capsule (certain Leptoceridae). Usually, the larva places further organic and inorganic material on this base, which is sometimes species-specific, and at other times the capsules change according to the age of the larva and the season. Light capsules of plant matter are typical for species inhabiting still water, while heavier mineral material is typical for species living in strongly flowing waters.

Pupa

Pupa is capable of biting (pupa dectica); sometimes enclosed in a cocoon.


pupa
dorsal (on left) and ventral (on right) view

Ecology

Imagos of most species occur in the summer months (but some also in spring and autumn). The lifespan of the imago ranges from several days to a maximum of 1 month.

Mating mostly occurs individually, while in certain species mass swarming is known. In the genus *Hydropsyche*, a swarm consists only of males circling around females sitting on a tree. In representatives of the families Leptoceridae and Philopotamidae, the swarm involves both sexes, and they frequently swarm during the day. Sperm is transferred in a spermatophore.

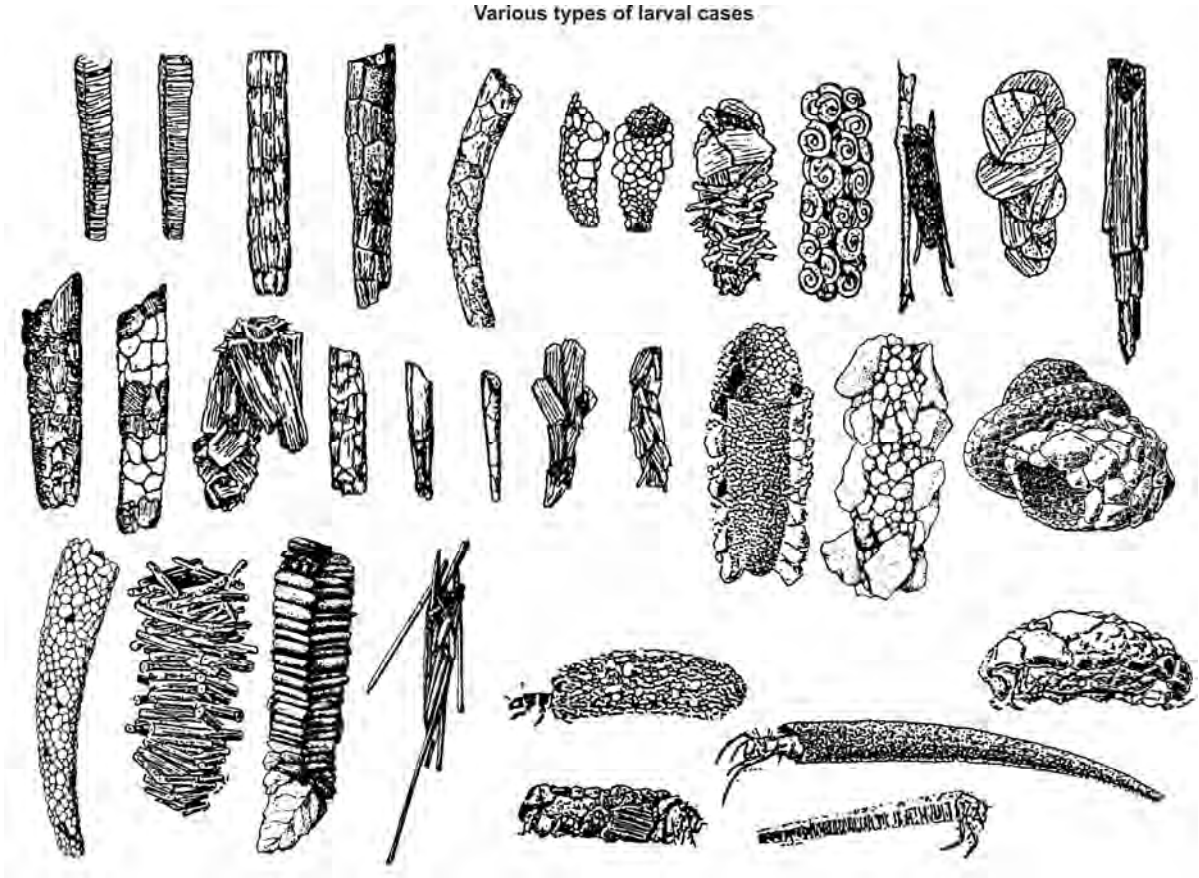
Up to a week (but even only a few hours) after fertilization, the female lays eggs, always together and bound by secretion (a total of 10–1,000 eggs). Egg clutches in the form of packets are either simply deposited into water (especially species of still and moderately flowing waters), or the females attach them to plants and other material in the immediate vicinity of water. The female covers the eggs with an adhesive that protects them very well from drying out. The adhesive loosens in rain and the packet falls into water. Females of certain species actively enter the water and stick the eggs onto objects underwater.

Embryonic development of 9–24 days. Hatched larvae develop in flowing waters, smaller numbers in still waters. Certain species develop in brackish water and 1 Australian species can be considered marine. In exceptional cases, the larvae are terrestrial. In the genus *Enoicyla*, the females are wingless and the larvae lack tracheal gills. They develop in the soil or moss. They construct simple capsules covered with soft soil particles and feed on mosses and algae (also on trees). These include for example the species *Enoicyla pusilla* of the Czech Republic, which develops in moist litter of deciduous forests.

All species have strongly developed salivary (spinning) glands, the product of which is spun by the forelegs, either for constructing complex hunting nets as well as the capsule or only for constructing the pupal capsule.

Larvae overwinter most frequently (eggs and pupae only rarely). They mostly have 1 generation per year (some species, however, have 2 generations per year, while others have 1 generation every 2 years).

Pupation occurs most frequently without a cocoon. With the exception of 2 terrestrial species of the genus *Enoicyla*, pupation occurs in water. The larva closes the front and back opening of the capsule with netting permeable to water and after approximately 2 days it transforms into a pupa. The pupal stage lasts 2 weeks at most. The pupa dectica is mobile, leaves the capsule, and swims or crawls above the surface. The imago usually hatches overnight.

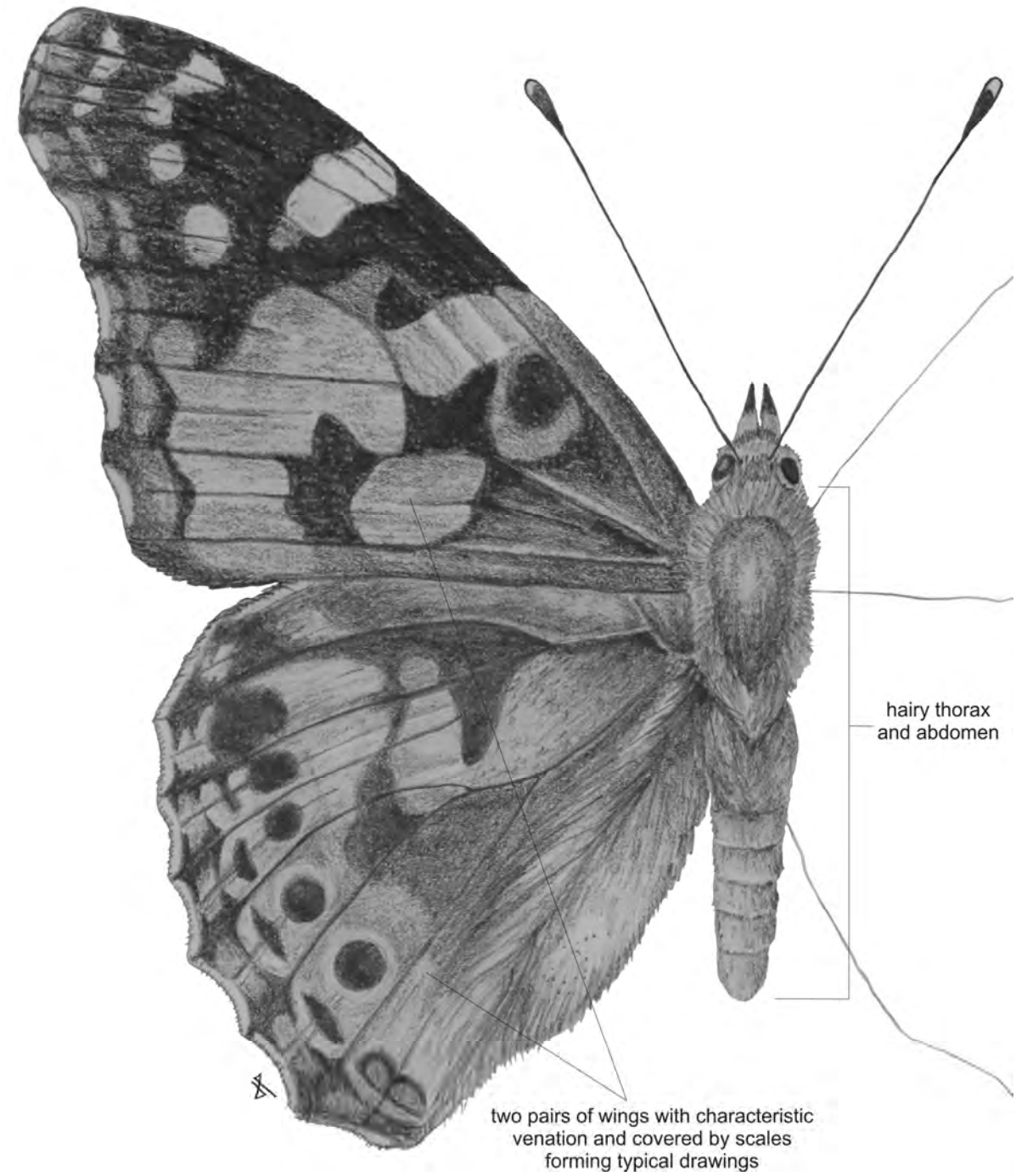


Food

The larvae of most species are phytophagous. They feed on algae coatings, but also consume dead and living parts of plants (mostly eruciform larvae). A number of species are, however, predatory (mostly campodeoid larvae).

Imagos feed on nectar and drink water.

Order: **LEPIDOPTERA**		
derivation of the order's name lepis (Greek) = scale, pteron (Latin) = wing	number of known species in the world 165,000	number of known species in the Czech Republic 3,450
Metamorphosis: **holometaboly**		



Systematics

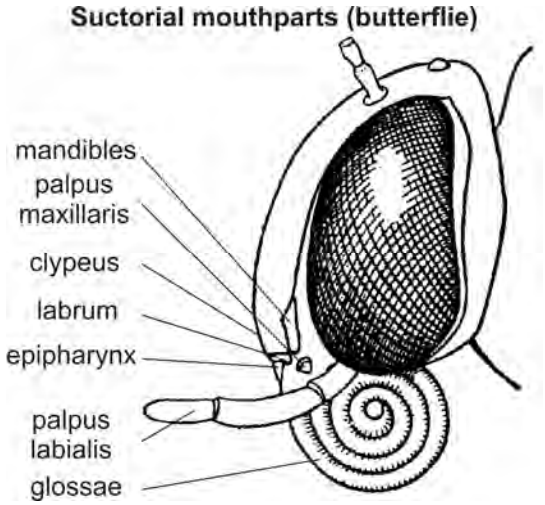
The third most numerous order (after beetles and Hymenoptera), the higher classification of which is still divided. Higher classification of the order stems from the morphology of the mouthparts, female reproductive system, wing venation connection of fore and hind wings, antennae, and even size.

- Suborder: Zeugloptera – only a single family, Micropterigidae; functional mandibles (only 9 species in the Czech Republic).
- Suborder: Aglossata – only 1 family, Agathiphagidae (only in the Australian region).
- Suborder: Heterobathmiina – only 1 family, Heterobathmiidae (only in the south of South America).
- Suborder: Glossata – all other species; rudimentary or completely reduced mandibles; in the majority of species, a proboscis is well-developed.

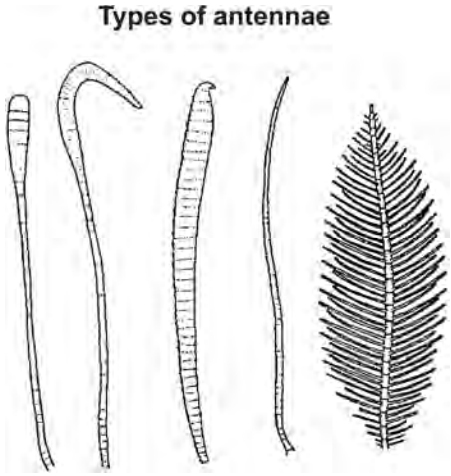
General characteristics and body description of the adult

The overwhelming majority of species are active at night or dusk; a much smaller number is active during the day.

Head is orthognathous, freely mobile. Compound eyes are well-developed, bulging, and, especially in nocturnal species, occupy almost the entire surface of the head (in this case, typically superpositioned eyes with a mobile pigment). In a number of species, 2 ocelli are developed (in the immediate vicinity of the eye orbits).



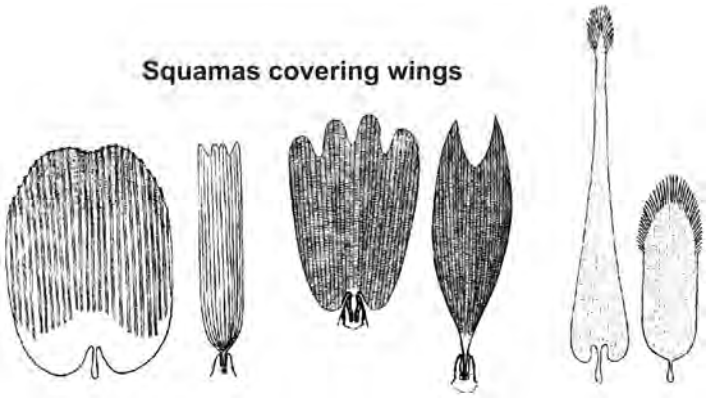
Suctorial mouthparts with a conspicuously elongated proboscis are formed by the galeae of the maxillae. At rest, the proboscis is rolled under the head in a spiral (in exceptional cases, the proboscis is short). Mandibles are vestigial (functional only in Micropterigidae, rudimentary in Eriocraniidae [i.e. in species feeding on pollen]). The labium is small with mostly well-developed labial palps, which are mostly 3-segmented, but may be vestigial in certain groups. Maxillary palps are mostly developed, from 5-segmented (primitive groups) to single-segmented to entirely reduced (although they may be strongly enlarged in some groups; for example, certain representatives of the family Tineidae, the genus *Nepticula* from the family Nepticulidae, the genus *Epicrocis* from the family Pyralidae, and others). In species not ingesting food, mouthparts are vestigial (e.g. in cossid millers [Cossidae], eggars [Lasiocampidae], and tussock moths [Lymantriidae]).



Antennae are variously formed, most frequently setaceous, filiform, sometimes slightly capitate at the end (in diurnal butterflies, exceptionally also elsewhere), or possibly serrate and one-sided or double-sided pectinate. The number of antennal segments ranges from 7 to almost 100 and their forms often reflect sexual dimorphism. Characteristic conspicuously long antennae far exceeding body length are found in the family Adelidae (fairy longhorn moths).

Thorax – prothorax is only very weakly developed; the meso- and metathorax are much larger.

Two pairs of wings are developed. In females, however, wings are frequently reduced and even completely absent (for example, in bagworm moths [Psychidae], many geometer moths [Geometridae], rarely also other families, such as the rusty tussock moth [*Orgyia antiqua*] and tussock moths [Lymantriidae]).

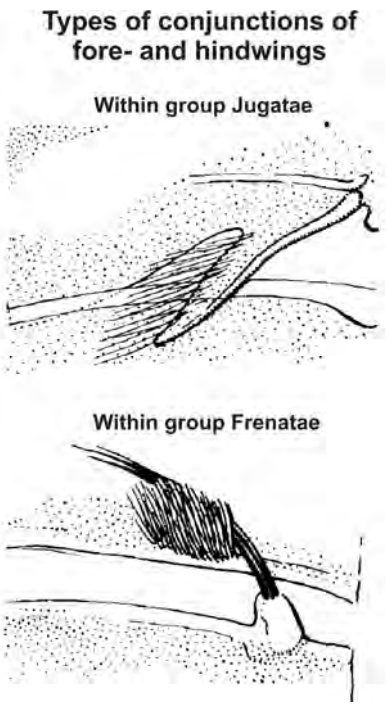


Wings are covered in scales that are only rarely absent in certain places. For example, Thyrididae (picture-winged leaf moths), Sesiidae (clearwing moths), some bee hawk-moths of the genus *Hemaris* (hawk moths [Sphingidae]), whites (Pierinae) of the genus *Aporia* (Pieridae), and Apollos of the genus *Parnassius* (swallowtail butterflies [Papilionidae]) have wings with larger or smaller areas not covered with scales. Very rarely, scales are replaced by fine hairs. The scales are flattened and extended hollow hairs filled with air and have a very specific structure. They have highly diverse shapes and colours, narrowed at the bases into a very short stem. They cover the wing membrane like roof tiles, frequently even in several layers, and thus create the wing's characteristic coloration or design. The scales, however, cover not only the wings, but also the body and frequently even all bodily appendages.

Wing venation provides one of the most significant systematic characteristics. In the more original groups, the number of longitudinal veins is larger and the wings also show cross-veins (e.g. Hepialidae [swift moths]), while in more derived groups the venation is more reduced (e.g. Pieridae). In two families, the wings are strongly divided between the veins (Alucitidae [many-plumed moths] and Pterophoridae [plume moths]).

The movement of the wings is synchronous. The connection of the fore and hind wings is provided:

- in the Jugatae group by the so-called jugum, a pointy protrusion of the back of the forewing wedged into the ciliation of the front edge of the hind wing;
- in the group Frenatae by one (in males) or more strong bristles (so-called frenulum) growing from the front edge of the hind wing, caught by the scale-covered folds on the underside of the forewing (so-called retinaculum);
- however, there are also forms where synchronous movement is only provided by a certain setting of the wings.



At rest, the wings are most often folded roof-like over the body. At other times, they are outstretched on a surface or raised (diurnal butterflies). Exceptionally, there may be a different resting position.

The frequency of oscillation and performance of wings vary. Undoubtedly, the best fliers are hawk moths (Sphingidae) and skippers (Hesperiidae), for which wing movement is so fast that they

are almost able to hover in place. Hawk moths are, however, also endurance fliers (e.g. the death's-head hawk moth [*Acherontia atropos*] is a migratory species extending to the Afrotropic region, must thus travel at least 2,000 km).

Legs are gressorial, tarsi have 5 segments, terminating in 2 claws, 1 arolium, and 2 pulvilli. Reduction of the forelegs is common in Papilionoidea (e.g. in Nymphalidae [brush-footed butterflies]) and reduction of the hind legs in Geometridae (geometer moths). Reduction of all legs is rare (males of Psychidae [bagworm moths]).

Abdomen has 10 segments, densely covered with scales. Cerci are not developed. It is more robust in females and slimmer in males. Membranes connecting the individual segments are especially long in females, so they enable the telescopic extension of the abdomen, thus forming a false ovipositor. In males, the 9th and 10th segments are genital. In females:

- in the Monotrysia group, there is 1 sexual orifice developed behind the 9th segment serving for copulation and laying eggs; and
- in the Ditrysia group, there is 1 ovipositor orifice developed behind the 9th segment, and 1 copulation orifice developed behind the 8th segment.

Sperm are transferred in spermatophores to an organ called the bursa copulatrix, which is equipped with chitinous protrusions, where the spermatophore is ruptured and as a result the sperm are released, passing through the seminal duct and reaching the spermatheca connected to the vagina. Female sexual organs are characteristic for individual species and are widely used for the taxonomy of Lepidoptera. The rather complexly structured male external genitalia are similarly used.

Sensory organs of the imago

- In members of various families, a drum-like (tympanal) auditory organ is developed, which is usually located either on both sides of the 3rd thoracic segment (Noctuoidea), on the base of the abdomen (Geometroidea and Pyraloidea, but also Drepanoidea), or at the wing base in certain Nymphalidae (especially Satyrinae [browns]) and Thyrididae (picture-winged leaf moths). Certain Sphingidae (hawk moths) hear with their mouthparts. They are able to perceive sound with the 2nd segment of the labial palp (in this case, not a tympanal organ).

The auditory organs register ultrasound with frequencies of 30–80 kHz (wavelengths that correspond to echolocation sounds produced by bats). Flying nocturnal lepidopterans react to these sounds in various ways. They either accelerate their flight while simultaneously zigzagging, or fall to the ground with wings drawn to the body and pretend to be dead. The most intense response was recorded during frequencies of 60–80 kHz and at a distance from the sound's source of under 4–5 m from the object.

- Females are equipped with scent organs serving for very intensive luring of males. These organs are located on the terminal abdominal segments and the smell of an unfertilized female is perceived by the male antennae. Sexual pheromones secreted by females are not entirely species-specific, and various species react to pheromones of another species (e.g. the males of *Lymantria monacha* respond to the pheromone of *L. dispar*, males of the Indian Meal Moth [*Plodia interpunctella*] respond to the pheromone of Mediterranean Flour Moths [*Ephestia kuehniella*], and vice versa).

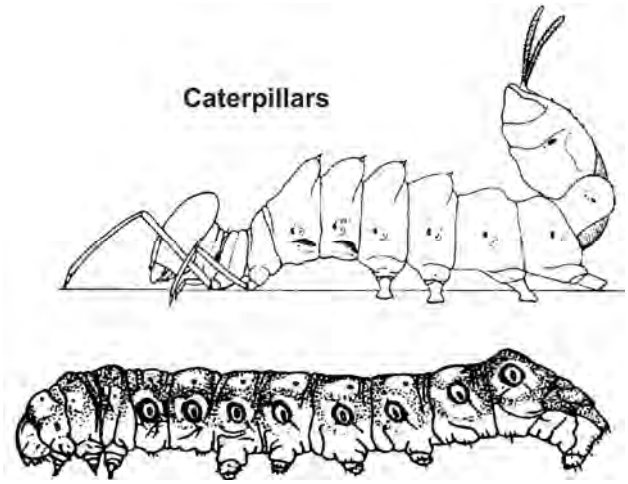
Antennae are equipped with several types of sensory organs called sensilla. Apart from setaceous sensilla sensing primarily mechanic impulses, there are also short sensilla shaped like short cones and recesses with thin walls covering small olfactory cones underneath. They are sites of olfaction and their numbers vary considerably (e.g. in the species *Inachis io* there are around 50 of these olfactory cones on a single antenna, while in nocturnal lepidopterans their number ranges between 500 and 1,300).

- Apart from olfactory orientation, sight also plays a large role in seeking food and partners (especially in diurnal butterflies). It seems that only the colour of the flower is decisive, while the shape apparently plays no role.
- Taste organs are located on mouthparts, but in certain lepidopterans they have developed secondarily also on middle and hind tarsi.

Egg

Eggs can have various shapes, with a smooth surface or with more or less distinctive surface structure (most frequently net-like or grooved). The size of eggs is closely related to their numbers. In species with small eggs (e.g. Hepialidae [swift moths]), the number of eggs can range up to around 2,000. In species laying large eggs (e.g. *Aglia tau* [Tau Emperor]), the number of eggs ranges only around 40. Eggs are fertilized just before laying. Even in Lepidoptera, however, there are known cases of parthenogenetic reproduction (e.g. in some bagworm moths [Psychidae] and tussock moths [Lymantriidae]). Embryonic development lasts for various periods, and frequently the cold winter season is a necessary condition for further development.

Larva



Larvae (so-called caterpillars) are eruciform, i.e. polypod and eucephalous.

The head is mostly well-developed, prognathous to orthognathous, with chewing mouthparts, strong mandibles, short maxillary palps, a labium with a spinning gland, short antennae (mostly 3-segmented), and developed lateral stemmata (6 of them, frequently reduced to as low as 1 or 2).

Thoracic limbs are 4-segmented, with 1 tarsal segment with a single claw.

The abdomen has 10 segments. On the 3rd–6th segment, there are usually 4 pairs of 2-segmented prolegs. Likewise, the last abdominal segment also has prolegs (so-called anal prolegs). Prolegs bear small hooks on the ventral side that can be developed along the entire circumference (crochets [pedes coronati]), or the ring of hooks is incomplete (pedes semicoronati). The first case is common in species with an endophagous lifestyle.

In many species, a tendency towards reduced abdominal limbs can be noted (e.g. in owlet moths [Noctuidae]). In geometer moths [Geometridae], anal prolegs and the last pair of prolegs are usually developed.

In certain species, even the anal prolegs can be modified. In prominents (Notodontidae) of the genus *Drepana*, the anal prolegs are transformed into a non-paired, short, bluntly ending protrusion. In the genus *Stauropus*, paired spherical protrusions are developed, and in the genera *Dicranura* and *Cerura* they have morphed into long furcated forms.

The number of limbs may differ from this scheme in exceptional cases. In Micropterigidae, for example, limbs are developed on all abdominal segments. In pigmy moths (Nepticulidae), with caterpillars mining in leaves, fruits, and stalks, the total number of limbs is 18. In species from the family Coleophoridae (case-bearers), which live in sacs, of the abdominal

appendages only the anal prolegs used for holding in position inside the sac have remained functional. In other species of the same family mining in fruits, only 3 pairs of abdominal prolegs are preserved (similarly, certain owlet moths [Noctuidae] also can have 3 pairs of prolegs).

The body is generally cylindrical, sometimes flattened (Lycaenidae [gossamer-winged butterflies] or mining species). In certain species, however, the individual body segments bear various protrusions or even humps (for example, a number of geometer moths [Geometridae]), and in extreme cases the overall shape of the caterpillar is strongly changed (for example, in prominents [Notodontidae] and in species of the genera *Stauropus*, *Dicranura*, *Notodonta*, and *Cerura*), especially in relation to the modification of anal prolegs. Highly atypical caterpillars can be encountered also in the family Limacodidae (slug moths), where the bald caterpillars resemble small slugs in their shape and secreted slime.

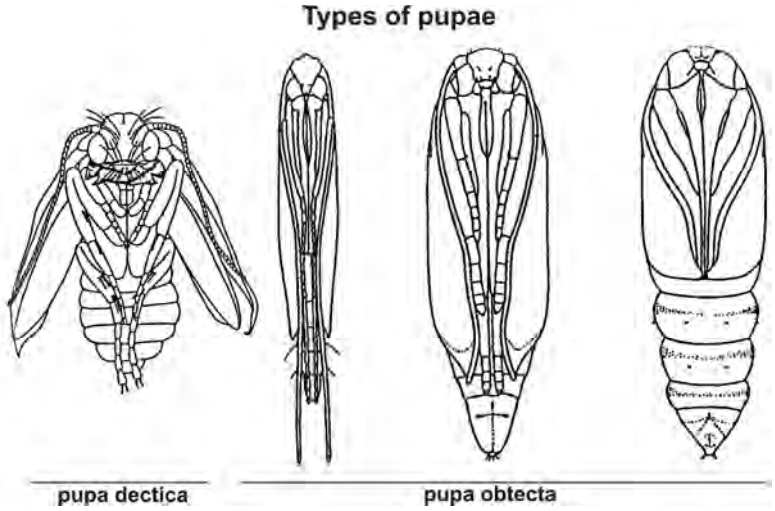
Hairs usually grow out of the skin to various degrees; rarely are they almost completely bald (owlet moths [Noctuidae]). In other cases, tubercules are developed; hairs are long and often concentrated into tufts (e.g. in black arches [*Lymantria monacha*] and *L. dispar*). Sometimes, the hairs even resemble a wide brush (e.g. in rusty tussock moths [*Orgyia antiqua*] and *Dasychira pudibunda*). The hairs of some species are poisonous, break off easily (especially on drying exuviae), and can cause irritating inflammation of mucous membranes and skin (e.g. oak processionary [*Thaumetopoea processionea*]).

There are 5–6 instars. In some species, however, the number of moults depends primarily on external conditions and thus may be much higher (for example, 6–12 in the common clothes moth [*Tineola bisselliella*]). In the course of development, significant changes in coloration occur in many places, which is the most striking among caterpillars of the 1st and 2nd instar.

Pupa

Pupae are essentially of two types:

- **pupa obtecta** – the only organs not connected to the body of the pupa are the sheaths of the long proboscis in lepidopterans with a very long proboscis (e.g. hawk moths [Sphingidae]); almost all species.
- **pupa dectica** – with freely protruding appendages. In the Czech Republic, only in primitive Micropterigidae and Eriocraniidae.



The last conical segment of the pupa is called the cremaster and frequently bears species-specific thorns, hooks, or other chitinous structures primarily used to hold the pupa to the spun thread.

The pupa either hangs upside down (frequently in diurnal butterflies) or is bound by threads with the head aiming upwards. Pupation frequently occurs in spun thread (cocoons), which are produced by the spinning glands and made by the caterpillar of the final instar. Various plant remains can also be interwoven into the cocoon. The pupation period has various durations; many species overwinter in the pupal stage. In some species, the pupa even lasts into other years, similar to Hymenoptera. When the

imago hatches, the pupa cracks on the head and back, and lengthwise along the line of the antennae sheaths.

Ecology

The overwhelming majority of species are active at night or dusk; a much smaller number is active during the day.

Most free-living species have 1 generation per year; more rarely, 2 generations per year or two-year generations occur. Synanthropic species can even have several generations per year due to man-made favourable conditions.

Caterpillars live:

- mostly freely:
  - on assimilatory organs (most species),
  - on the surface of soil (e.g. Micropterigidae), and
  - in soil (certain owlet moths [Noctuidae]).
- covertly in constructed shelters and sacs (e.g. case-bearers [Coleophoridae] or bagworm moths [Psychidae]) from various plant materials. Certain species also use soil particles for its construction (or rather covering), such as the genera *Diplodoma* and *Narycia* from the family Psychidae, and others. Many species roll up leaves (e.g. totrix moths [Tortricidae]).
- endophytically (inside plant tissues):
  - A large number of species develop in leaf mines (Eriocraniidae, Tischeriidae, and most Gracillariidae);
  - in other plant organs; in seeds, inside stems and stalks of herbaceous vegetation, and some even in wood; and
  - certain species commence development in mines, but later live in sacs (e.g. fairy longhorn moths [Adelidae] and Incurvariidae).
- Apart from characteristically terrestrial forms, lepidopterans can exceptionally also be encountered in an aquatic environment, where some caterpillars have even developed tracheal gills. In the fauna of the Czech Republic, such species are represented in the unusually adaptive family Pyralidae [snout moths], and, for example, in species of the genus *Nymphula*, or in *Acentropus niveus*, where not only the caterpillar lives in water, but also the imago (more precisely the wingless female).

Pupation occurs on plants, inside plants, on the ground, in moss, and in litter. All developmental stages can overwinter, most frequently eggs and pupae, but also caterpillars and adults.

Food

The food of imagos is very uniform and is comprised of

- liquid food, such as the nectar of flower blossoms, the juices of fermenting fruit, fluids from faeces and urine of vertebrates (practically all species); and
- pollen (in the Czech Republic, only primitive Micropterigidae).

Caterpillars feed on a much more diverse variety of food.

- The majority of species consume live plant food:
  - most frequently assimilatory organs (almost all families),
  - fruit,

- seeds (a number of species are typical warehouse pests, such as some species of the family Pyralidae [snout moths], for example the meal moth [*Pyralis farinalis*], with caterpillars spinning flour, kernels, seeds, and other materials, and the Mediterranean Flour Moth [*Ephestia kuehniella*]),
- roots (e.g. swift moths [Hepialidae] and certain owlet moths [Noctuidae]),
- wood (e.g. cossid millers [Cossidae] and clearwing moths [Sesiidae]), and
- stems of herbs (clearwing moths [Sesiidae]).

- Other species feed on dead plant food:
  - quintessential decomposers (Micropterigidae), and
  - dead plant parts in insect hives and vertebrate nests (in snout moths [Pyralidae]; for example, *Hypsopygia costalis* develops in the nests of squirrels, birds, in henhouses, and thatched roofs).
- Animal food is relatively rare:
  - animal products such as fur, plumage, horns, etc. (e.g. fungus moths [Tineidae]);
  - bee's wax with a content of pollen grains (some of snout moths [Pyralidae], for example the greater wax moth [*Galleria mellonella*] and lesser wax moth [*Achroia grisella*]);
  - live organisms (caterpillars of certain owlet moths [Noctuidae] feed on, for example, scale insects, aphids, and mites; other species of the same family even consume pupae of other species of insects);
  - caterpillars of other lepidopterans (e.g. the genus *Cosmia* [owlet moths {Noctuidae}]; best-known species is *Cosmia trapezina*, known for facultative predation; on the Hawaiian Islands, an obligatory form of predation has developed, with caterpillars of the local genus *Eupithecia* from the family Geometridae feeding only on caterpillars of other Lepidoptera species and on other insects); and
  - some development is tied to ant colonies, where they consume ant larvae (gossamer-winged butterflies [Lycaenidae]).
- Development in fungi, especially polypores, is an extremely rare form of development (e.g. *Scardia boletella*).

Importance for humans

A number of Lepidoptera species are very significant pests in forestry and agriculture. Many species negatively influence vegetable and fruit production or act as warehouse pests, damaging and devaluing stored products of all kinds, and often directly in households.

The snout moth family also includes perhaps the only Lepidoptera species that was very successfully used in biological control with undesirable plants. The South-American species Cactus Moth [*Cactoblastis cactorum*] was introduced in Australia in 1930 to control the *Opuntia* cacti, which occupied almost 90% of grazing areas. After the introduction of 3 billion eggs, the grazing areas were restored and rid of *Opuntia* in a relatively short period of time.

Suborder: ZEUGLOPTERA

There is only one family in the Czech Republic.

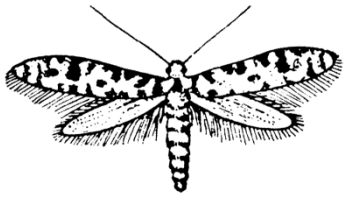
Family: MICROPTERIGIDAE

There are 7 species in the Czech Republic. They are primitive groups, similar to caddisflies in terms of growth habit. Adults have functional mandibles. Wings are covered with scales with a metallic shine that form a pattern, thus differing from the caddisflies. They have a size of 1.5–5 mm and a wingspan of 7–11 mm. Adults feed on pollen of the plant family Ranunculaceae (buttercup). Caterpillars are quintessential decomposers.

Suborder: GLOSSATA

Family: **TINEIDAE** (fungus moths)

There are 67 species in the Czech Republic. They are mostly small lepidopterans with wingspans of 6–30 (60) mm. The proboscis is vestigial. Males have a tuft of hair at the end of the abdomen and the females a conspicuous ovipositor. Caterpillars feed on various substances of plant and animal origin. Feeding sites are frequently spun, or they build sacs. A number of species live synanthropically, frequently causing significant damage. The common clothes moth (*Tineola bisselliella*) and case-bearing clothes moth (*Tinea pellionella*) feed on wool, furs, and products made thereof. The European grain moth (*Nemapogon granella*) is a pest to stored cereals, legumes, dried mushrooms, pastries, etc.



Nemapogon granella

Family: **GRACILLARIIDAE**

Over 120 species in the Czech Republic. Body length of 2–8 mm. Caterpillars are miners at least in the first instars, more mature ones live under folded edges of leaves or freely. Most species are monophagous.

For example, the horse-chestnut leaf miner (*Cameraria ohridella*) is well-known, mining on the horse-chestnut.

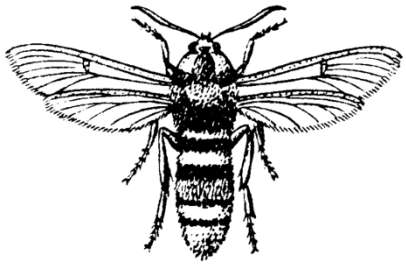
Family: **COLEOPHORIDAE** (case-bearers)

Over 170 species in the Czech Republic. Wingspan of 8–18 mm. Caterpillars mine at first and later live in sacs formed from cut-off bits of leaves, needles, and spun threads.

Larches are sometimes seriously damaged by the western-larch case bearer (*Coleophora laricella*).

Family: **SESIIDAE** (clearwing moths)

Over 40 species in the Czech Republic. Small to medium-sized lepidopterans, resembling hawk moths, and often coloured like various wasps. A large part of the wings is translucent, not covered with scales. The abdomen of males is equipped with a small brush with hairs on the end. Adults usually have diurnal activity. Caterpillars live under the bark and in the wood of woody plants or in roots and rhizomes of herbs.



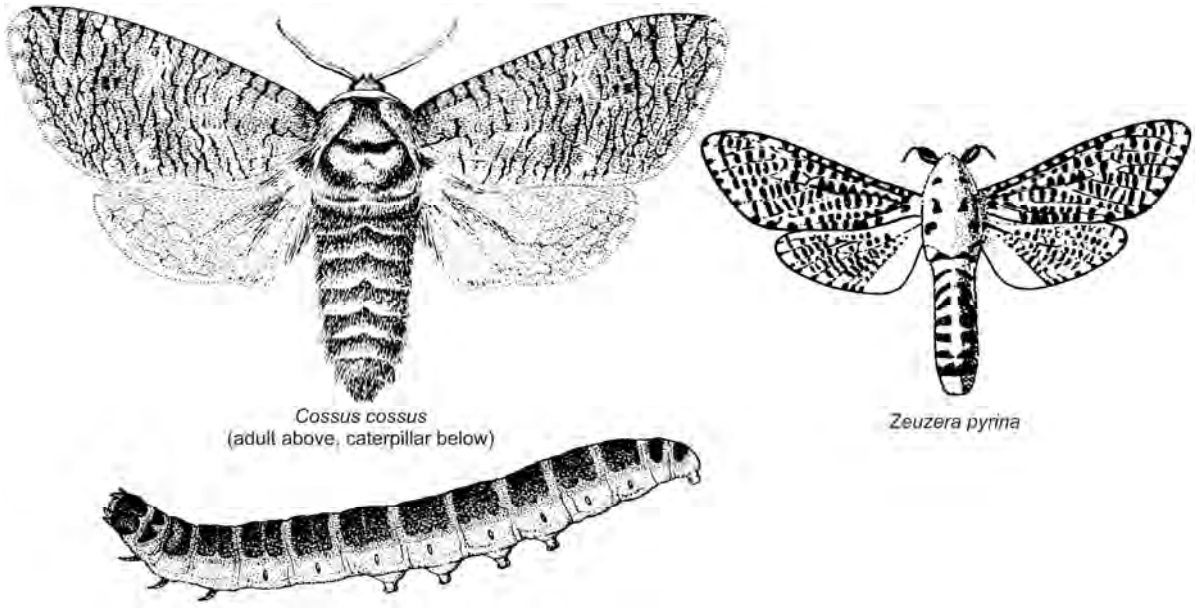
Sesia apiformis

The hornet moth (*Sesia apiformis*) and dusky clearwing (*Paranthrene tabaniformis*) are conspicuous species, the caterpillars of which develop in the wood of poplars. Alders and birches are infested by the red-belted clearwing (*Synanthedon culiciformis*) and white-barred clearwing (*Synanthedon spheciformis*).

Family: **COSSIDAE** (cossid millers)

There are 5 species in the Czech Republic. They are medium-sized and large lepidopterans. Males are usually much smaller than females. Adults exhibit nocturnal activity. Caterpillars live under bark, in wood, in herbs, and roots of monocot plants.

A well-known species is, for example, the goat moth (*Cossus cossus*), which develops in the bases of trunks of willows, poplars, oaks, fruit trees, and others. The leopard moth (*Zeuzera pyrina*) lives similarly, attacking higher parts of fruit trees, ash, oak, maple, beech, elm, alder, birch, and walnut.



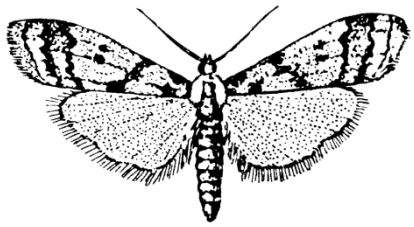
Family: **TORTRICIDAE** (tortrix moths)

A very numerous family with over 470 species in the Czech Republic. Imagos are mostly active during dusk; during the day they sit with their wings folded roof-like. Development is very diverse: in shoots, buds, bark and bast, leaves woven together, rolled up or folded leaves, between two leaves with interwoven surfaces, fruits, cones, and the like. In the conditions of the Czech Republic, usually with a single generation per year. Eggs usually overwinter, caterpillars less commonly. They are very important in forestry and agriculture.

For example, *Archips oporana* develops on various conifers; *Choristoneura murinana, Epinotia nigricana*, and the red-headed fir tortricid (*Zeiraphera rufimitrana*) on firs; *Dichelia histrionana*, the spruce bark tortrix (*Cydia pactolana*), spruce seed moth (*Cydia strobilella*), spruce needle tortricid (*Epinotia tedella*), larch tortrix (*Zeiraphera griseana*) (also on larch), and pygmy needle tortricid (*Epinotia pygmaeana*) on spruce; the larch gall moth (*Cydia millenniana*) on larch; and the pine shoot moth (*Rhyacionia buoliana*), summer shoot moth (*Rhyacionia duplana*), pine bud moth (*Pseudococcyx turionella*) (in older literature as *Blastesthia turionella*), and pine resin-gall moth (*Retinia resinella*) on pine. Some brown oak tortrix (*Archips crataegana*), rose tortrix (*Archips rosana*), and variegated golden tortrix (*Archips xylosteana*) develop on deciduous trees, and the European oak leafroller (*Tortrix viridana*) and yellow oak button (*Aleimma loeflingiana*) on oak. In agriculture, the pea moth (*Cydia nigricana*) is a pest of peas, the codling moth (*Cydia pomonella*) causes worminess of apples, and the plum fruit moth (*Cydia funebrana*) causes worminess of plums. Peach and apricot trees are damaged by the oriental fruit moth (*Cydia molesta*) and cherrybark tortrix (*Enarmonia formosana*). There is, nevertheless, a number of economically important species.

Family: **PYRALIDAE** (snout moths)

There are over 100 species in the Czech Republic. Similar to tortrix moths (Tortricidae) in terms of growth habit, adults are active in the evening and at night. Caterpillars live in corridors of spun thread in plants or in dead organic matter.

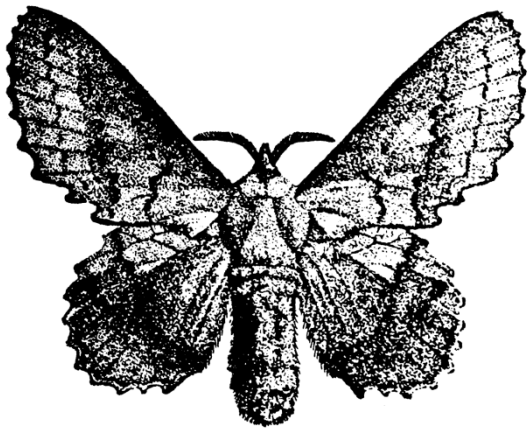


Ephestia kuehniella

Seeds of conifers inside pinecones are frequently infected by the spruce coneworm (*Dioryctria abietella*); the new pine knot-horn (*Dioryctria sylvestrella*) feeds on pine bast; and warehouse pests include the cacao moth (*Ephestia elutella*), Mediterranean flower moth (*Ephestia kuehniella*), and Indian meal moth (*Plodia interpunctella*).

Family: **LASIOCAMPIDAE** (eggars)

There are 18 species in the Czech Republic. They are robust, intensely hairy lepidopterans. Adults have a vestigial proboscis and significant sexual dimorphism. Males are smaller with pectinate antennae, females with serrate. Caterpillars are large and hairy, sometimes with tufts of brightly coloured hairs.



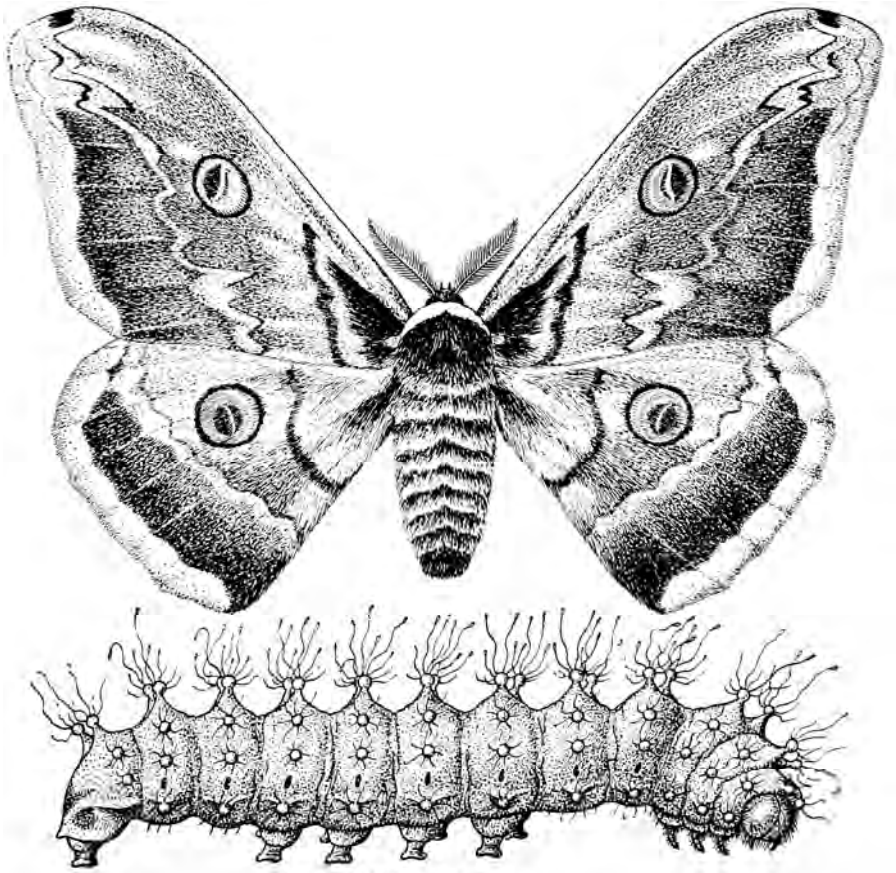
Gastropacha quercifolia

The most important species is the pine-tree lappet (*Dendrolimus pini*), causing defoliation on pine. The lackey moth (*Malacosoma neustria*) and small eggar (*Eriogaster lanestris*) are polyphagous on deciduous trees, primarily damaging fruit trees. The oak eggar (*Lasiocampa quercus*) is a less important polyphage of deciduous trees (sometimes also conifers).

Family: **SATURNIIDAE** (saturniids)

There are 5 species in the Czech Republic. They are large and robust lepidopterans with pectinate antennae. The wings bear large eye-shaped markings. The body is intensely hairy; the proboscis vestigial. Caterpillars are large, with protrusions and tubercules covered with hair. Pupation occurs in a spun cocoon.

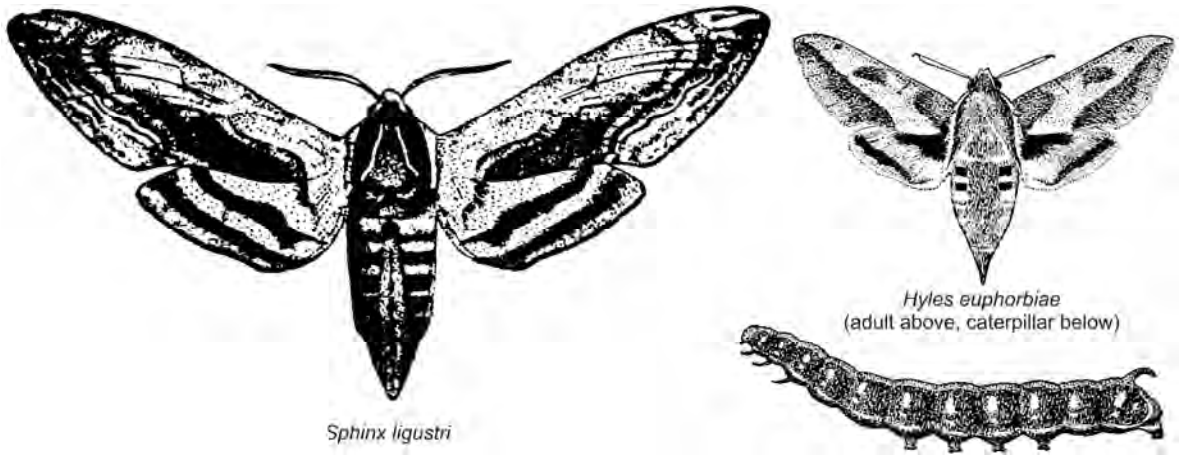
Caterpillars are mostly polyphagous. This family includes the largest European lepidopteran (protected by law), the giant peacock moth (*Saturnia pyri*), which develops on fruit trees.



Saturnia pyri
(adult above, caterpillar below)

Family: **SPHINGIDAE** (hawk moths)

There are 19 species in the Czech Republic. They are medium-sized to large, intensely hairy lepidopterans. They have a conspicuous, very long proboscis, strongly developed forewings, and much smaller hind wings. They are excellent fliers. They are primarily active in the evening and at night. Caterpillars have a typical horn-like protrusion on the 11th abdominal segment.



Sphinx ligustri

Hyles euphorbiae
(adult above, caterpillar below)

The largest species of this family in the Czech Republic, as well as one of the largest lepidopterans in the Czech Republic, is the death's-head hawk moth (*Acherontia atropos*). The hummingbird hawk-moth (*Macroglossum stellatarum*) is also prominent. The pine hawk moth (*Sphinx pinastri*) is important from a

forestry perspective, causing defoliation on pine as well as spruce and larch. The polyphagous eyed hawk-moth (*Smerinthus ocellatus*), poplar hawk moth (*Laothoe populi*) damaging poplars, and the lime hawk moth (*Mimas tiliae*) damaging lime trees do not cause significant damage. Protected species, on the other hand, include the oak hawk moth (*Marumba quercus*) and the spurge hawk moth (*Hyles euphorbiae*).

Family: **PAPILIONIDAE** (swallowtail butterflies)

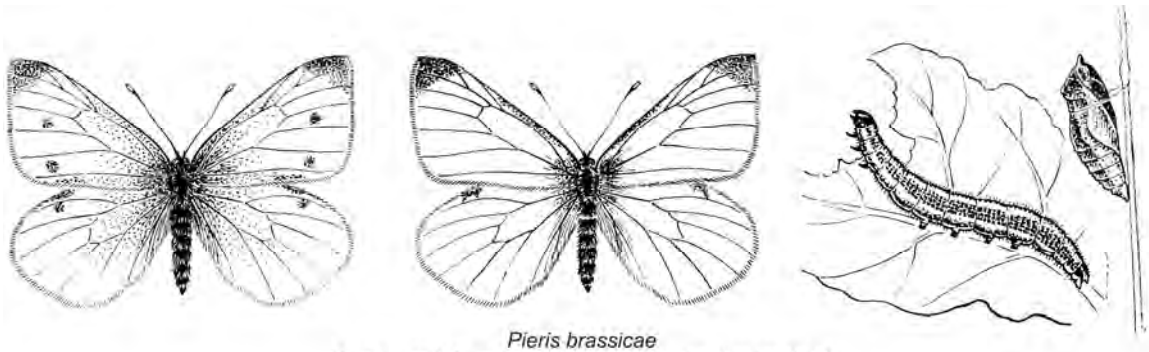
Only 5 species in Czech Republic. Large butterflies with wingspan over 5 cm; diurnal activity. Wings are very colourful. A number of species have spurs on the hind wings. Caterpillars are conspicuously coloured, pupate on a plant or, in the case of *Parnassius*, in a sparse cocoon on the ground. All 5 species are protected by law. These are the Apollo (*Parnassius apollo*), clouded Apollo (*Parnassius mnemosyne*), southern festoon (*Zerynthia polyxena*), Old World swallowtail (*Papilio machaon*), and the scarce swallowtail (*Iphiclides podalirius*).

Papilio machaon
(adult above, caterpillar bellow)

Family: **PIERIDAE**

There are 18 species in the Czech Republic. They are relatively large butterflies, white or yellow-coloured, usually with black markings. They exhibit diurnal activity. Caterpillars are relatively inconspicuous, usually various shades of green, often with dark bands or spots. They have short, sparse hair.

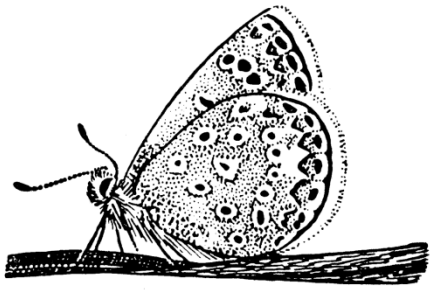
They primarily feed on Brassicaceae and Fabaceae. Certain species are notorious pests to agricultural crops. Brassicaceae plants may be seriously damaged by the large white (*Pieris brassicae*), small white (*Pieris rapae*), and green-veined white (*Pieris napi*). The moorland clouded yellow (*Colias palaeno*) is a protected representative of this family.



Pieris brassicae
(female on left, male in the middle, caterpillar on right)

Family: **LYCAENIDAE** (gossamer-winged butterflies)

There are 48 species in the Czech Republic. They are mostly smaller butterflies exhibiting diurnal activity. Coloration may be blue in males, brown in females, with the fiery orange wings with very high shine, or different coloration. Caterpillars are wide, flat, and with a small head retractable into the first thoracic segment.



Polyommatus icarus

Certain Lycaenidae develop in anthills, where they feed on ant larvae or pupae. Nutritive plants include Fabaceae, sorrel, and trees and bushes. The large blue (*Maculinea arion*) and alcon blue (*Maculinea alcon*) are among protected species.

Family: **NYMPHALIDAE** (brush-footed butterflies)

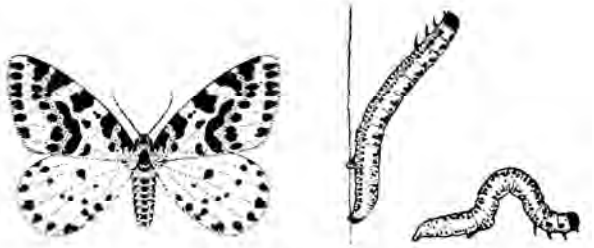
There are 71 species in the Czech Republic. They are rather large butterflies with diurnal activity. The first pair of legs is strongly reduced. They have clavate antennae. The dorsal side is typically brightly and variously coloured; the ventral side is inconspicuous. The butterflies like sucking on thistles and other plants, as well as on fallen and rotting fruits. Caterpillars are morphologically diverse, from brightly coloured to entirely black with the body covered in thorns. Caterpillars of certain species live socially. They are frequently polyphagous. Pupae also often have various thorns or protrusions, sometimes also shiny metallic patches. Caterpillars, pupae, or adults overwinter, depending on the species. In the Czech Republic, a number of species have two generations per year.

The scarce fritillary (*Euphydryas maturna*), hermit (*Chazara briseis*), emperors (*Apatura* spp.), admirals and typical sailors (*Limenitis* spp. and *Neptis* spp.), and bog fritillary (*Proclossiana eunomia*) are protected in the Czech Republic.

Family: **GEOMETRIDAE** (geometer moths)

There are more than 390 species in the Czech Republic. They are a very numerous family with small to medium-sized lepidopterans. In most species, the proboscis is well-developed. In females, the wings are often strongly reduced. They are mostly active in the evening and at night. Caterpillars are bald, mostly thin (frequently imitating the surface in shape and colour [twigs, petioles, and stems]). They have well-developed thoracic legs and only the last pair of prolegs and anal prolegs. This leg arrangement enables typical, so-called inchworm movement. They overwinter in the egg or pupal stage, exceptionally as caterpillars or imagos. A number of species are significant pests in forestry and agriculture.

Operophtera brumata
(male on left, female on right)



Abraxas grossulariata
(adult on left, caterpillar on right)

For example, the bordered white (*Bupalus piniaria*) can cause serious damage to pine stands. Significant polyphagous species on deciduous trees include the winter moth (*Operophtera brumata*), northern winter moth (*Operophtera fagata*), and mottled umber (*Erannis defoliaria*). Moreover, the tawny-barred angle (*Macaria liturata*) and barred red (*Hylaea fasciaria*) develop on pine. *Lycia isabellae* sometimes affects larches.

Family: **NOTODONTIDAE** (prominents)

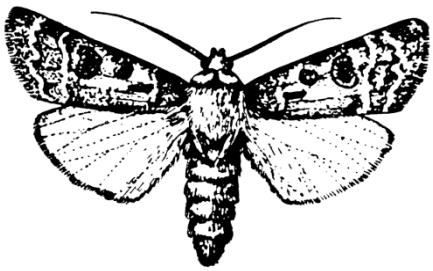
There are 36 species in the Czech Republic. They are medium-sized to large lepidopterans with a vestigial proboscis. The antennae are pectinate in males. Caterpillars are bald or hairy, living freely on deciduous trees.

Several species may also have slight importance in forestry. For example, the polyphagous buff-tip (*Phalera bucephala*) and oak processionary (*Thaumetopoea processionea*) occasionally damage oaks (caterpillars are extremely poisonous, causing intense inflammation of mucous membranes and skin).

Family: **NOCTUIDAE** (owlet moths)

The most numerous family of Lepidoptera in the Czech Republic, including more than 480 species. Small to large species, with characteristic markings on the forewings. Most species are relentless flyers with nocturnal activity. Caterpillars are mostly bald, inconspicuously coloured. In a number of species, the number of pairs of prolegs is reduced (from the usual number of 4 to 3 or 2 pairs).

The pine beauty (*Panolis flammea*), for example, may cause significant defoliation of pines. The polyphagous silver y (*Autographa gamma*), turnip moth (*Agrotis segetum*), heart and dart (*Agrotis exclamationis*), and black cutworm (*Agrotis ipsilon*) can cause serious damage to agricultural crops or seedlings in nurseries. The rosy underwing (*Catocala electa*) and *Phragmatiphila nexa*, on the other hand, are protected in the Czech Republic.



Agrotis exclamationis

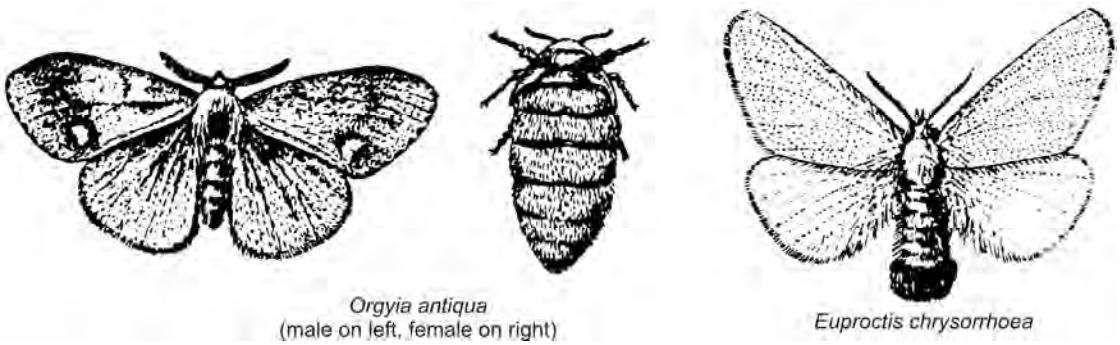
Autographa gamma

Family: **LYMANTRIIDAE** (tussock moths)

There are 16 species in the Czech Republic. It is a family with few members. They are medium-sized lepidopterans with a missing or vestigial proboscis, not ingesting food. Antennae are pectinate, simple in females and double in males. Wings are broad, rounded at the end, sometimes vestigial. Caterpillars are densely covered in long hairs, and in some cases with thick and long brushes of hair (genera *Orgyia* and *Dasychira*). Hairs of certain species cause inflammation (brown-tail [*Euproctis chrysorrhoea*]). Pupation occurs either in a cocoon or the pupa is bound only by a few threads.

A smaller number develops on herbaceous vegetation; a larger number on woody plants. Among these are the most feared polyphagous defoliators of conifers and deciduous trees. The nun moth

(*Lymantria monacha*) is a quintessential polyphage, with significant overpopulation on monocultures of spruce and pine in lower and medium altitudes. The Asian gypsy moth (*Lymantria dispar*) is very broadly polyphagous (recorded on over 100 species of woody plants). It was introduced to North America before the end of the last century, where to this day it causes immense damage in forests and orchards. The brown-tail (*Euproctis chrysorrhoea*) is also broadly polyphagous. This species was also introduced to North America, with a similar impact as the Asian gypsy moth. The white satin moth (*Leucoma salicis*) prefers poplars, but also willingly attacks other woody plants. The rusty tussock moth (*Orgyia antiqua*) is highly polyphagous on deciduous trees and conifers, but damage arises almost exclusively in spruce. The pale tussock (*Calliteara pudibunda*) is another strong polyphage on deciduous trees.

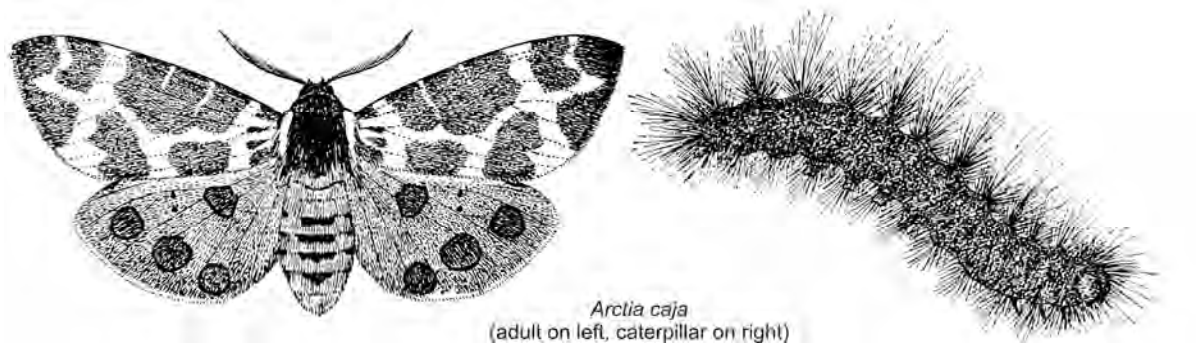


Orgyia antiqua
(male on left, female on right)

Euproctis chrysorrhoea

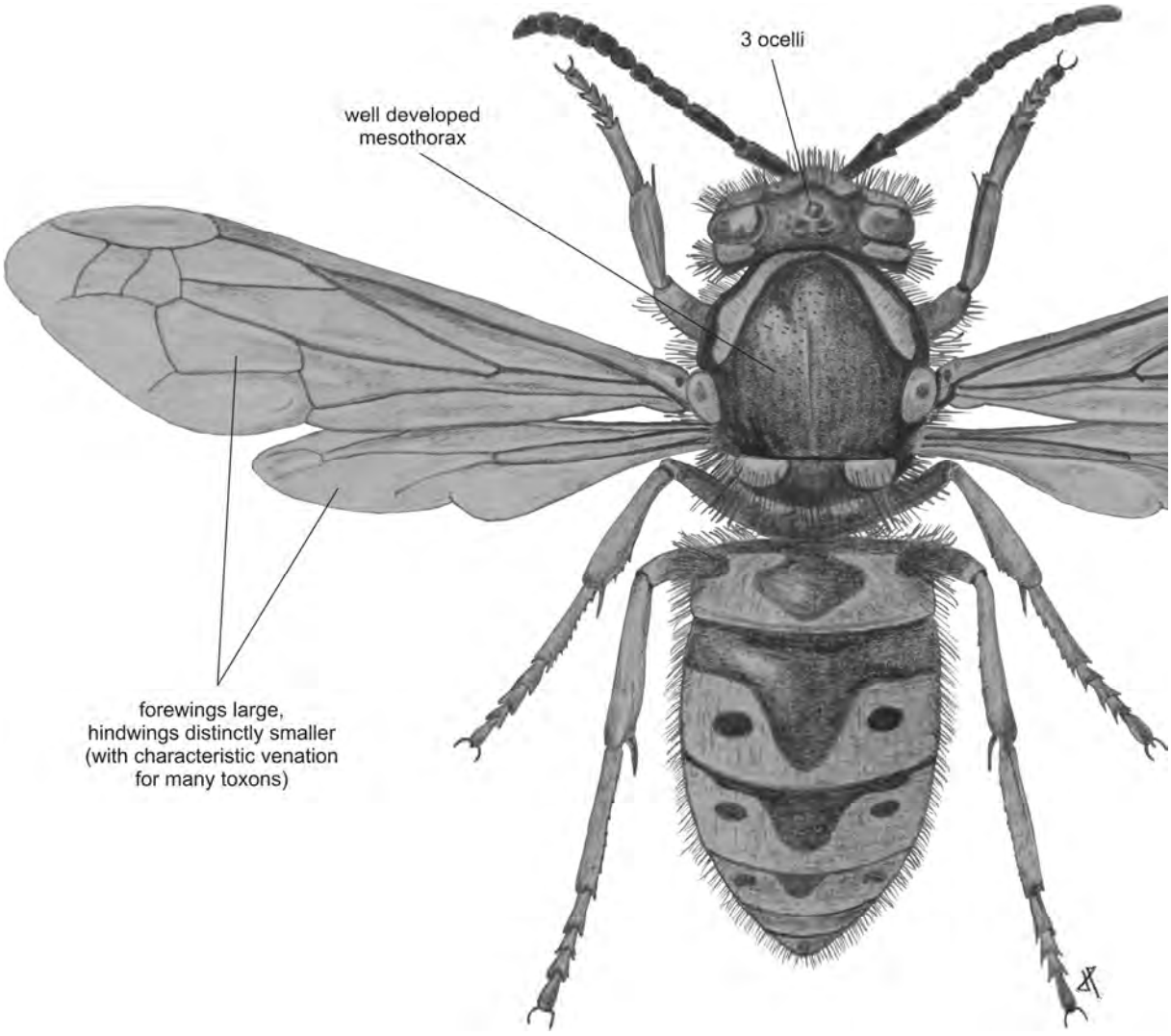
Family: **ARCTIIDAE**

There are 46 species in the Czech Republic. They are smaller to larger species, predominantly nocturnal. Wings are often very brightly coloured. Caterpillars have thick long hair. Development occurs mostly on herbs, and thus they are harmless from a forestry perspective. An abundant species, for example, is the garden tiger moth (*Arctia caja*). Occasional defoliation of fruit and other deciduous trees may be caused by the fall webworm (*Hyphantria cunea*), a species introduced from North America. The species *Watsonarctia casta* and *Chelis maculosa* are protected in the Czech Republic.



Arctia caja
(adult on left, caterpillar on right)

Order: **HYMENOPTERA**		
derivation of the order's name hymen (Greek) = membrane, pteron (Latin) = wing	number of known species in the world 125,000	number of known species in the Czech Republic 8,000
Metamorphosis: **typical holometaboly or modified holometaboly: polymetaboly**		



Systematics

The order Hymenoptera is systematically divided into 2 traditional suborders:

- Suborder: **Symphyta (sawflies)**, and
- Suborder: **Apocrita**.

Extensive changes of the system can be expected soon, as Symphyta (the group from which Apocrita evolved) is evidently paraphyletic. For example, the family Xyelidae is a sister group of the rest of the Hymenoptera.

General characteristics and body description of an adult

It is the most numerous order in Central Europe, with ca 10,000 species (ca 25% of the entire fauna of Central Europe). Size ranges from very small species (from several tenths of a millimetre, e.g. egg parasitoids) to species of considerable size of around 35 mm (e.g. European hornet [*Vespa crabro*]), and certain exotic species with maximum body length around 6 cm. Bodies have various shapes with widely varied coloration (pigmented and structural), frequently also with very vivid metallic shades (e.g. cuckoo wasps [Chrysididae], numerous species of chalcid wasps, and others). The body is generally bald to intensely hairy.

Sexual dimorphism is usually distinct (antennae, legs, eyes, winglessness of one sex [mostly females, only rarely males], etc.). Sometimes, the two sexes are so different that it is practically impossible to classify them as a single species without breeding. In other cases, males and females are mutually indistinguishable on the basis of external morphological characteristics.

Polymorphism is also typical for a number of species. For example, the castes within a single species, and similarly the individual generations within the course of development during the year (e.g. the summer generation of the ichneumon wasps of the genus *Sphecophaga* is winged, while the autumn generation is micropterous; in certain Cynipidae the look entirely changes in generations that transfer to another part of the plant).

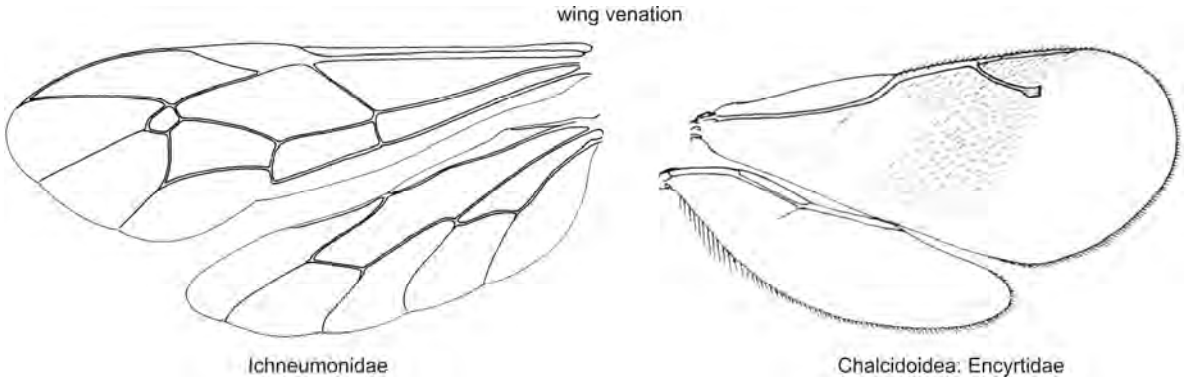
Head is freely mobile, mostly orthognathous (in certain groups with a transition to the prognathous type; e.g. in Bethylidae).

Mouthparts are typically chewing (in Symphyta and most Apocrita); in certain groups of Apocrita, they are modified to various degrees to characteristic lapping-sucking mouthparts (e.g. European honeybee [*Apis mellifera*] or bumblebees [*Bombus*]). The formation of the lapping-sucking mouthparts is especially contributed to by the elongated labium and maxillae.

Eyes are mostly well-developed, usually composed of a relatively large number of ommatidia, mostly 300 to 7,500 (drones of the European honeybee). Three ocelli are always developed (in apterous individuals the ocelli are absent).

Antennae are variously formed, with the number of segments from 3 (certain Symphyta, some small chalcid wasps [Chalcidoidea]) to 70 (certain species of Ichneumonidae). Strongly developed sexual dimorphism is often reflected in the structure of the antennae. In males, the antennae can sometimes be markedly pectinate (e.g. in conifer sawflies [Diprionidae], some chalcid wasps, and others). In Vespoidea and Apoidea, males have 13 segments and females 12.

Thorax is strongly developed. The mesothorax is the most developed, which is further divided on the dorsal side. The other thoracic segments are usually less developed.



Two pairs of wings are developed. The first pair is significantly larger than the second. They are membranous, mostly transparent and colourless, more or less covered with hair on the surface and on the edges, but in many cases also milky or with various markings. Frequently with very characteristic venation for the individual taxonomic groups. Venation is rich (e.g. in Symphyta) to reduced to various degrees (in certain Apocrita, for example Chalcidoidea and Platygastroidea). Brachyptery is not very common. Aptery is common in females of certain taxonomic groups (e.g. velvet ants [Mutillidae]), castes (ants [Formicidae]), or certain generations (e.g. gall-forming Cynipoidea). Both pairs of wings move simultaneously in flight (the front edge of the hind wing bears hooks that link into a nook on the back side of the forewing). The order includes excellent fliers (a number of groups within Apocrita), while a number of species of the suborder Symphyta fly only clumsily. At rest, the wings are folded lengthwise on the abdomen, sometimes even longitudinally folded (certain Vespidae).

Legs are gressorial, frequently variously adapted to the particular lifestyle of a given species, with raptorial legs (Dryinidae), saltatorial legs (certain chalcid wasps [Chalcidoidea]), and pollen-carrying legs (a significant portion of bees [Apidae]) occurring. Smaller adaptations are also common, such as the formation of tibial spurs, hairs, and the formation of the tarsi, etc. In a number of species, the femur is connected to the coxa by two segments (trochanter and trochantellus), as, for example, in all Symphyta. Tarsal patterns (5,5,5) to (4,4,4), exceptionally (3,3,3) (e.g. Trichogrammatidae). Heteromerous tarsi (different numbers of tarsal segments in the individual leg pairs) are a rare exception. For example, the female chalcid wasp *Macromesus amphiretus* has (5,4,5), while the male normally (5,5,5).

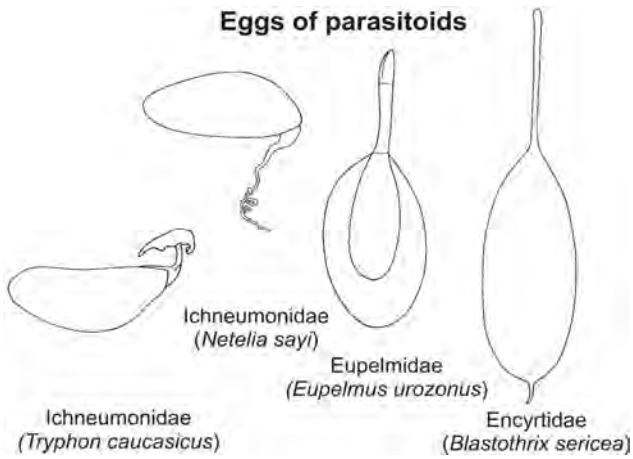
Abdomen in original form has 9 segments. Nevertheless, only a smaller number of segments is visible as some segments are telescopically retracted into preceding segments, or they are reduced or merged. The first abdominal sternite is reduced to absent; the tergite in Symphyta is normal, while in Apocrita it forms a so-called propodeum. Propodea are completely connected to the metathorax. It is connected to the petiole and then the rest of the abdomen (gaster). In Symphyta, therefore, the abdomen joins the thorax on a wide base, while in Apocrita it is separated from the thorax (along with the first abdominal segment [propodeum]) by distinct constriction.

The tracheal system is originally opened on each abdominal segment, but in many species the number of spiracles is strongly reduced. In a number of species, the tracheal system is supplemented with air sacs.

Females of most Symphyta have a serrated ovipositor, which is protected from the outside by sheaths. In Apocrita, it is transformed either into the typical ovipositor of parasitic species or into a stinger (along with the associated development of venom glands).

Egg

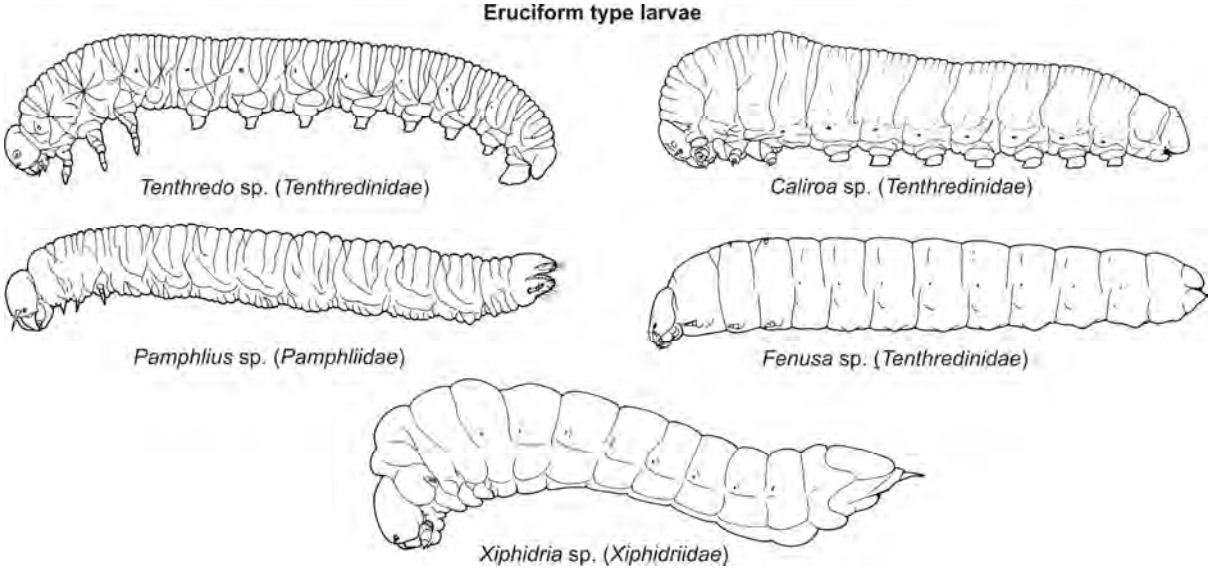
Eggs are considerably species-specific, mostly oval, in parasitoids often bearing a mechanism that prevents the host from removing it. Colour is translucent to dark.



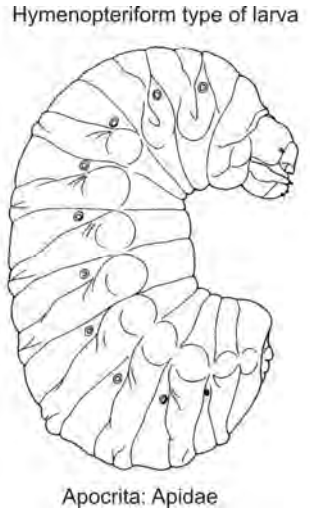
Larva

Larvae are essentially of two types:

- **Eruciform** – polypod, eucephalous caterpillars occurring in Symphyta. Abdomen has 10 segments, bearing 6–8 pairs of prolegs on the 2nd–7th (or 8th) and 10th segment. In exceptional cases, prolegs are also present on the 1st and 9th segments (Xyelidae). They are, however, commonly absent in endophytic and parasitic species. Antennae are short, with 1–7 segments. Usually 1 larger larval eye is developed (apart from endophytic and parasitic species). Chewing mouthparts. Digestive system is unobstructed.



- **Hymenopteriform** – apod, eucephalous, hemicephalous to acephalous larvae occurring in Apocrita. Antennae have 1 segment or are absent; larval eyes (stemmata) are absent. Mandibles are always developed; maxillae and labium may be strongly reduced. Larvae of the 1st (sometimes even 2nd) instar have a very different shape (polymetaboly). It is therefore possible to distinguish around 10 types of larvae of the first instar. The digestive tract is obstructed in the area of the passing between the mid- and hindgut. The two parts merge only once the larva passes to the pupal stage.



Symphyta larvae have 4–8 instars. Females usually have one more instar than males. Apocrita larvae apparently originally had 5 instars, and in parasitoids this number may be significantly reduced.

Pupa

Pupa adectica exarata libera. Pupation apparently originally without a cocoon, in an underground chamber or in plant tissues (phytophagous species). In a considerable number of species, however, the last larval instar spins a cocoon from the secretions of the labial glands. For example, leaf-rolling sawflies (Pamphiliidae) build an underground chamber from soil particles stuck together by the secretions of the labial glands instead of a cocoon. The actual pupation period is relatively short, lasting 2 to a few weeks.

Ecology

Species of this order may be encountered practically anywhere – from deserts to swamps, from equatorial rainforests to tundra, from lowlands to the snow line (e.g. wingless ichneumon wasps of the genus *Gelis*). Certain species even enter water and parasitize aquatic insect species (e.g. chalcid wasps of the genera *Caraphractus* and *Prestwichia* and ichneumon wasps of the genus *Agriotypus*). Most Hymenoptera, however, are thermophilic, although they do not always seek directly sunlit places (practically all Symphyta, many Ichneumonidae and Braconidae).

Most Hymenoptera (more than 90% of all species) live solitarily, only ants, certain bees, and some hornets live in an obligatorily eusocial manner.

Even though both sexes occur in most species (and the related sexual reproduction), obligatory or facultative parthenogenesis is very common in Hymenoptera. Haploid males usually hatch from unfertilized eggs, and diploid females from fertilized eggs (e.g. *Apis mellifera* [European honeybee]).

Facultative parthenogenesis is enabled by the female's spermatheca, wherein the sperm is stored and released only when the egg is to be fertilized (sperm may be stored in the spermatheca for a number of years, as in social species). In certain species, the males are exceptionally rare or are not even known, and more parthenogenetic females arise from unfertilized eggs (e.g. inchneumon wasps of the genus *Hemiteles*, gall wasps of the genus *Diplolepis*, and others).

All Hymenoptera are oviparous, even in some species of Ichneumonidae the eggs can be retained under the subgenital plate for longer time periods, almost until the hatching of the larvae (ovovivipary).

Parasitoids sometimes use polyembryony for reproduction (e.g. some chalcid wasps of the family Encyrtidae parasitizing butterfly caterpillars and certain similarly living Braconidae).

The number of eggs laid differs significantly and ranges around 10–80 for solitary wasps, bees, and many parasitoids; in the hundreds for social bees and many sawflies; in the thousands for certain parasitoids (where eggs are laid outside the host and the larva of the first instar must actively search for it); and even in the millions for certain ants.

Protandry occurs frequently (males hatch earlier than females).

Parental care for offspring is a very widespread phenomenon in Hymenoptera. Laying of eggs on a certain host plant or host can be considered the most primitive display of care. A higher degree is providing food for the larvae's development (e.g. Crabronidae, Sphecidae, and Pompilidae). The highest level of development is the eusocial way of life, wherein the deposited egg and larva is cared for by specialized workers until the adult hatches.

A large number of species overwinter as fully-developed larvae. In a number of phytophagous species, this is possibly with variously long (up to several years) diapause (in *Gilpinia hercyniae* up to 6 years). A similar situation, however, also occurs in specialized parasitoids of such diapausing species. Frequently, however, the imago overwinters (fertilized female). In rare cases, the egg overwinters (e.g. European pine sawfly [*Neodiprion sertifer*] and sawflies of the genus *Apethymus*).

Parasitic lifestyle

Parasitoids may be divided

a) according to the number of parasitoids that can develop in a single host:

- **Solitary parasitoid** – a single individual parasitoid develops in the host. The host is approximately the same size as the parasitoid.

- **Gregarious parasitoid** – more than one parasitoid develops within the host (usually a much larger number) of the same species. One female parasitoid usually lays more eggs into the host or, more rarely, polyembryony occurs (in certain representatives of chalcid wasps [Chalcidoidea], Scelionidae, and Braconidae). The host is usually much larger than the parasitoid. Small parasitoids thus efficiently use large host species.

b) according to the type of host:

- **Primary parasitoid** – parasitoid larva develops on a host which is not yet parasitized. The female avoids already parasitized hosts.
- **Hyperparasitoid** (i.e. parasitoid of the 2nd and higher level) – the host of the hyperparasitoid larva is the larva of a primary parasitoid (or hyperparasitoid of the previous level). This case is common, for example, in a number of species of chalcid wasps of the genera *Tetrastichus* and *Eurytoma*. Even a hyperparasitoid, however, can be a direct host of a hyperparasitoid of a higher order:
    - **Obligatory hyperparasitoid** – the species behaves only as a hyperparasitoid;
    - **Facultative hyperparasitoid** – in the case that the female of the facultative hyperparasitoid cannot find an already parasitized host (by a primary parasitoid), it behaves as a primary parasitoid itself.

c) according to the frequency of host infestation, the following phenomena occur:

- **Multiparasitism** – the host is parasitized by several different species of primary parasitoids. Most frequently, all species die, and only rarely a single species of parasitoid survives.
- **Superparasitism** – the host is gradually parasitized multiple times by the same species of parasitoid, but by different females (in contrast to gregarious parasitism, where all parasitoids are offspring of a single female). Usually only a single larva survives.

Due to the excellent detection abilities of females, these two phenomena occur only relatively rarely. The female parasitoid can mostly tell very precisely whether a host has already been parasitized, and even whether the host has been visited by that female, even if eggs had not been deposited. Multi- and superparasitism occur considerably more often if unparasitized individuals are already absent in the host population.

d) according to the method of consuming the host:

- **Endoparasitoid** (internal parasitoid) – develops inside the host;
- **Ectoparasitoid** (external parasitoid) – consumes the host from the outside.

Many families and superfamilies include both types of parasitism, while in certain families only a single type of parasitism occurs. Cases in which the larvae of a single species undergo part of development as endoparasitoids and part as ectoparasitoids occur more rarely (e.g. Trigonalidae).

Kleptoparasitism is a special type of parasitism in which the female kleptoparasitoid lays eggs on stored food prepared for the host species. The hatched larva of the kleptoparasitoid first consumes the host egg or young larva and continues developing on the host's storage. Kleptoparasitism is common in some bees (Apidae), spider wasps (Pompilidae), cuckoo wasps (Chrysididae), and others.

Parasitoids use two strategies to infest the host:

- **Idiobiont** – more mature host stages are infested (advanced larvae and pupae). The host is permanently paralysed by the stinger, and therefore does not develop further.
- **Koinobiont** – the youngest developmental stages are infested. The host is not paralysed and therefore develops normally. The development of the parasitoid is usually delayed and only continues when the mature larva of the host prepares for pupation or diapause.

Food

Adults:

- Do not ingest food – many species, even despite having fully developed and functional mouthparts.
- Plant juices and flower nectar – for a large number of species, certain Apiaceae are particularly highly attractive (e.g. *Heracleum* and *Angelica*).
- Honeydew – a number of parasitoids.
- Animal food:
  - predators of other insects (e.g. certain sawflies [Tenthredinidae], ants [Formicidae], and Vespidae);
  - haemolymph – a considerable number of parasitoids consume the haemolymph that flows from the host after the ovipositor is inserted, either for the purpose of depositing the eggs or merely to acquire the host's bodily fluid as food.
- Seeds – rarely certain ants (Formicidae) returned secondarily to plant food.
- Fungi – very rarely certain ants (Formicidae).

The type of food can also change seasonally (e.g. Vespinae switch from animal food to plant food when sweet fruits are ripening). Generally, saprophagous species are entirely absent.

Larvae:

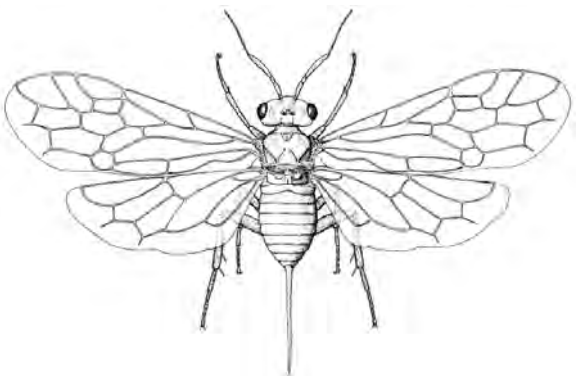
- Plant food – the entire suborder Symphyta (besides Orussidae), and secondarily some Apocrita, have switched to plant food (e.g. certain Cynipoidea, chalcid wasps [certain Eurytomidae and Torymidae], and bees [Apidae]).
- Animal food:
  - predators – typical predators (species that consume more than one individual prey during their development are relatively scarce among larvae). For example, certain ichneumon wasps parasitizing spider cocoons, where the larva gradually consumes the host's eggs; certain chalcid wasps live similarly on Orthoptera egg clutches. Larvae of certain Vespidae can also be considered predatory, as well as those of Sphecidae and Crabronidae, which gradually consume the prepared storage of the permanently paralysed insects.
  - parasitoids.
  - simple carnivory – in eusocial Vespidae, where the larvae of wasps are fed chewed bodies of other insects.
- Mixed food – in kleptoparasitic species the hosts of which are species preparing plant food for their larvae. For example, larvae of cuckoo wasps (Chrysididae) eat the eggs or larvae of a bee and continues developing on stores prepared for the bee (pollen and honey).

Suborder: SYMPHYTA (sawflies)

There are 7 superfamilies in the Czech Republic.

Superfamily: *XYELOIDEA*

Only 1 family in the Czech Republic.



Family: XYELIDAE

There are 6 species in the Czech Republic. Very small species (around 5 mm), antennae have a very long 3rd segment followed by 9 and more very long segments. Long ovipositor. Polypod larvae,

pseudopods on all abdominal segments, including the first one. Antennae have 7 segments.

Species in the Czech Republic are tied to pine (*Xyela*) or juniper (*Pleuroneura*).

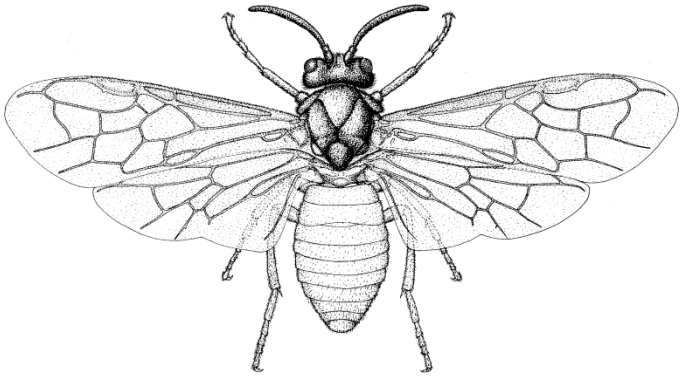
In *Xyela* spp., eggs are deposited into germinating male pine blossoms, and the larvae (often several in one blossom) consume developing sporophylls. Feeding is very short; the larva falls to the ground after 3 weeks and there it stays until the next spring (some with a one-year diapause). Other Xyelidae develop in shoots or leaves of deciduous trees.

Superfamily: *TENTHREDINOIDEA*

There are 5 families in the Czech Republic, encompassing the majority of sawflies, most of which are bound (for food) to woody plants and can be significant pests. The saw-like ovipositor is an important systematic characteristic, its formation frequently being the only feature enabling identification of often very close and otherwise hard to distinguish species. Larvae are typical caterpillars, developing most frequently on vegetative organs.

Family: **ARGIDAE**

There are 24 species in the Czech Republic. Size of 5–12 mm. Imagos with low mobility, frequently on Apiaceae blossoms. Antennae have 3 segments, with a long terminal segment that can be also split in males. Short ovipositor.

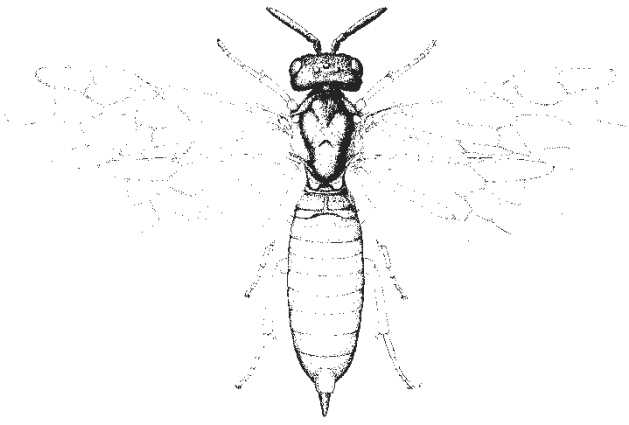


Eggs are laid into leaf nerves, most species on the woody plants of the families Salicaceae, Rosaceae, and Betulaceae. Free-living larvae with 6–8 pairs of pseudopods and single-segmented antennae. Cocoons have two layers and lie in the surface layer of soil or on branches.

A well-known representative is, for example, *Arge rosae*, a ca 10 mm large and mostly yellow-coloured species generally with two generations per year. The female lays eggs in late May and early June in a line of 16–18 eggs into a notch on fresh shoots of rose, which warp or dry out. Highly voracious caterpillars hatch from the eggs and can even cause defoliation. In late July and early August, a second generation occurs in warmer areas.

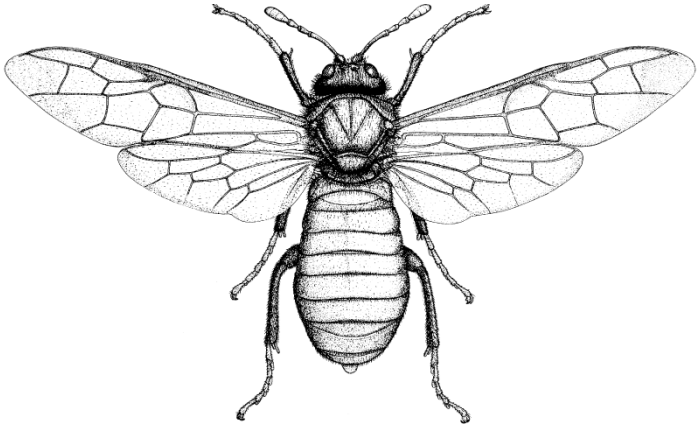
Family: **BLASTICOTOMIDAE**

There is a single species in the Czech Republic. Size of 7–9 mm. Antennae with 4 segments, with a long 3rd and very small 4th segment. Abdomen with a lateral crease. Ovipositor is visibly protruding, length of about half of the abdomen. Development in ferns. Larva has no pseudopods, antennae have 6 segments, and the 8th and 9th abdominal segments have lateral projections. Feeding is visible according to the presence of foam secreted on the fern's petiole.



Only a single species is represented in the fauna of the Czech Republic, *Blasticoma filiceti*, developing in petioles of the common lady-fern.

Family: **CIMBICIDAE**



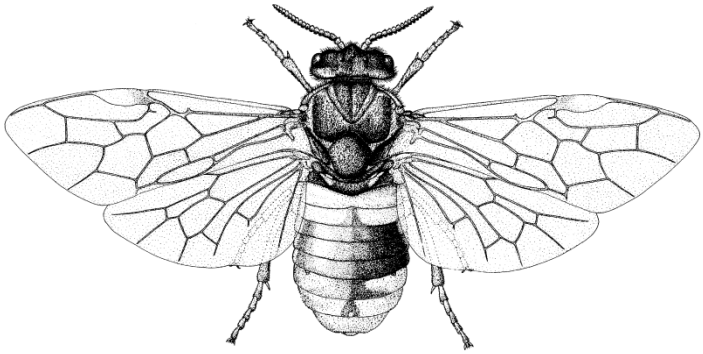
There are 24 species in the Czech Republic. Representatives of this family are characterized primarily by the 6–7 segmented capitate antennae and a relatively large (9–28 mm), compact and robust body. In contrast to most sawflies, they fly relatively well, although noisily. Some species bite severely when caught.

Caterpillars have 8 pairs of prolegs on the abdominal segments and 2-segmented antennae. They roll up when disturbed. They are usually solitary. Pupation in a cocoon attached to a nutritive plant.

Development occurs on various woody plants (hawthorn, bird cherry, birch, alder, beech, willow, poplar, rowan, honeysuckle, snowberry), certain species also on herbs (genus *Amasis* on *Geranium*, genus *Abia* also on *Knautia* and *Fragaria*). Adults consume bark on that year's shoots.

One of largest species in the Czech Republic is *Cimbex femorata*. The female lays ca 200 eggs individually or in groups on the edge or underside of leaves. Caterpillars feed primarily at night on the edges of leaves. An adult caterpillar (3+8 pairs of legs) spins itself in a dark cocoon attached to a branch where it overwinters and pupates in the spring. It is a relatively abundant species, occurring most frequently on birch. For the most part, however, the damage can hardly be described as considerable.

Family: **DIPRIONIDAE** (conifer sawflies)

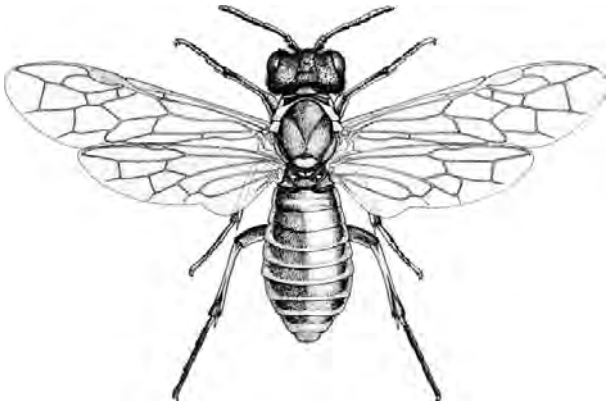


There are 16 species in the Czech Republic. Representatives of this family are 5–10 mm long, robust, clumsily flying species. Antennae have 14–32 segments, in males markedly pectinate (single- and double sided), in females serrate on the underside. Pronotum is short and carved at the back. Ovipositor is short, not visible from above. Larvae have 22 legs (3 pairs of thoracic + 8 pairs of pseudopods on the abdomen) and 3-segmented antennae. Pupation occurs in a cocoon attached to a nutritive plant or in the surface layer of litter.

Occurrence in coniferous forests of the temperate zone of the Northern Hemisphere. All species are biologically connected to conifers, most frequently with two generations per year.

The majority of species are found on pines (the common pine sawfly [*Diprion pini*] and European pine sawfly [*Neodiprion sertifer*] have particular significance for forestry). Two rare species of the genus *Monoctenus* occur on juniper and *Gilpinia polytoma* and *G. hercyniae* on spruce.

Family: **TENTHREDINIDAE**



There are 472 species in the Czech Republic. They are a cosmopolitan family and by far the largest of the entire suborder, with the largest abundance of species in the Holarctic region. The family also includes a number of decidedly harmful species.

Imagos range in size of 2.5–15 mm. Antennae have 7–15 segments, usually 9 segments, and pectinate only in males of the genus *Cladius*. Short ovipositor.

Eggs are entirely or partially submerged

into the incision created by the saw-shaped ovipositor in the tissue of the host plant. They are usually deposited individually, though multiple incisions are made on a single leaf. The larva usually hatches in the course of 9–14 days. Caterpillars overwinter in cocoons (only in *Apethymus* does the egg overwinter), pupating in the spring. The majority of species live freely, but certain species mine in leaves, shoots, stems, and fruits. Several species also roll up leaves and create galls (e.g. species of the genera *Euura* and *Pontania* on willows). Caterpillars usually have 7 pairs of prolegs. Caterpillar swarming and feeding occur in the spring, less frequently (in bivoltine and multivoltine species) also in the summer.

The family includes a number of subfamilies.

From a forestry perspective, sawflies developing on spruce are especially important (the small spruce fly [*Pristiphora abietina*] consuming only newly sprouting needles, *Pachynematus scutellatus* and *Pachynematus montanus*). The latter two also start feeding on young needles, but later the caterpillars can also switch to needles from previous years, and in high population density they can even cause full defoliation.

Sawflies developing on deciduous trees have lesser importance, such as *Apetymus braccatus* on oaks (subfamily Emhytinae), *Periclista lineolata* (Blennocampinae) also on oaks, and *Tomostethus nigritus* (Blennocampinae) developing on ash. Certain species have the ability to cause deformation of leaf tissue by secretions of accessory glands when laying eggs, causing rolling up of leaf edges (*Phyllocolpa*) or typical galls (*Euura* – galls on shoots, branches, petioles, and buds; *Pontania* – galls on leaves).

A number of other species from the subfamily Fenusinae develop on woody plants, their larvae mostly mining in leaves (members of the genera *Metallus*, *Parna*, *Messa*, *Scolioneura*, and *Fenusa*) or living freely on leaves (e.g. polyphagous species of the genus *Caliroa* with slug-like larvae). However, they do not have economic significance.

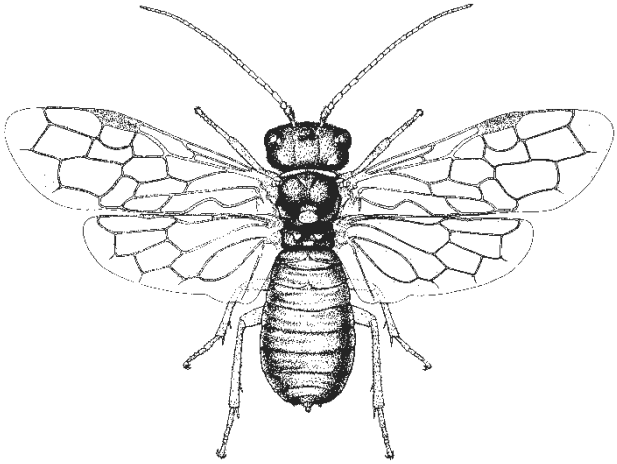
Species of the genus *Hoplocampa* can also have a certain importance as pests in fruit production. The sawflies *Hoplocampa flava* (yellow imagos) and *Hoplocampa minuta* (black imagos) develop on plums. They occur in the spring, laying all together around 70 eggs into incisions on flower calyces. The hatched larvae bite into young fruits, preferring the areas of the core, gradually devouring several (up to 5) other fruits. The fruits are filled with faeces that smell, similarly to the caterpillar, slightly like bedbugs. Damaged fruits fall down, and the caterpillars cocoon in the ground and overwinter. Under normal circumstances, sawflies ensure an adequate selection of fruits. Caterpillars of *Nematus ribesi* live on gooseberry and currant, in two to three generations per year. The imago is black-yellow and lays eggs on the underside of leaves. Caterpillars are blue-green, with a dark head and yellow 1st and 11th segments. They first gnaw on the underside of leaves, then eat out the leaves, and finally eat entire leaves with the exception of the venation. Certain damage can be also caused by *Caliroa cerasi* to cherry and pear trees, of which the dark larvae covered in slime (with the exception of the last instar) consume the leaves of these trees in June and July and from August to September. The imago is inconspicuous and black.

Species causing damage in agriculture include also the yellow-coloured turnip sawfly (*Athalia rosae* [= *A. colibri*]), distributed almost throughout the entire world and developing in two generations per year on leaves of free-growing and cultivated Brassicaceae (rapeseed, mustard, cabbage, etc.). Dark grey (grey-green in the last instar) caterpillars gnaw the vegetative organs of these plants for a period of 3–4 weeks.

Superfamily: *PAMPHILIOIDEA*

There are 2 families in the Czech Republic.

Family: **PAMPHILIIDAE** (leaf-rolling sawflies)



There are 40 species in the Czech Republic. From a biological perspective, this group is characterized by larval life in variously thick webs, where they live either individually, but more frequently gregariously, often in considerable numbers. The caterpillars are adapted to life in the cocoon to the extent that their movement is conditioned by the web threads. Not only do caterpillars entirely lack limbs on abdominal segments, but also the limbs on the thoracic segments are relatively very weak. The relatively long multi-segmented antennae on the larvae's head are also prominent. Segmented cerci at the end of the abdomen are another significant feature.

Imagos have a strongly dorsoventrally flattened abdomen with lateral crease. The first and second abdominal tergites are medially separated. Pronotum is long, the hind edge is almost flat, and the fore and middle tibiae have pre-apical spines. Antennae with 18–24 segments, setaceous, almost as long as the body.

They are distributed only in the Holarctic region.

They are divided into two subfamilies:

- Cephalciinae – development on conifers, mostly on spruce and pine, rarely on larch (the genera *Cephalcia* and *Acantholyda*). Eggs are deposited into a shallow incision on needles (mostly old ones). The larva spins the threads that are a requirement for its movement. The larvae initially live gregariously, but later often individually. They pupate without a cocoon in an underground pupation chamber usually at a depth of 5–15 cm, where they overwinter as larvae. A diapause of several years is also common.
- Pamphiliinae – development on deciduous trees, especially trees of the families Rosaceae, Betulaceae, and Salicaceae. Eggs on the underside of leaves, usually near to the main nerve. The caterpillar creates a cocoon and moves to the end of the leaf, which it rolls up.

Family: **MEGALODONTESIDAE**

There are only 4 species in the Czech Republic. This species similar to leaf-rolling sawflies often resemble wasps. Larvae are phytophagous.

Superfamily: *CEPHOIDEA*

Family: **CEPHIDAE** (stem sawflies)

There are 16 species in the Czech Republic. The imago is thin, size of 4–18 mm, with a long, straight-at-the-back prothorax, with a single spur on the fore tibia and an abdomen slightly flattened from the sides. Antennae have 16–30 segments usually slightly thickening towards the end or thickest in the middle. The female ovipositor is short, and visible from above.

Larvae are morphologically very similar to larvae of horntails, without stemmata, pseudopods are missing, thoracic limbs are rudimentary and unsegmented, and the antenna has 5 segments. The abdomen

has a distinct supraanal protrusion. They develop in culms of grasses (Cephini), but also in stems and branches of other plants (Hartigiini in the twigs of woody plants and Rosaceae herbs).

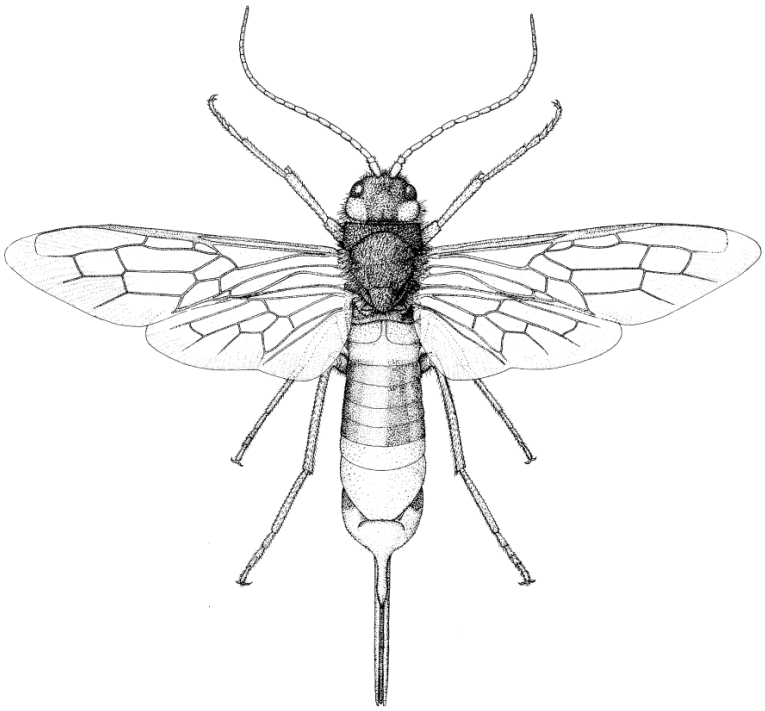
Among the species in the Czech Republic, *Cephus pygmaeus* is probably the best known and most important species, developing in culms of cultivated grasses (rye, wheat, barley, oats). Another damaging, but not very abundant species in the Czech Republic is *Janus compressus*, the larvae of which gnaw primarily in the main shoots of pear trees that then die.

Superfamily: *SIRICOIDEA*

There are 2 families in the Czech Republic.

Family: **SIRICIDAE** (horntails)

There are 8 species in the Czech Republic. These are among the largest and most conspicuous representatives of the suborder Symphyta. Antennae have 14–30 segments, a cylindrical body, and the last abdominal segment bears a horn-like protrusion. The female's ovipositor is always protruding and is usually conspicuous by its length.



Eggs are deposited relatively deep into wood, in relatively high numbers (up to 1,000 per female). Larval development takes several years (usually 2–3 years, but in drying wood up to 4 years). During this time, the larva gnaws an up to 40 cm deep gallery very densely packed with boring dust. Together with the egg, spores of certain fungi also get into the wood, and larvae of some species are to a certain degree dependent on them. When development is finished, the horntail pupates close to the surface of the wood and then the imago eventually chews its way out through a fixed circular opening that corresponds to the circular diameter of its body.

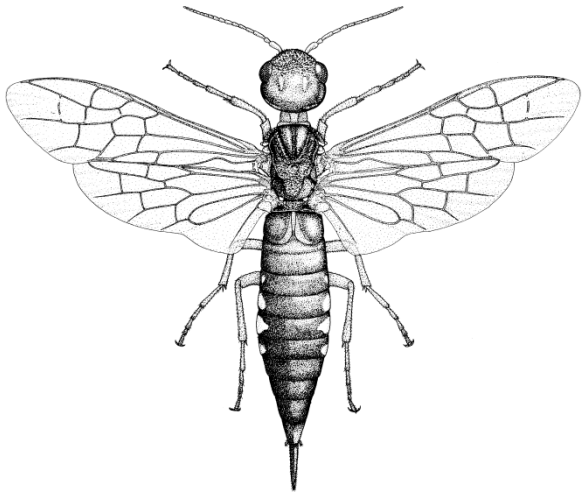
The larva is considerably different from typical caterpillars – no prolegs, vestigial thoracic limbs, single-segmented antennae, no sight organs, and a horn-like supraanal protrusion.

Development in the wood of conifers and deciduous trees:

- Subfamily: Siricinae (species of the genera *Xeris*, *Sirex*, and *Urocerus*) develop in wood of conifers.
- Subfamily: Tremitinae (species of the genus *Tremex* [*T. magus* and *T. fuscicornis*]) live in deciduous trees.

Superfamily: *XIPHYDRIOIDEA*

There is one family in the Czech Republic.



Family: **XIPHYDRIIDAE**

There are 3 species of a single genus (*Xyphidria*) in the Czech Republic. They are very close morphologically and biologically to horntails. Imagos are slim, over 14 mm long, with a long neck and the last abdominal segment bearing a horn-like protrusion. The ovipositor visibly protrudes.

Larvae are like those of Siricidae, only the antenna has 3 segments.

Development in broadleaved trees (Salicaceae, Betulaceae, Aceraceae and Ulmaceae), with a generation of only 1 year.

Superfamily: *ORUSSOIDEA*

Family: **ORUSSIDAE** (parasitic wood wasps)

There is a single species in the Czech Republic. It includes the only parasites (parasitoids) within the entire suborder Symphyta. Concerning the number of species, it is an insignificant family.

Imago is 9–15 mm long. Antennae in females have 10 segments, in males 11 segments, based above the clypeus. The female ovipositor is very delicate and long, and even though its length can exceed that of the body, at rest it is retracted inside the abdomen. Among other features, reduced venation is characteristic for the imago.

Larvae are apod, without stemmata, with single-segmented antennae, tridentate mandibles, and without a supraanal protrusion. Eggs are deposited into the host's gallery filled with grit, and the larva actively seeks the host and lives as an ectoparasite. They probably go through only 3 instars. They pupate near to the host's remains.

In Central Europe, this family is represented by only one rather important species, *Orussus abietinus* (15–18 mm in size; black, red at the back), which may be encountered on tree trunks. The precise biology of this species is unknown. It is presumed that it parasitizes larvae of wood-dwelling insect species (Buprestidae, Siricidae). Species of this family outside of Europe parasitize Buprestidae and Cerambycidae.

Suborder: APOCRITA

Superfamily: *STEPHANOIDEA*

Family: **STEPHANIDAE** (crown wasps)

A primarily tropical family, represented in the Czech Republic by a single rare species, *Stephanus serrator*, parasitizing beetle larvae living in wood (longhorn beetles, jewel beetles). Visually, they somewhat resemble Gasteruptionidae or Ichneumonidae (females with a long ovipositor). They are characterized primarily by a crown of 5 thorn-like protrusions around the middle ocellum, a long pronotum, darkly spotted wings, and thickened hind femora bearing three strong spikes.

Superfamily: *TRIGONALOIDEA*

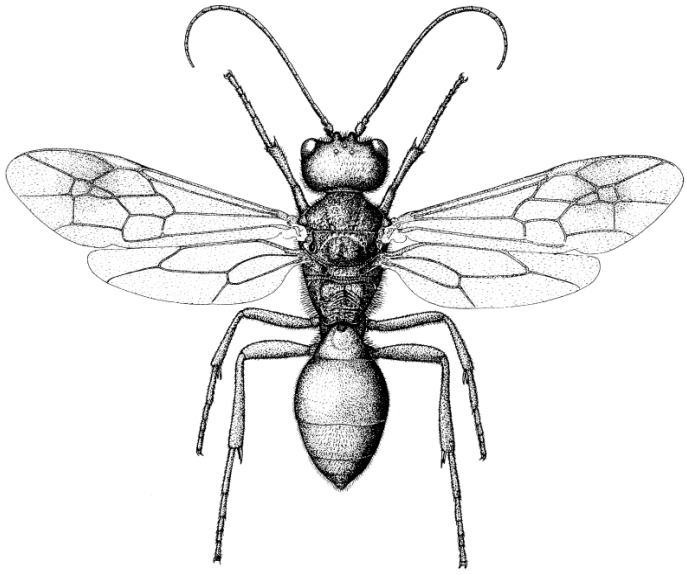
A small and considerably isolated superfamily with a single family, Trigonalidae. Visually, they somewhat resemble ichneumon wasps (Ichneumonidae), but their venation differs and they have some other primitive features. They are hyperparasites of Ichneumonidae.

Family: **TRIGONALIDAE**

In the Czech Republic (and in all of Europe) there is only 1 species, *Trigonalis hahni*. It is a species with an extremely interesting biology, developing in caterpillars as a hyperparasite of Ichneumonidae or as a primary parasitoid in Vespoidea larvae. Several thousand eggs are laid in groups on vegetative organs. These are then consumed by the caterpillar. Larvae only hatch from the eggs when passing through the caterpillar's digestive tract, and then invade trough the wall of the digestive tract into the haemocoel. They then develop only if:

the caterpillar was parasitized by an ichneumon wasp (most often *Ophion distans*, *Enicospilus merdarius*) or tachinid. They then seek its larva, invade it, and during the first three instars they develop further as endoparasitoids of these primary parasitoids. After the death of the caterpillar caused by the ichneumon wasp or tachinid, the Trigonalidae larva also kills the primary parasitoid. The Trigonalidae larva leaves the host's (tachinid's, ichneumon wasp's) body and as the 4th instar (already as an ectoparasitoid), consumes the remains of the caterpillar, and changes into the 5th instar which usually does not ingest food and pupates in a sparse cocoon.

the caterpillar is captured by a member of Vespidae. The wasp larva is fed by the chewed body, and the Trigonalidae then also develops in the first three instars as an endoparasite of the wasp larva, and in the 4th as an ectoparasite on the larval remains. Finally, the complete imago leaves the cell of the host species.

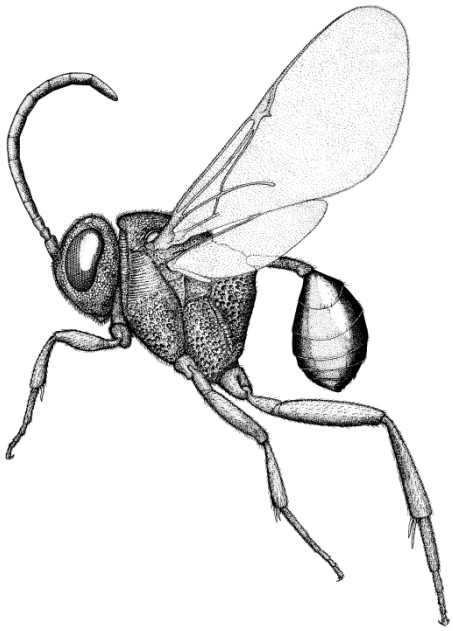


Superfamily: *EVANIOIDEA*

A superfamily with few species encompassing only 3 very small families (Evaniidae [ensign wasps], Aulacidae, and Gasteruptiidae) with a characteristic and very visible common feature – an abdomen based high above hind coxae.

Family: **EVANIIDAE** (ensign wasps)

There are 2 species in the Czech Republic. The family is easily discernible by the small, lentil-like laterally flattened abdomen on a thin stem. Ovipositor is short and frequently hidden. Venation is more or less reduced. The hind wing has a jugal lobe (the only example in Apocrita besides Aculeata). Antennae have 13 segments.



All species develop in the oothecae of cockroaches, where their larvae live rather like predators, while only one individual hatches from the ootheca. Females lay only a single egg into an ootheca (of various age) of the host species of cockroach. The egg is deposited into one of the eggs of the ootheca, which serves as nourishment for the larva of the first instar. Then the ensign wasp larva gradually consumes the other eggs. Larval development is concluded at the end of summer, the larva overwinters in the ootheca, pupates in the spring, and leaves the ootheca during the period of activity of the host species. The ensign wasp *Evania appendigaster* parasitizes the cockroaches *Periplaneta americana* and *Blatta orientalis*, and *Brychygaster minutus* parasitizes the genus *Ectobius*.

Family: **AULACIDAE**

There are 5 species in the Czech Republic. They are morphologically similar to the family Gastruptionidae (except for the shape of the abdomen), from which they also differ in their biology.

They are parasitoids of longhorn beetles (Cerambycidae) and wood-dwelling alder woodwasps (*Xyphidria camellus*). The parasitoid finishes its development and kills its host only after the host's larva has finished its development, pupates in a cocoon on its body, and chews its way out.

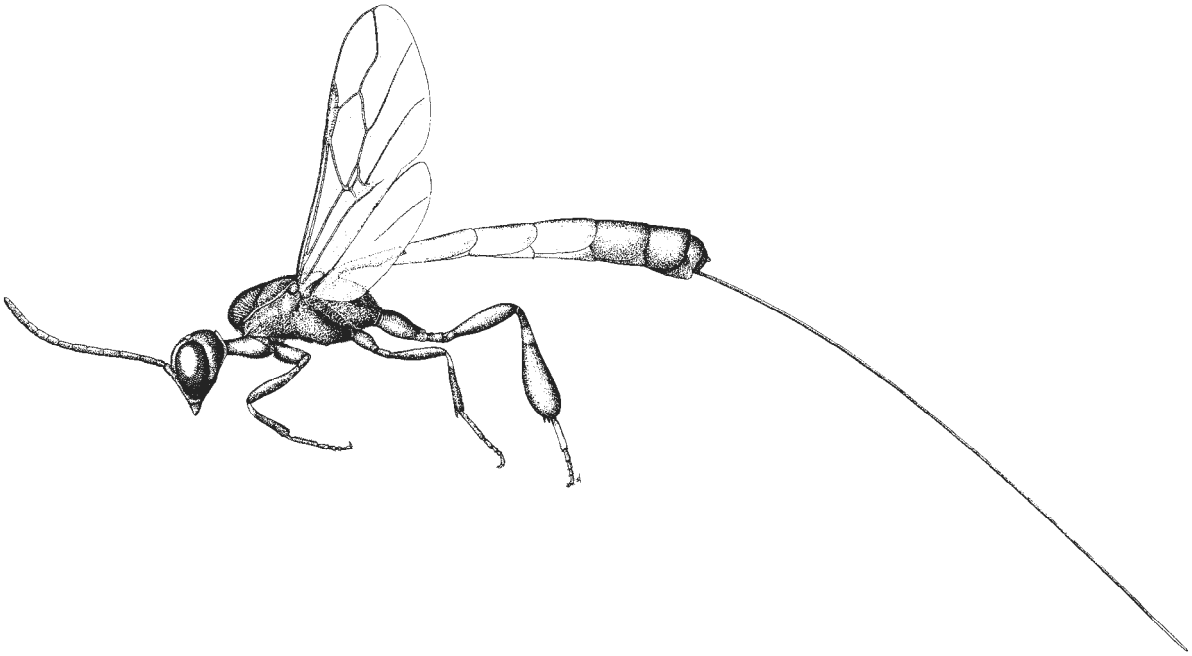
Species of the genus *Pristaulacus* (=*Aulacostethus*) parasitize jewel beetles (Buprestidae) and longhorn beetles (Cerambycidae). The most common species is *Aulacus striatus* (ca 10 mm long, black, with a red abdomen).

Family: **GASTERUPTIIDAE**

There are 17 species in the Czech Republic. Antennae have 13 segments; abdomen is elongated, laterally flattened, thin at the base and expanding towards the back. The ovipositor is visibly protruding. Forewings can be folded over longitudinally. Hind legs are long, with conspicuously extended tibiae.

Development as kleptoparasites of solitary bees and Crabronidae nesting in wood and twigs. They invade directly through the host's entrance and lay the egg into a cell (on the bee's egg or anywhere else). After hatching, the larva consumes the egg and eventually also the larva of the host species, and continues developing on food prepared for the offspring of the solitary bee. It often invades into an adjacent cell. It probably has 3 larval instars. The last instar forms a thin cocoon in which it overwinters and pupates in the early summer of the next year.

The species *Gasteruption affectator*, for example, is relatively common, found from the Polar Circle to Sicily and in the Alps up to the permanent snow line.

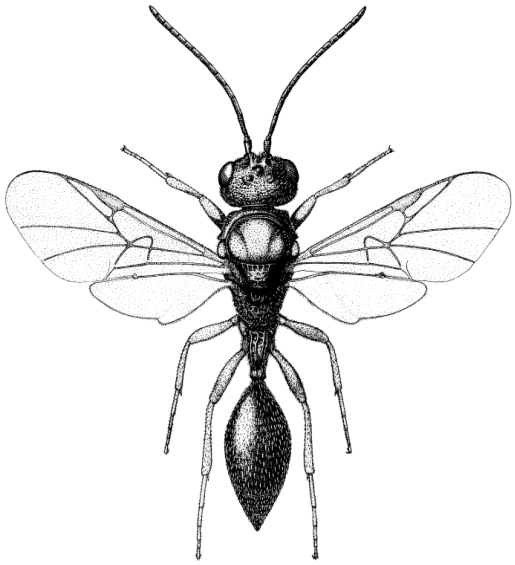


Superfamily: ***PROCTOTRUPOIDEA***

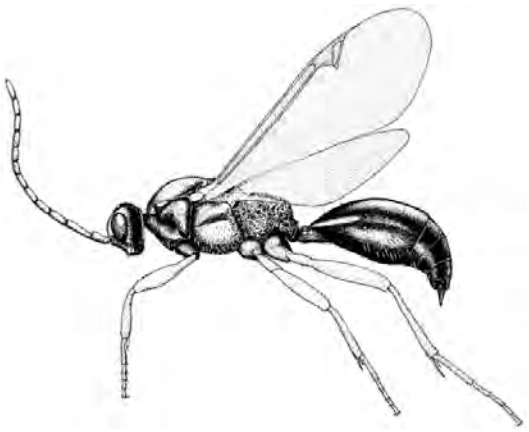
Family: **HELORIDAE**

Small, mostly black species with characteristic, relatively rich venation of the forewings. Pterostigma is present.

Species parasitizing larvae of green lacewings (Neuroptera: Chrysopidae). The parasitoid finishes development only when the green lacewing forms a cocoon.



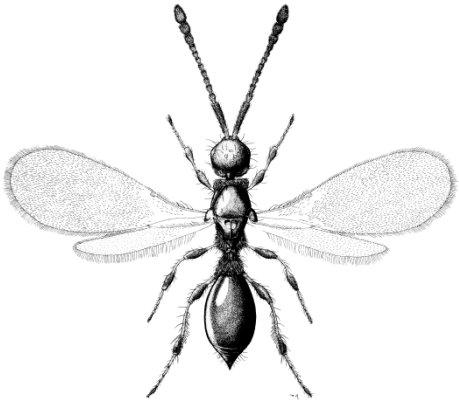
Family: **PROCTOTRUPIDAE**



Mostly small to medium-sized black glossy species. Some species are micropterous or apterous. Venation of the forewing is strongly reduced at the front edge (with only 2 enclosed fields). Pterostigma is present. One to four sternites and two to four tergites are merged.

A parasitic family parasitizing insect larvae hidden under bark, in rubbish, in fungi, and similar places. Hosts are mainly beetles, but also fungus gnats (Diptera: Mycetophilidae) and even Lithobiidae (Chilopoda [centipedes]).

Family: **DIAPRIIDAE**



Mostly small, black or brown species. Venation of the forewing is mostly even simpler than in Proctotrupidae, and pterostigma is absent.

A relatively large parasitic group, the biology of which is not well-known. The majority of species are endoparasitic and develop in puparia of Diptera, some develop as hyperparasitoids and infest Hymenoptera: Dryinidae parasitizing on leafhoppers (Hemiptera: Cicadellidae).

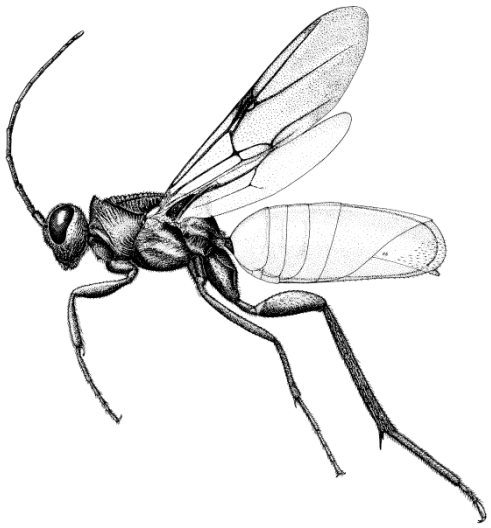
Superfamily:

CYNIPOIDEA

Body structure is very uniform with very characteristic features; especially the laterally flattened body and simplified, very characteristic venation. Antennae are filiform (12–16 segments), strongly developed sculptured scutum frequently with 1–2 dimples. Although the ovipositor is very long, its sheaths only protrude slightly (it is rolled spiral-like inside the abdomen).

The superfamily includes both phytophagous gall-forming species (some Cynipidae [gall wasps]) and entomophagous endoparasitic species (all remaining families).

Family: **IBALIIDAE**

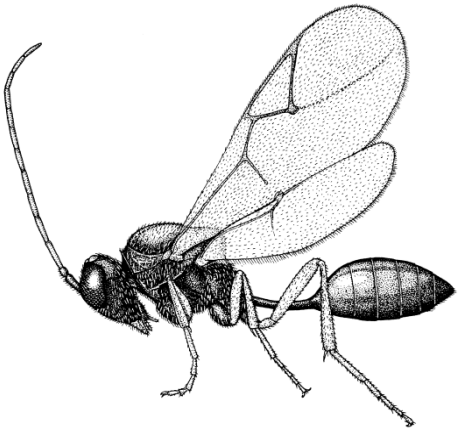


There are 2 species in the Czech Republic (*Ibalia leucospoides* and *I. rufipes*). Initial development as endoparasites in horntail (Siricidae) larvae, later instars as ectoparasites. Eggs and young larvae are parasitized. With its long and delicate ovipositor, the female follows the incision of the horntail until it reaches the host. An adult larva pupates in the galleries of the host. Total development takes almost 3 years.

Species of this genus were introduced to New Zealand and Australia as biological regulators of horntails damaging pine stands.

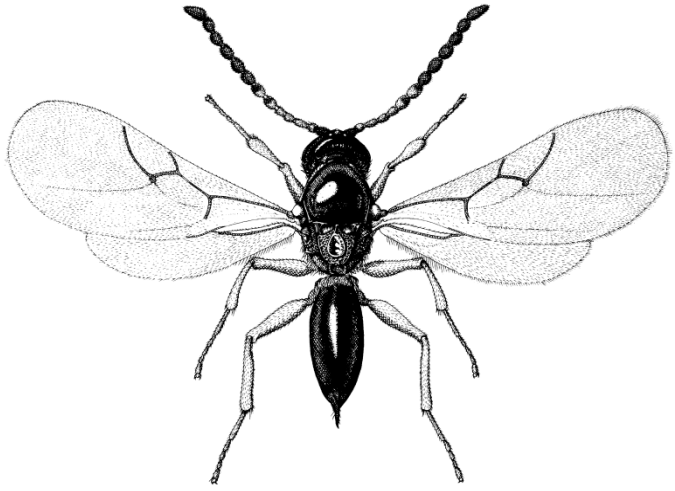
Family: **FIGITIDAE**

Species parasitizing larvae of brown lacewings (Neuroptera: Hemerobiidae) and hoverflies (Diptera: Syrphidae), especially aphidophagous (consuming aphids). They also have been recorded on other groups of Diptera.



Family: **EUCOILIDAE**

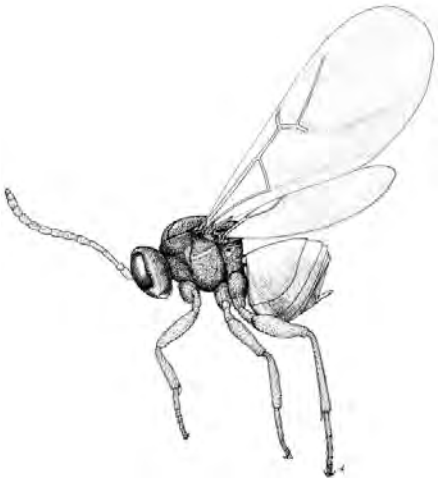
Parasites of larvae of various species of Diptera. A number of species have considerable economic significance, as they parasitize harmful Diptera from the families of leaf-miner flies (Agromyzidae), frit flies (Chloropidae), and Anthomyiidae.



Family: **CYNIPIDAE** (gall wasps)

Phytophagous species. Only a few cause the formation of galls (cecidia). Certain species not forming galls develop in galls of other gall-forming species. Galls are characteristic of particular gall-forming species and vary only slightly, so many species are easier to identify according to galls than according to imagos. In Central Europe, almost 85% of gall-forming species concentrate on oaks. The genus *Rosa* is the second most common target. Gall wasps occur only sporadically on other plants.

Galls, however, are not exclusively produced by gall wasps. They are also created by a number of species from other groups, such as gall midges, some Tenthredinidae, caterpillars, beetles, aphids, mites, nematodes, and others. Around 800 zoocecidia are known from north and central Europe alone.



Some species are characterized by alternating parthenogenetic and sexual generations (i.e. metagenesis), while the imagos of the individual generations can differ considerably. The galls they form are also different and may be found on entirely different organs. The imago lives for a relatively short time and apparently does not ingest food, with the possible exception of liquids.

Family: **CHARIPIDAE**

Some of this family parasitize Psylloidea and some develop as hyperparasitoids of aphids, the hosts of which are the aphidophagous Hymenoptera: Braconidae and Hymenoptera: Aphelinidae.

Superfamily: *CHALCIDOIDEA*

There are over 1,490 species in the Czech Republic. It is one of the most abundant groups of Apocrita and is systematically divided into 17 families (species occurring in Czech territory). The families are as follow: Aphelinidae, Chalcididae, Encyrtidae, Eucharitidae, Eulophidae, Eupelmidae, Eurytomidae, Leucospidae, Mymaridae, Ormyridae, Perilampidae, Pteromalidae, Signiphoridae, Tanaostigmatidae, Tetracampidae, Torymidae, and Trichogrammatidae.

They are exceedingly abundant in nature, but due to their insignificant size they remain almost unnoticed.

Average size between 2–4 mm, a number of species (especially egg parasites) far below 1 mm. Size over 4 mm is rather exceptional, although a few species reach sizes of almost 1 cm.

A considerable number of species have metallic coloration. Antennae always (with the exception of chalcid wasps of the family Eucharitidae) are geniculate, with a maximum of 13 segments, but mostly far less. They are characterized by generally strongly reduced venation.

The ovipositor ranges from entirely hidden (sometimes only the tips of its sheaths protrude) through various transitions to very long, exceeding body size.

Chalcidoidea differ from species with similar venation (certain species of Proctotrupoidea, Platygastroidea, and Ceraphronoidea) mainly in that:

- the pronotum does not reach to the tegulae and a prepectus is developed (only in *Mymaridae* is it very thin), and
- there are longitudinal rhinaria on the flagellum (the opposite is true for both aforementioned superfamilies).

Similarly to other Apocrita, imagos feed on flower nectar, but also on the host's bodily fluids after it is wounded by the ovipositor.

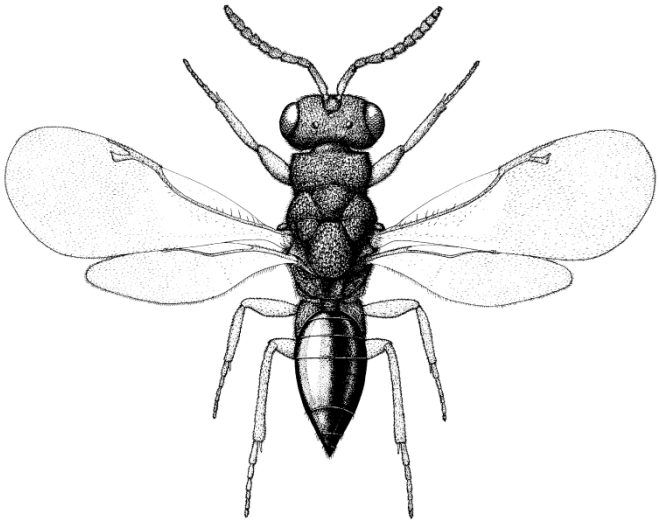
Chalcid wasps apparently demonstrate the largest biological diversity of all superfamilies.

Over 90% of larvae are parasitoids, but certain families also include phytophagous species or a combination of both types (Eurytomidae, Torymidae, exceptionally also in other families). They develop as solitary and gregarious parasitoids, endo- and ectoparasitoids. Hosts are the eggs of spiders, and mites; larvae and pupae of butterflies, beetles, Hymenoptera, Diptera, thrips, various sucking insects, and fleas; as well as eggs of various insect species. Certain species are very mobile in water, parasitizing eggs of aquatic insects (e.g. certain chalcid wasps of the families Trichogrammatidae and Mymaridae). Apart from primary parasitoids, the group also includes numerous parasitoids of higher levels. Polyembryony occurs most frequently here of all Hymenoptera, and parthenogenesis is also common.

Certain groups (Perilampidae, Eucharitidae) develop as hyperparasites of Ichneumonidae and Tachinidae. In such case, eggs are not laid on the host, but directly on a plant, where the characteristically formed larva of the first instar (planidium) waits for the host to approach. A condition for further development, however, is that the host already contains the larva of the primary parasitoid. The planidium then penetrates the parasitoid larva and waits for the moment when it leaves the host and pupates in the ground. Only then will it consume the primary parasite. Each species of the genus *Perilampus*, however, demonstrates deviations from this pattern.

A number of species have been successfully used in the biological struggle against insect pests (e.g. Aphelinidae for aphids and scale insects, Encyrtidae for scale insects, Mymaridae for Auchenorrhyncha, and Trichogrammatidae for destroying eggs of butterflies and Hymenoptera).

Family: **EURYTOMIDAE**



In contrast to other chalcid wasps, the body is strongly sculptured, black (exceptionally with yellow spots or entirely yellowish) with a very weak metallic shine. Body size of 1.4–6.0 mm. Female antennae are filiform, while males have serrate antennae with long cilia.

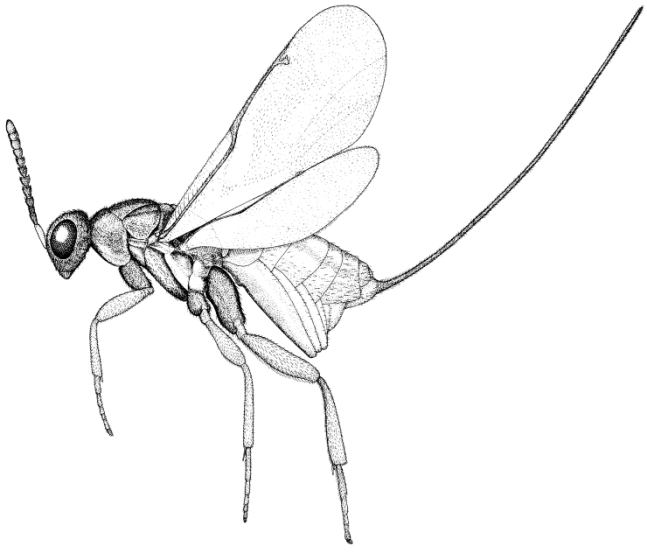
All species are endophytic. They develop either in seeds or stems of plants (certain species are gall-forming). The majority of species develop in plant tissue, but there they live as idiobiont ectoparasitoids of other insects.

Certain species of Eurytomidae of the genus *Bruchophagus* (eating the seeds of clover and alfalfa) and *Systole* (seeds of caraway and coriander) have significance for humans. Certain species develop in bark beetle larvae either unparasitized or parasitized by Braconidae (and thus they are facultative hyperparasitoids). Such species include, for example, the very common *Eurytoma morio* and *E. arctica*.

Family: **TORYMIDAE**

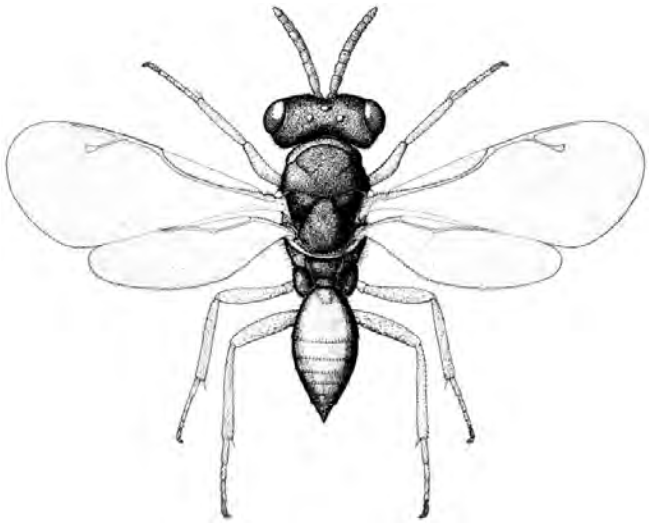
Body is mostly highly metallic, forewings with a long marginal and very short postmarignal and stigmal vein. Females have a long ovipositor protruding outside the body.

Development in plant tissue (mostly galls of another insect), where they develop as insectivores (parasitizing the actual gall-forming insects) or feed on tissue of the galls, sometimes both. Certain Torymidae develop in the endosperm of developing seeds (most are in the genus *Megastigmus*). Certain species of this genus are significant from a forestry perspective as pests of conifer seeds (and from an agricultural perspective also as pests of other plants).



Family: **PTEROMALIDAE**

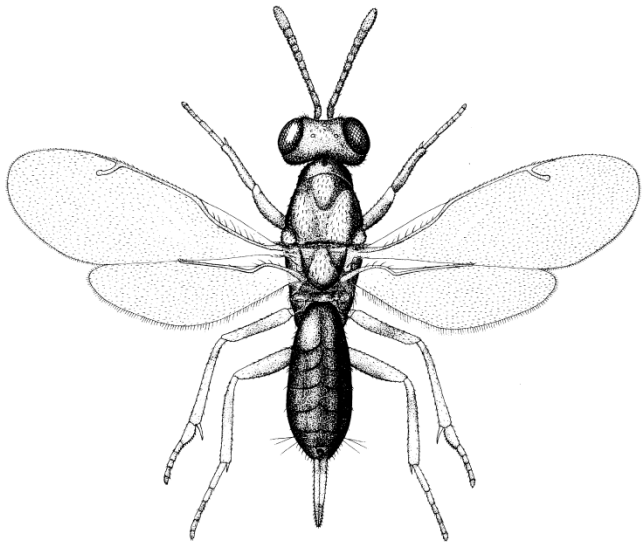
Usually metallic to very metallic species, body size of 1.2–6.7 mm. They are one of the largest families of Chalcidoidea. Lifestyles are very diverse; the majority of species are either solitary or gregarious ectoparasitoids of larvae and pupae of hosts from the orders Diptera, Coleoptera, Hymenoptera, Lepidoptera, and Siphonaptera. They parasitize hosts hidden in plant tissue, wood-destroying insects, plant leaf and stem miners, gall-forming insects, and others.



A number of species infest bark beetle larvae. *Raphitelus maculatus*, *Cheropachus quadrum* and *Dinotiscus* spp., for example, are common parasitoids of bark beetles of the genus *Scolytus*. *Rhopterocerus xylophagorum* and *R. mirus* infest larvae of the European spruce bark beetle (*Ips typographus*). An interesting species is *Tomicobia setneri*, which develops as an endoparasitoid of adult European spruce bark beetles.

Family: **EUPELMIDAE**

Both sexes have conspicuous, enlarged spurs on the tibiae of the middle legs. Body size of 1.3–7.5 mm.

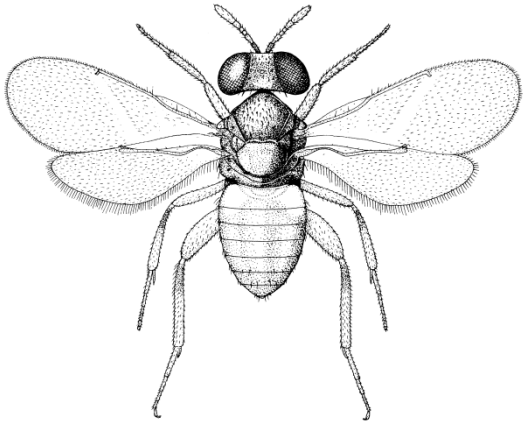


An overwhelming majority of species develop as parasitoids or facultative hyperparasitoids of juvenile stages of other insect species. Hosts have been recorded in the orders Lepidoptera, Hemiptera, Hymenoptera, Coleoptera, Neuroptera, and Orthoptera.

On bark beetles, the species *Eupelmus urozonus* can be encountered, developing as a primary ectoparasitoid or an ectoparasitoid of a large number of other primary parasitoids.

Family: **APHELINIDAE**

Very small species with body size of 0.6–1.4 mm. Coloration from light yellow to dark brown. Rarely slightly metallic.

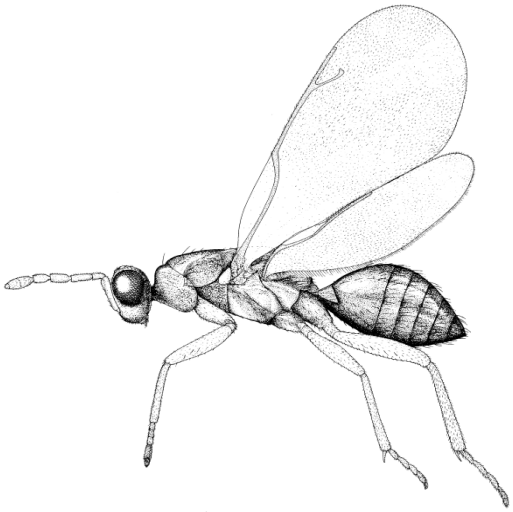


The majority of species parasitize larvae of Heteroptera: Sternorrhyncha. Most species infest scale insects (Coccoidea), aphids (Aphidoidea), whiteflies (Aleyrodoidea), and Psylloidea. A number of species infest eggs of Auchenorrhyncha, Lepidoptera, and Orthoptera.

Family: **EULOPHIDAE**

Extremely small to small species (0.4–0.6 mm). Coloration is yellowish to brownish, slightly to entirely metallic.

An extensive group including primary parasitoids of covertly living larvae (especially mining larvae of various orders). Certain species are also endoparasitoids of insect eggs. The egg-larva parasitoid *Entedon ergias* is important from a forestry perspective, infecting many species of bark beetles developing on deciduous trees.



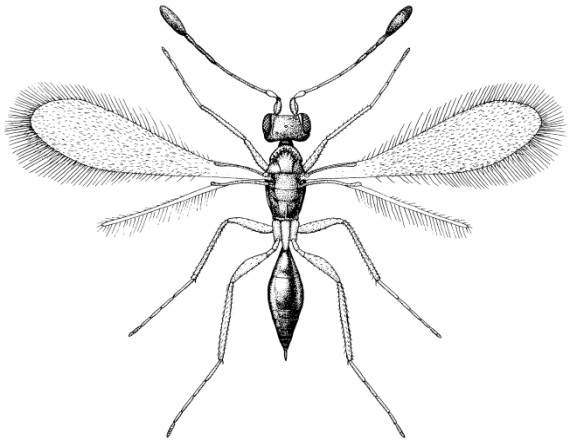
Family: **TRICHOGRAMMATIDAE**

Minute to small species (0.3–1.2 mm) with absent post-marginal vein on the forewings. Tarsi have three segments.

They are primary, solitary, and gregarious endoparasitoids of eggs of various insects. Hosts are mainly Lepidoptera, Hemiptera, beetles (Coleoptera), thrips (Thysanoptera), Hymenoptera, Diptera, and Neuroptera.

Family: **MYMARIDAE** (fairy wasps)

Minute species (0.35–1.8 mm), wings and venation strongly reduced, hind wings are stem-like. Solitary or rarely gregarious endoparasitoids of another insect's eggs.



Superfamily: *PLATYGASTROIDEA*

Family: **PLATYGASTRIDAE**

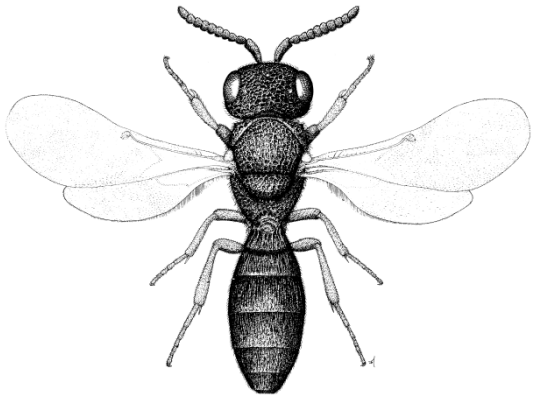
Small to minute species (0.5–3.0 mm). Forewings without stigmal and post-marginal veins.

Platygastridae are endoparasitoids. Their hosts are mostly Diptera larvae, especially gall midges (Cecidomyiidae). The first larval instar of certain species is considerably different (cyclopiform type).

Family: **SCELIONIDAE**

Small or minute (0.5–6.0 mm) very uniform species. Forewings always without sub-marginal and stigmal veins.

Scelionidae are exclusive egg parasites of other insects, especially lepidopterans and typical bugs, but also beetles (possibly spiders). The connection to the host is usually very close. The first larval instar is very bizarre, with a conspicuous small tail with a tendency to form a cephalothorax (so-called teleaform [protopod] type).



Superfamily: *CERAPHRONOIDEA*

Family: **CERAPHRONIDAE**

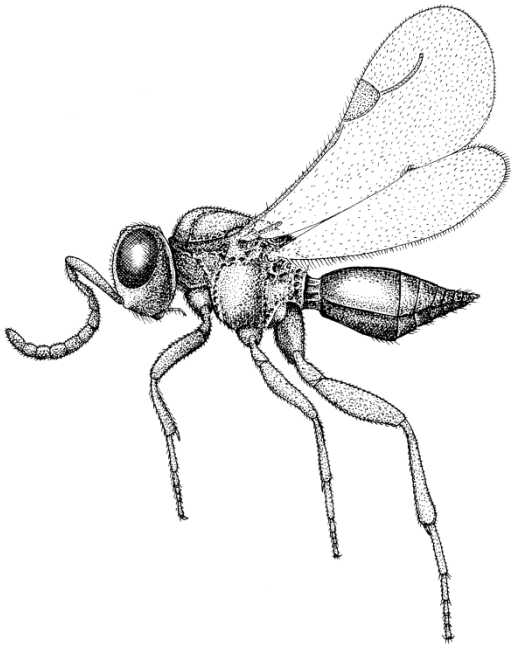
There are 9 species in the Czech Republic. Pronotum reaches to the tegulae.

Mostly endoparasites of Diptera: Nematocera larvae, especially gall midges (Cecidomyiidae). Other species parasitize thrips.

Family: **MEGASPILIDAE**

There are only 5 species in the Czech Republic. Pronotum reaches to the tegulae. Fully winged, brachypterous or apterous species.

Primary ectoparasites. Known hosts include Homoptera (Coccoidea), Mecoptera (Boreidae), Neuroptera (Hemerobiidae, Chrysopidae, Coniopterygidae), and a number of families in the order Diptera (Cecidomyidae, Syrphidae, Chlorophidae, Muscidae). They are known hyperparasites of Hymenoptera (a number of primary parasitoids from the suborder Apocrita [Braconidae, Chalcidoidea, Cynipoidea]). A number of species live in anthills, apparently as parasitoids of myrmecophilous Diptera.



Superfamily: *ICHNEUMONOIDEA*

There are 2 families in the Czech Republic with 2,340 species. All Ichenumoniodea live parasitically, their larvae develop in various insects and spiders, either as parasitoids or as predators (on spider eggs).

Family: **BRACONIDAE**

To date, 530 species have been reported in the Czech Republic. These species are generally small to medium-sized, mostly also inconspicuously coloured (1 mm to ca 10 mm without an ovipositor).

They have characteristic venation of the forewing with a single median cross-vein, and with the exception of the subfamily Aphidiinae the 3rd and 4th abdominal segments are merged (free in Ichneumonidae). Antennae consist of 40 and more segments, frequently exceeding the length of the body. Ovipositor is sometimes long (even in species in the Czech Republic exceeding body length several times over), while in other cases it does not protrude at all.

Imagos ingest sweet juices from blossoms. Females, however, frequently prick the host's body with the ovipositor and lick the outflowing bodily fluids.

Almost all species are primary parasitoids, only rarely hyperparasites (some species of the genus *Syntrechus* parasitize Ichneumonidae). They develop as ectoparasitoids (Doryctinae, Histeromerinae, Braconinae, and some Rhoganinae) or endoparasites (all other subfamilies).

An absolute majority of species parasitize larvae. The pupal stage is not parasitized at all, although in exceptional cases adults that parasitized adult larvae that were still able to pupate can emerge from a pupa.

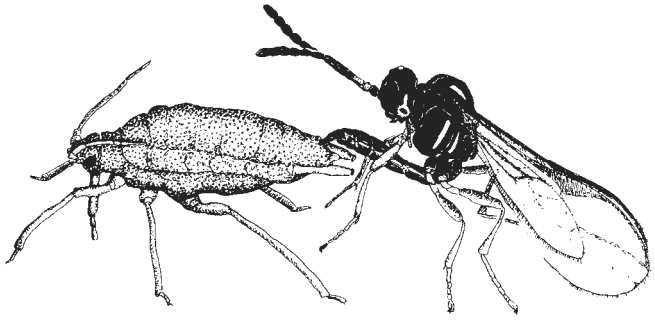
They only exceptionally parasitize imagos of beetles (certain species of the subfamily Euphorinae) or parasitize on imagos of ichneumon wasps (*Syntrechus lyctaea*) or ants (Neonurinae). Quintessential parasitoids of eggs are not represented. Members of the subfamilies Cheloninae and Ichneutinae lay their eggs into the host eggs, but their development only finishes in an adult larva.

Larvae frequently live together (gregarious parasitoids), though larger species individually. Polyembryony is known in certain species (e.g. *Macrocentrus*). The female often permanently paralyses or kills the host with the prick when laying eggs. In endoparasitoids, the larva of the first instar is considerably different from the following instars. In certain species, the primary larva is of the pseudopolypod type. Later instars lack these specialized features. In ectoparasites, larvae of the first instar are also of the normal hymenopteroid type (i.e. maggot larva, only with a cross-band of bristles on each segment).

Pupation of most species occurs in the cocoon formed from the product of the labial glands on the body surface of the host. Only some species pupate inside the host body (e.g. certain Rhogadinae in caterpillars). In gregarious parasites, many cocoons occur together, sometimes wrapped in additional thread. In the genus *Meteorus*, the cocoons are hanging.

The range of hosts is very wide. The most frequent hosts are caterpillars of Lepidoptera, and among other orders thereafter Diptera and Coleoptera (especially underbark and fungivorous). Relatively rarely parasitized groups include Neuroptera, Heteroptera, Psocoptera and Mecoptera, Hymenoptera [Symphyta], and exceptionally also other groups of Hymenoptera (e.g. Ichneumonidae and Formicidae).

An interesting group is the subfamily Aphidiinae (formerly classified under the separate family Aphidiidae [around 125 species in the Czech Republic]) which is strictly specialized on aphids. In contrast to the other Braconidae, they can bend their abdomen between the third and fourth segment under the body so that the ovipositor protrudes in front of the head. Larvae of the first instar have very strong mandibles and if a single aphid is parasitized multiple times, only the strongest larva survives. The other instars have vestigial mandibles and only ingest haemolymph. Nevertheless, they do not risk being endangered by multiparasitism of the same species because if an aphid is parasitized at this time once more, the embryo degenerates.



The fourth instar again has strong mandibles with which it feeds on all the remains of the aphid. Most Aphidiidae (but not all) pupate inside the body of the mummified aphid.

The number of generations differs depending on the species from one to several per year. They overwinter in the larval, pupal, and imaginal stages.

Family: **ICHNEUMONIDAE** (ichneumon wasps)

There are 1,810 species in the Czech Republic. An exceedingly numerous family concerning the number of species with worldwide distribution, but the centre of distribution is the temperate zone of the North Hemisphere. The body of Ichneumonidae is slim, greatly varied, but mostly medium-sized. The largest species (*Megarhyssa* [parasite of horntails]) reach 5 cm without the ovipositor and over 10 cm with the ovipositor. The smallest ones are only a few millimetres long.

The ichneumon wasps are characterized primarily by forewing venation with two median cross-veins. Certain species are apterous (wings entirely absent), or micropterous to brachypterous. In females of most species, the ovipositor visibly protrudes. It protrudes on the underside of the abdomen and before its end. Its length is highly variable and to a considerable extent reflects the host's way of life. The ovipositor serves primarily for laying eggs, but certainly in some species it also has a defensive function (especially in species with short and strong ovipositors). Venom glands are developed in a large number of species, used for temporary or (more rarely) permanent paralysis of the prey, exceptionally also for killing it.

Imagos live in the vegetative period usually for 6–8 weeks, overwintering females of course much longer (from summer to spring of the following year). Males do not overwinter and their lives are shorter.

Adults ingest honeydew, nectar, and other plant juices. Females of many species also lick the bodily fluids of the host they wound with the ovipositor, often without depositing an egg. This phenomenon is very distinctive in relatively abundant species of the genera *Pimpla* and *Exerites*, where it can be said the imago undergoes a certain shift to predation, extending the wounds after piercing also using its mandibles. Both the imago and the parasitic larvae of the ichneumon wasp therefore impact the host.

They develop in various stages of insects (most frequently endoparasites, less frequently also ectoparasites in larvae and pupae) and as mobile predators they consume eggs of spiders. The overwhelming majority of the species are primary parasitoids, although some species are hyperparasites and parasitize other parasitic Hymenoptera including ichneumonids (facultative or obligatory hyperparasitoids [e.g. mostly wingless, yellowish coloured ichneumonids of the genus *Gelis*] parasitizing other ichneumonids and Braconidae; other species of the same genus and ichneumonids of the genus *Trematobia* develop as predators in cocoons with spider eggs).

The wasps are usually solitary parasitoids, only rarely gregarious (only in ectoparasitoids and hyperparasitoids [e.g. of the genera *Gelis*, *Hemiteles*] with development in pupae).

The connection to the host is relatively narrow, i.e. these are most often strictly oligophagous to monophagous species. Polyphagous species include especially ectoparasites permanently paralysing their hosts and thus attacking hosts from various orders (i.e. species available in the given ecological niche).

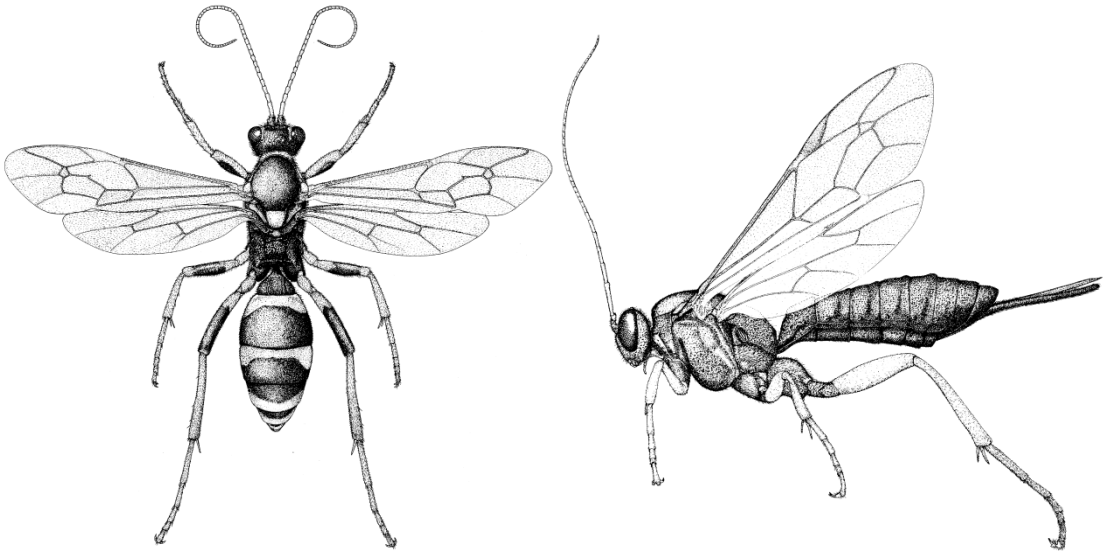
Ectoparasitic species also usually pierce the host (temporary paralysation). Females lay from some 10 to several thousand eggs, according to species. Eggs are usually deposited into the host, less frequently onto the host, which can be permanently or temporarily paralysed (usually these are species with a more primitive idiobiont strategy attacking advanced stages of larvae and pupae), and rarely on a leaf outside of a host (*Eucerotinae*, in this case planidial larva). In species parasitizing larvae of younger development instars, the parasite's development is delayed (koinobiont strategy) and proceeds only when the host's adult larva prepares for pupation or diapause.

These wasps parasitize mostly larvae and pupae of butterflies and Hymenoptera: Symphyta (ca 75% of species). Other hosts include especially larvae and pupae of beetles; relatively few species parasitize Diptera and other orders (Neuroptera, Mecoptera and Trichoptera). Among Hymenoptera: Apocrita, they parasitize gall wasps, bees and wasps. Insect eggs are parasitized rather rarely. In such case, however, the development is closely adapted to the host's development, as the parasite's development is delayed and its eggs only begin to develop once the host reaches the required size. For example, the genus *Diplazon* lays eggs into the eggs of hoverflies, but the imagos hatch only from puparia.

The number of larval instars ranges from 3 to 5. Larvae of the first instar of most ectoparasites and a number of endoparasites have the usual hymenopteroid, spindle shape and essentially do not differ from the following instars. They can have strongly developed mandibles, spiracles on the meso- and metathorax and on 8 abdominal segments. In a number of families, however, the larvae of the first instar are considerably different, characterized especially by a long caudal protrusion, absence of spiracles, etc. In other instars, the caudal protrusion gradually shortens and the larvae transform to the normal hymenopteroid type. In Eucerotinae the first instar is of the planidial type, flatter, and having numerous setae.

Pupation occurs on the place of the killed host, usually in the cocoon. It can be solid, but also very delicate (especially in multivoltine species and in species pupating inside butterfly pupae). They overwinter either as a free imago (relatively rarely), an imago in a cocoon, or as a first instar larva in a diapausing host.

The number of generations also varies, from one to three generations per year, and in bivoltine and multivoltine species frequently with alternating hosts.



Species with interesting biology:

- In the genus *Grotea*, the wasps parasitize solitary bees. Larvae consume the eggs and larvae of the host, then continue to feed on the stored food prepared for the bee's larva.
- Unusually interesting is the biology of *Agriotypus armatus*. It is black, the scutum protrudes into a conspicuous thorn, the abdomen has a stem, and its underside is also strongly sclerotized, so that the abdomen maintains its shape even after death. The imago enters the water and parasites on larvae of

caddisflies. The infected caddisfly larvae are conspicuous for the ca 30 mm long and 2–3 mm wide band of tracheal gills protruding from them.

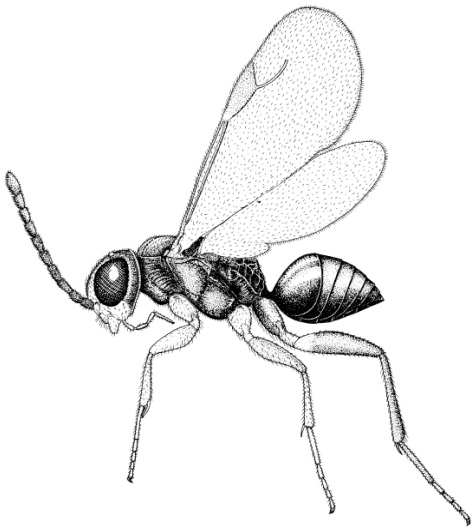
- The development in the subfamily Paxylommatinae is interesting, although not entirely understood, reportedly parasitizing ants of the genera *Myrmica* and *Lasius*.
- *Sphecophaga vesparum* develops as a parasitoid in wasp larvae
- The rust-coloured species of the genera *Netelia* and *Ophion* fly to light.

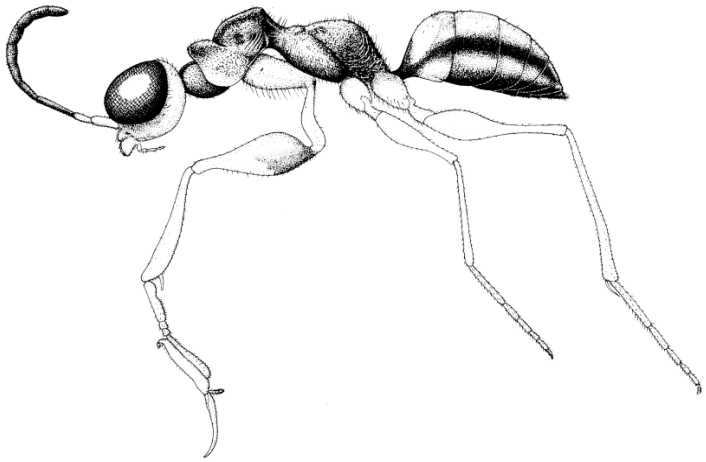
Superfamily: *CHRYSIDOIDEA*

Family: **DRYINIDAE**

Females have characteristically formed tarsi of the forelegs as a mighty seizing organ (chela). This is formed by the last tarsal segment and an enlarged claw (absent only in the subfamily Aphelopinae). Females are often brachypterous or apterous, males always winged (with the exception of the genus *Mystrophorus*).

They parasitize nymphs and rarely also imagos of Hemiptera: Auchenorrhyncha. The host is seized by the pincers (in Aphelopinae by the fore and mid legs), paralysed by a short prick, and the egg is placed between two segments. Larvae of the first instar are sac-like, other instars are hymenopteriform, and live on the surface of the host in special sacks. At the end of development, the host is either killed or seriously injured, the larva leaves the sac and pupates on a plant or on the ground in a thick cocoon. The pupa overwinters. Imagos frequently feed on honeydew secreted by the hosts.

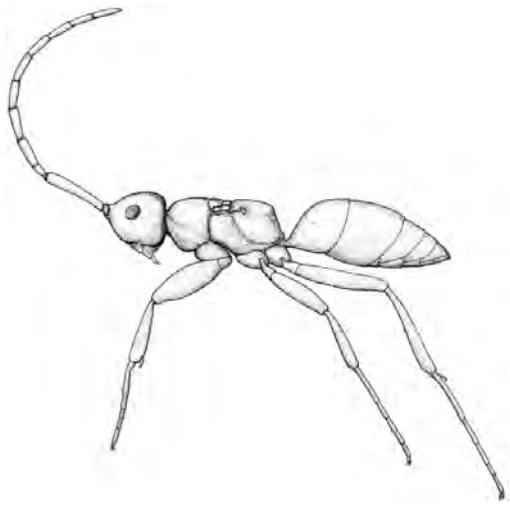




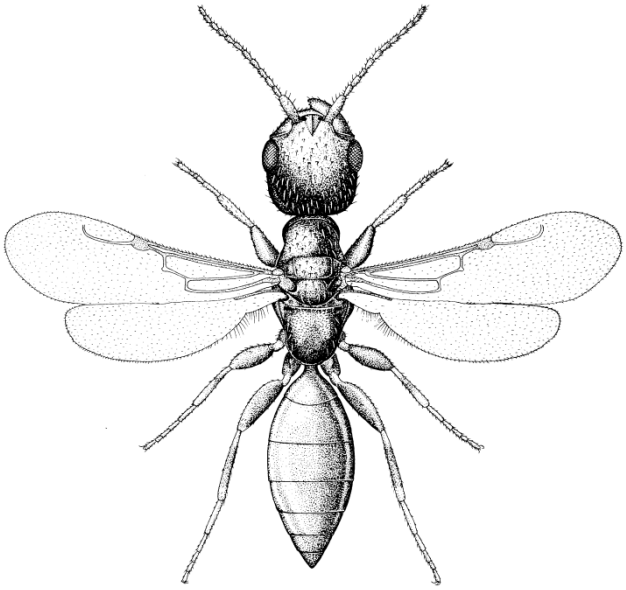
Family: **EMBOLEMIDAE**

A small family, imagos have 10-segmented antennae, females are wingless and males winged.

In the Czech Republic, there exists only *Embolemus ruddii*. Its biology is unknown. American species parasitize Hemiptera: Fulgoromorpha.



Family: **BETHYLIDAE**

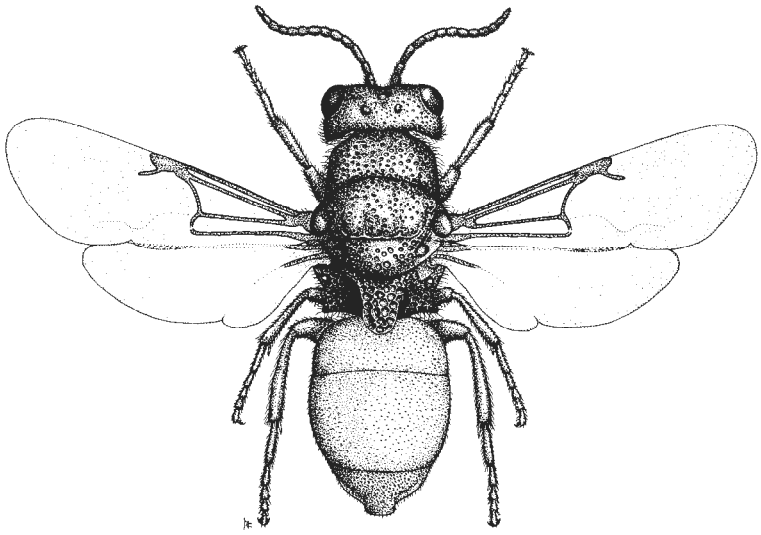


There are 42 species in the Czech Republic. The head is flat and prognathous. Forewings have reduced venation, and hind wings lack enclosed fields. Males are almost always winged, and females can be winged, brachypterous or apterous. In the latter case, the females are similar to ants.

Larvae and adults of Bethylidae are specialized predators of beetle and butterfly larvae. They attack especially those with various obscure lifestyles, such as inside rolled leaves, under bark, or in pieces of decaying wood. They pupate in a cocoon.

Occasionally an unfertilized female may lay only haploid eggs onto the prey, with only males hatching. The female then waits until these males complete their development and mates with them. Then it can lay eggs of the second generation that now include haploid and diploid individuals.

Family: **CHRYSIDIDAE**

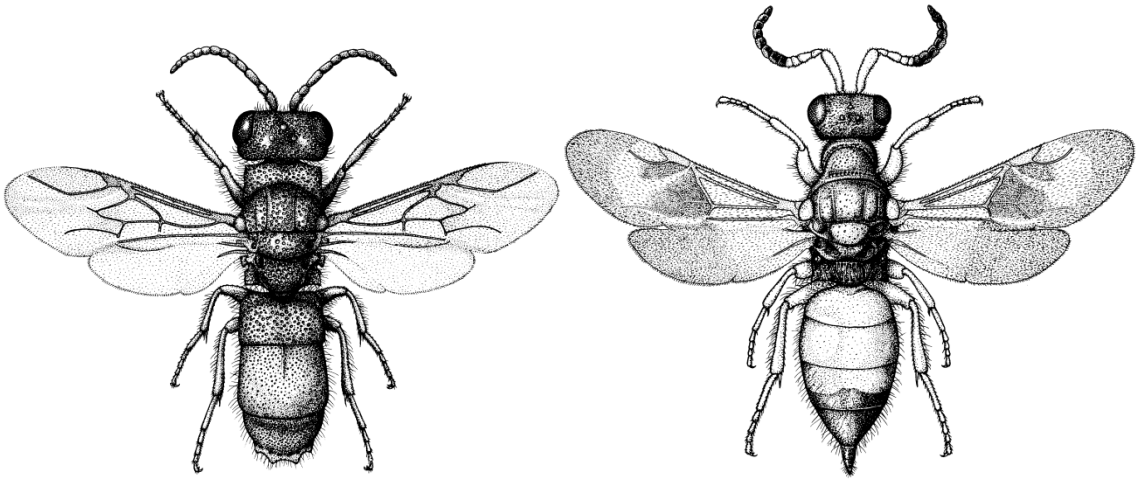


Small to medium-sized species (1.5–13 mm). Very colourfully metallic. Most frequently fiery blue, green, copper, yellow and gold coloured (structural colours). In the subfamily Cleptinae, the number of abdominal segments is reduced to 4 (females) or 5 (males), and in the subfamily Chrysidinae (cuckoo wasps) to 3 (females) and 4 (males). Antennae have 13 segments.

In Chrysidinae, the thorax and abdomen have rough spotting, hind segments telescopically inset, and the last segment frequently has characteristic indentations. The underside of the abdomen is concave, thus allowing it to roll up into a ball so perfect that only the wings protrude. The stinger is reduced, and a false telescopic ovipositor is developed.

Chrysidinae are very thermophilic and heliophilous, frequently visiting flowers with easily available nectar. The female lays eggs into the nests of solitary bees, Sphecidae, potter wasps and other Aculeata. The larva lives as an ectoparasitoid. The parasitoid begins to develop later, after the host has the necessary head start in development, as it is the only source of food for the larva. Alternatively, the Chrysididae larva consumes the egg or larva of the host and continues consuming the stored animal food prepared for the larva (kleptoparasitism).

Cleptinae develop in cocoons of horntails.



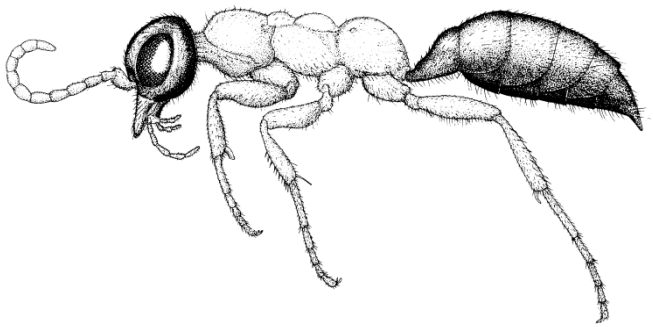
Superfamily: *VESPOIDEA*

Family: **TIPHIIDAE** (flower wasps)

Medium-sized species (5–28 mm). Males are always winged, females either winged (Tiphiinae) or apterous (Methochinae). Antennae have 12 (females) or 13 (males) segments. Claws of the tarsi are split. Males have an upward curved point at the end of the abdomen.

Tiphiinae seek out the larvae of soil-dwelling Scarabaeoidea beetles, permanently paralyse them with their stingers and lay one egg on each victim.

In the Czech Republic, Methochinae are represented by just a single species, *Methocha articulata*. Methocinae seek out the galleries of larvae of Coleoptera: Carabidae, paralysing them, then closing up the gallery after laying the egg.



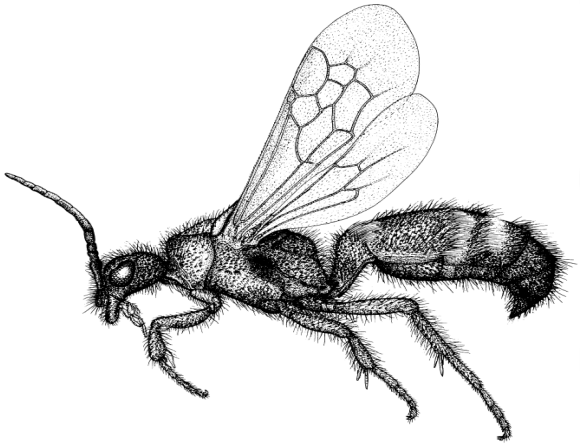
Family: **MUTILLIDAE** (velvet ants)

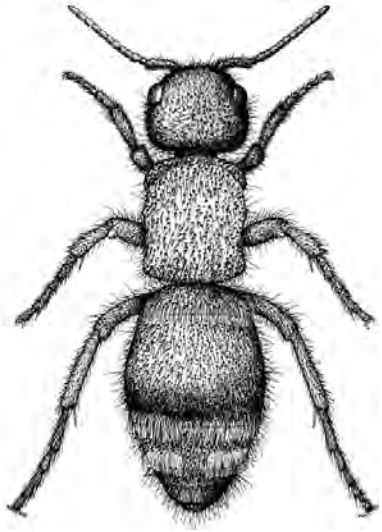
There are 20 species in the Czech Republic. Females are wingless, antennae have 12 segments, head lacks ocelli, thorax and abdomen frequently with dense spotting and covered by a dense pile of hair with conspicuous spotted pattern. Males are winged, with 13-segmented antennae, but the pattern is usually various.

Males carry the females in nuptial flight and thus contribute to spreading of the species. Eggs are laid into nests of other Hymenoptera (mainly bees, spider wasps and Crabronidae). They develop as kleptoparasites, their larvae living with the host larva.

Subfamily Mutillinae: species of the genus *Mutilla* develop in bumblebees (*Bombus* spp.), *Smycromyrme* spp. in a number of species from various families of other Hymenoptera. They open their cells, but only lay eggs into cells where the maturing larvae are preparing to pupate and without paralysing the prey (younger larvae are not parasitized). After consuming the larva, the velvet ant larva pupates in a cocoon. One of the largest European species is *Mutilla europaea*, with size of around 16 mm. It parasitizes, for example, bumblebees and can greatly decimate their colonies. As in other species of this family, the connection to the host is on the whole relatively free, so it can parasitize a number of species.

Subfamily Myrmosinae: species of this subfamily develop in solitary bees and Sphecidae.

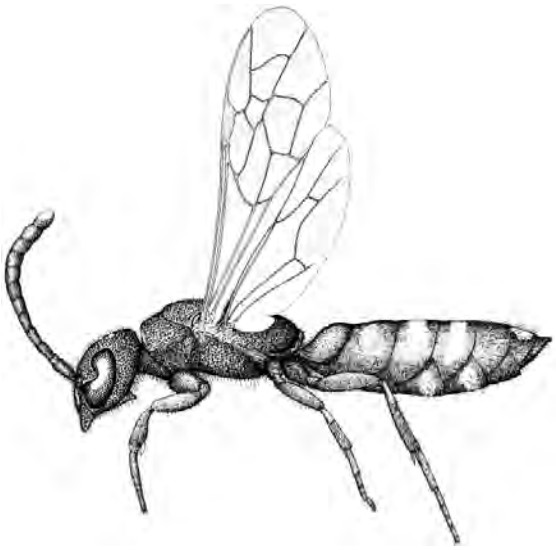




Family: **SAPYGIDAE**

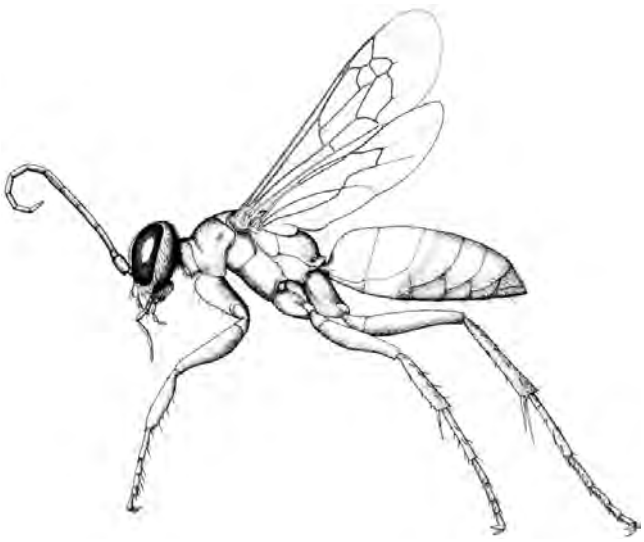
Four species exist in the Czech Republic. A number of species are characterized by antennae thickened at the end (capitate) and deeply curved eyes.

They are kleptoparasites of bees (Apidae) and certain potter wasps (Hymenoptera: Vespidae: Eumeninae) nesting in wood and in reeds. In contrast to the other Aculeata, they use their stingers for invading the cell of the host species. The larva of the first instar destroys the egg of the host and consumes the stored food prepared for the progeny of the host species of bee.



Family: **POMPILIDAE** (spider wasps)

Mostly medium-sized species with black and red body coloration, sometimes also with additional yellow pattern. Both sexes are winged, wings are not folded at rest, and venation of the forewing is complex. Antennae have 12 segments in females and 13 in males; females have curved antennae. Mesopleuron has a straight diagonal groove. Eyes are not kidney-shaped. Legs are conspicuously long, forelegs are fossorial with conspicuous thorns, and the hind legs have a cleaning apparatus (for cleaning the wings and body).



Adults feed on readily available nectar from flowers. Spider wasps are characterized by "nervous" flying close above the ground and jerky movement on the ground which relates to their seeking prey, and therefore it is different from that of Sphecidae. They hunt spiders for their larvae, permanently

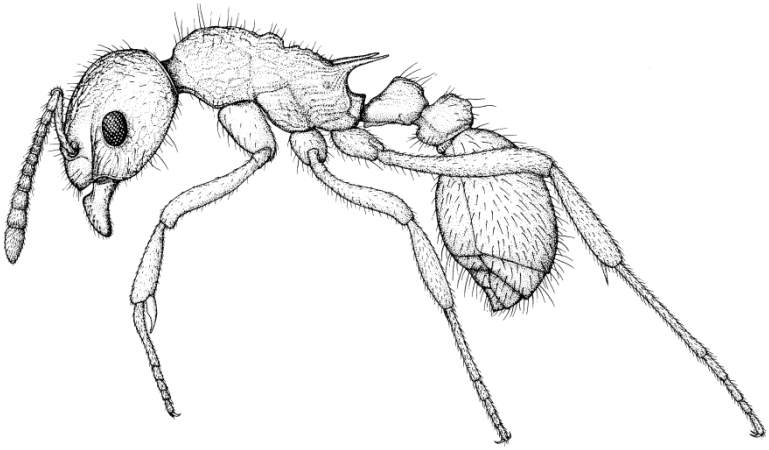
paralysing them with their stingers. The prey is usually larger than the imago, so a single prey suffices for the development of the larva of a single spider wasp (spiders are also preyed upon by members of Sphecidae, but they supply their larvae with larger numbers of small spiders).

Most species hunt spiders solitarily. These species mostly dig burrows into which they drag the spider and place the egg onto it. Then they close the burrow. Certain species have specialized and chase away another species of spider wasp from their prey. When the original species is chased off, they lay the egg into the lung sacs (either in depositing the prey when the original spider wasp digs the burrow, or while transporting the prey). Then it lets the original species finish the construction. However, the larvae of these species hatch earlier and destroy the egg of the original species. Then they develop normally on the spider. Species of the subfamily Ceropalinae live exclusively in this way.

Kleptoparasitism also sometimes occurs, with the female seeking the already prepared cell with the egg and prepared food of the original species and places its own egg inside. A larva soon hatches from the egg, consumes the egg of the original species, then continues to develop on the spider.

Pupae are in cocoons, of a single type for the entire family having a number of characteristic lateral protrusions on the abdomen.

Family: **FORMICIDAE** (ants)



Antennae have 10–12 segments in females and 10–13 in males and are geniculate. The first segment of the abdomen is short and scale-like, or the first two segments are short and knot-like. Hair on the body is only sparse. Eusocial species are characterized by the presence of three castes:

- **Workers** – apterous females with reduced sexual organs (having non-functional ovaries), ocelli are absent, eyes developed in various degrees (they can be entirely absent), but they are always smaller than in queens (maximal number of ommatidia is in males). The main role of the senses in the antennae is orientation. Workers are almost the same size or smaller than the queens (fertile females). Size depends on the species, most frequently 2–15 mm, but there is also considerable polymorphism within a given species. A special caste of workers (so-called soldiers) is only created in one Czech species *Colobopsis truncata* (Formicinae). The workers perform all the necessary work (collecting food, building the nest, protecting the nest, and caring for the young). They are short-lived (in *Formica rufa* ca 3 years)
- **Queens** – reproducing females with fully developed sexual organs, winged (wings are present or can be shed after nuptial flight) or exceptionally apterous. Thorax is much more developed than in workers (due to the presence of the wing musculature), ocelli are present, eyes are present. Their size is 1.5–3 times larger (but frequently even much larger still) than that of workers. Long-lived (in *Formica rufa* ca 15–20 years).
- **Males** – usually winged, exceptionally apterous, ocelli are present, eyes are most developed of the three castes, are visibly more slender than workers and queens, external copulation organs frequently well-visible. Very short-lived (die shortly after copulation or within several days).

Males hatch from unfertilized eggs, females from fertilized eggs. Caste of larvae hatching from fertilized eggs depends whether they are fed by the content of the crop (in which case workers occur) or by the secretion of the labial glands (when fully developed females are formed). This system applies for *Formica rufa* (southern wood ant). Otherwise, the conditions can be more complicated and we know little about them. For example, in the ant *Pheidole pallidula* the more robust soldiers develop from larvae that were fed upon meat in a certain stage of development.

In the Czech Republic, there occur representatives of 4 families:

- Ponerinae – only 3 species in the Czech Republic, locally rare, the most primitive in this country, their larvae are incapable of feeding themselves, armed with a stinger;
- Myrmicinae – armed with a stinger;
- Dolichoderinae – four species in the Czech Republic, no stinger, with repellent glands; and
- Formicinae – no stinger, secrete formic acid.

Ants form permanent colonies, situated specifically according to species in galleries underground, under stones, under tree bark, in wood of old trees, inside various plant parts (especially frequent in the tropics), etc. A functional nest (colony) contains

- one queen (monogynous colony) or several queens (polygynous colony);
- a quantity of workers;
- ants in various stages of developmental (eggs, larvae, and pupae); and
- males, occurring 1–2 times per year, most frequently at the end of summer and in early autumn.

A colony can last for many years, and its size is species specific. In monogynous colonies, the size of the colony is limited by the fertility of the queen (but still can reach several hundred thousand individuals). Polygynous colonies contain up to several hundred queens and the number of individuals can reach into the millions (e.g. certain forest species of *Formica*).

The social life and differentiation of individual members of a specific colony are determined by a constant exchange of substances and information. This occurs both between the workers and larvae (their mouthparts and rectums secrete substances vigorously licked by the workers, apparently stimulating them for increased care) and between the female and the workers around it (they constantly clean and lick the female), but also between the individual workers. Workers returning from outside regurgitate part of the content of the crop to the other workers. A similar permanent contact and licking is also connected to frequent cleaning, with the individuals helping one another. Communication is also apparent from movement of antennae, etc.

Swarming occurs when the males are present. Fertile females (future queens) and males copulate in the air or on the ground. The male dies shortly thereafter and the fertilized female seeks a suitable place for founding a new colony, then hides, usually overwintering. Losses are high, however, so even isolated females found new colonies.

In the spring, the queen starts laying eggs, and, without leaving her closed chamber, she cares for the young until the first workers are born. It is nourished by products obtained by degradation of the now useless wing muscles. The first workers, smaller than later generations of workers due to their poorer nourishment, open the chamber and take over all the tasks necessary for the life of the colony. The colony begins to grow, although it sometimes takes several years before the colony reaches normal strength (in some species up to 2,000,000 individuals). This basic cycle is more or less significantly modified in a number of species, however, as described below:

- Autoparasitism – a fertilized female re-invades the mother colony, and
  - a colony with several fertile females can occur, which notably accelerates the colony's growth, or
  - a new female can leave the colony with a number of workers and start a new colony.
- Temporary social parasitism – a fertilized female invades a colony of another species. Here it kills the host female and lays its own eggs, which will be taken care of by the workers of the host species. The host workers will die out quickly and the numbers of the parasite's workers increase.
  - When the parasitic species has sufficient numbers of workers it starts its own colony, or
  - this goes on until the host workers die off and the colony transforms into a pure colony of the parasitic species.
- Permanent social parasitism (inquilinism) – a fertilized female invades the colony of the host species, kills the female of the host, and its workers care for the parasite's young (i.e. identically as in temporary social parasitism). The parasitic species

    - has no workers and only produces females and males capable of reproduction, which invade other ant colonies after mating (with the death of the last host worker, the entire colony expires); or
    - the caste of workers is retained but it becomes so degenerated that the workers no longer contribute to the sustenance of the colony (with the death of the last host worker, the entire colony expires); or
    - in the extreme case, the parasite does not kill the female host and permanently parasitizes with coexistence of the two species (host and parasite).
- Slavery (dulosis) – the fertilized female founds a colony by one of the previous methods. Workers of the enslaving species, however, attack colonies of other ant species and carry away their pupae. The workers that hatch then procure everything the enslaving species needs to exist.

Interesting in the Czech Republic is *Formica sanguinea*, the females of which invade colonies of their own species (autoparasitism) or colonies of *Formica fusca* (temporary social parasitism). Such female, if successful, kills the female *F. fusca* and along with it also any hostile workers of this species. Workers hatching from the pupae consider the female their own and take on all the normal functions. During summer, the numbers of *F. fusca* workers is replenished through 1–2 attacks on other colonies of *F. fusca*, from whence the pupae are carried away (slavery).

While *Formica sanguinea* is capable to live in either mixed or pure colonies, the dependence of *Polyergus rufescens* on the host species of ant, which again is *Formica fusca*, is much greater. The start is similar, as the female *P. rufescens* invades a colony of *F. fusca*, kills their female, and leaves all subsequent care to the workers of the host species, as its own workers are incapable of caring for the offspring due to their own sharp mandibles. They are even dependent on the workers of the enslaved host species to feed them. Workers of *P. rufescens* replenish the numbers of workers of the enslaved species by attacking other colonies (slavery).

Among Czech fauna, only the corpulent *Anergates atratulus* is entirely without workers. It is a rare parasite of the ant nests of the genus *Tetramorium* (permanent social parasitism – inquilinism).

The life of the so-called shining guest ant, *Formicoxenus nitidulus*, is also connected to colonies of the species *Formica rufa* and *Formica polyctena*. It does not build its own nests and is dependent on consuming the remains of food and begging from workers of the host species and without harming them in any way (an example of xenobiosis).

Division of labour is usually not so significant as in the European honeybee, and usually all workers are able to perform any tasks arising from the social life. Care for the young is one of the main tasks of the workers. They collect the eggs of the female, deposit them at a suitable place, and by licking they protect them from moulds and loss of humidity. Eggs and young larvae are usually situated near the female, and older larvae are gradually transported closer to the surface of the structure. Temperature and humidity are very effectively regulated by ventilation – for example, summer temperature inside the mound of the southern wood ant (*F. rufa*) ranges between 26 and 31°C. Especially in species building mound-like nests, the material of the construction is in continuous movement in relation to regulating the climate, but at the same time it also prevents the plant material from moulding. Other duties include the transport of detritus of all kinds, including dead workers, outside of the colony, import of building material, and gathering food.

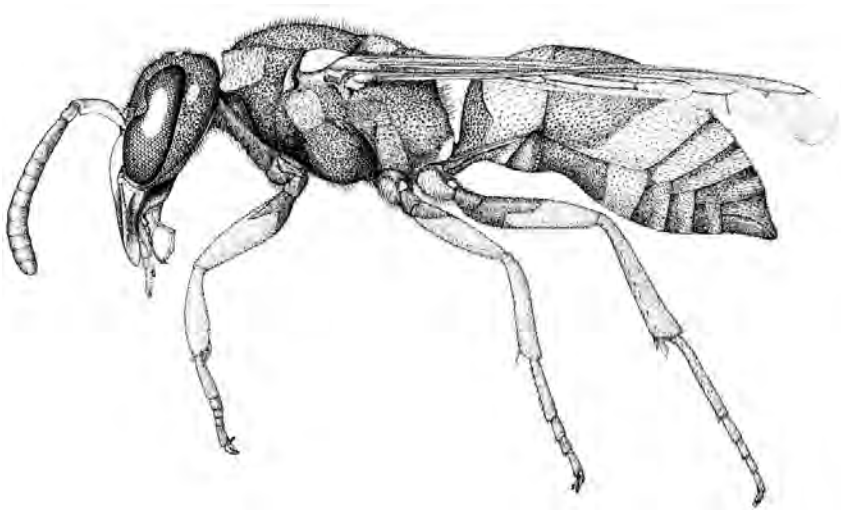
On frequently very long trips for food, ants orient themselves according to the sun (on cloudy days according to the polarization pattern of the sky), but the antennae probably play the main role. Among psychic features, memory is exceptional (utilizing the corpora pedunculata). It is most developed in workers and least developed in males.

Larvae of ants are apod, usually with a strongly reduced cranium, have little apparent segmentation, and are more or less immobile. Labial glands are very well-developed, producing also the cocoon. Larvae of most species are dependent only on input of liquid food from the crop or products of the labial glands of the workers. Only in the subfamily Ponerinae are the larvae more visibly segmented, mobile, and with better developed mouth parts so that they can eat also small pieces of solid food.

The majority of ants are omnivores. They frequently consume all developmental stages of various insects. When there is a large outbreak of pests, they can be very useful. However, there are a number of food specialists (e.g. ants of the genus *Messor* collect seeds of cultivated grasses, and other species collect seeds of particular plants). The preferred food of workers is honeydew secreted by aphids, scale insects, Psylloidea and leafhoppers. Ants provide considerable protection for these species by chasing away parasites, eating the individuals that have attacked them (therefore an ant-frequented aphid population fares better than usual). Certain species intentionally introduce root aphids onto roots traversing under their nest structures or cover the aphids on the plant with their mounds. Among Czech species, especially those of the genus *Lasius* specialize in raising aphids. According to the species, they combine their own "flocks" with visiting free-living aphid colonies.

For the most part, ant species in the Czech Republic are beneficial due to their consuming considerable quantities of other insects. Their prey are not only phytophagous species, including various insect pests, however, but also such beneficial insects as parasitic Hymenoptera and hoverflies. In the tropics, there are species definitely harmful, or feared due to their venom. Some species are very problematic in households, such as the currently cosmopolitan Pharaoh ant (*Monomorium pharaonis*).

Family: **VESPIDAE** (wasps)



There are 76 species in the Czech Republic. Species are of medium size (7–40 mm), black–yellow coloration. Both sexes are fully winged, forewings longitudinally folded at rest (except for the pollen wasps subfamily Masarinae). Eyes are more or less kidney-shaped on the inside edge, mandibles strongly developed, body only slightly haired (in comparison to Apoidea). The stinger has similar construction as in the European honeybee, but the barbs are much smaller, so the stinger can be pulled out without injury.

Species live mostly solitarily (subfamilies Masarinae and Eumeninae) or eusocially (subfamily Vespinae). Imagos feed mostly upon plant food (nectar, plant juices, honeydew). The genus *Polistes* even stores small amounts of nectar in its cells.

Larvae are fed either with pollen and sweet juices (subfamily Masarinae) or the bodies of other insects (subfamilies Eumeninae and Vespinae).

In Central Europe, there is only 1 species from the family Masarinae. It is the 6–7 mm long *Celonites abbreviatus*. The areas nearest to the Czech Republic where it lives are the warmest parts of Slovakia. They build nests in the form of rows of clay cells attached to plant stems. If touched they roll up into a ball and hide their wings between the thorax and abdomen similarly to cuckoo wasps (Chrysididae).

Species of the most numerous subfamily Eumeninae (60 species in the Czech Republic) build structures from mud and clay which they situate on plants and clay walls. Other species use holes in wood, galls, etc. After completing a cell, an egg is attached to the top wall and then the cell is filled with paralysed small insects and closed. The most usual larval food is caterpillars (especially inchworms and totrix moths) and larvae of certain beetles (especially leaf beetles and true weevils). They are paralysed by stinging. Certain species choose only one of these families, while others are not so choosy and use also other species from these orders. Pupation occurs in a cocoon inside the cell.

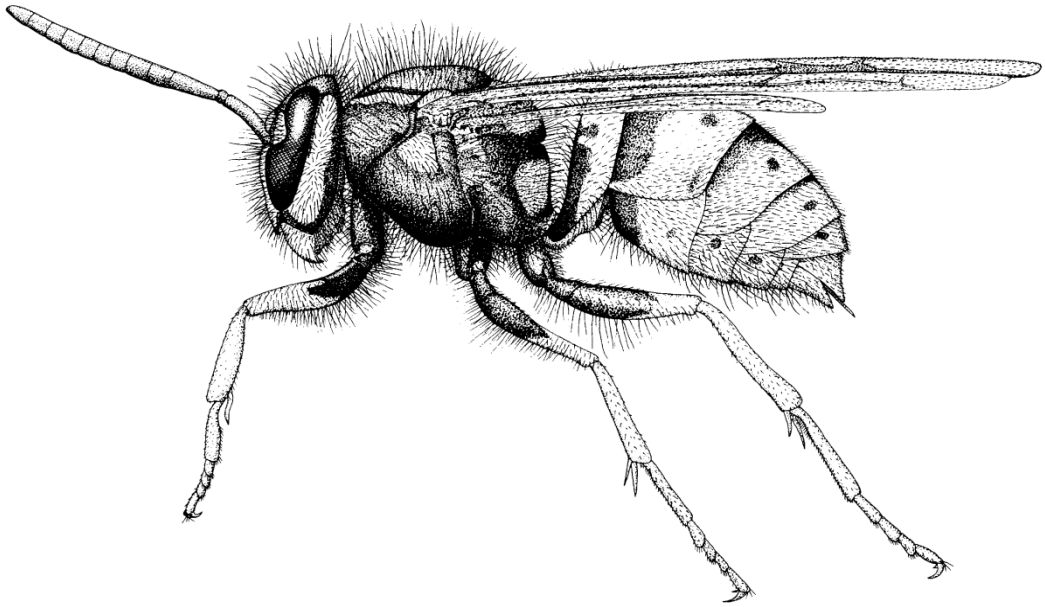
Species of the subfamily Vespinae (15 species in the Czech Republic) are eusocial, forming one-year monogynous colonies. Wasp colonies reach far lower numbers of individuals than in the cases of bee or ant colonies. Fertile females together with males (who are hatched from unfertilized eggs just as in ants) hatch at the end of summer. After fertilization, females seek winter grounds (usually under bark, in decayed wood, moss, rock cracks and human structures, etc.). Workers, males and unfertilized females die in autumn.

In spring, the female feeds on blossoms for a certain time and then establishes a new nest (old nests are not repopulated). It constructs the basis of the nest, where it lays a small number of eggs and provides food. Imagos feed on insects, nectar and, especially at the end of summer and in autumn, on fruit juices.

Larvae are fed with ground insects. In contrast to Eumenidae, food is transported already dead and chewed. Combs have a single layer (versus two layers in the European honeybee), open parts directed downward, and eggs are attached to the cells by secretions that also function for the younger larvae, while older larvae hold on by pressing their bodies against the cell walls.

Placement, shape, and material used for nest construction are species-specific. Construction material is always plant fibres, most frequently from wood. Other materials are also possible, however, such as bark, dry stems of herbaceous plants, or dry leaves. Depending on material, the nests also have various consistencies. In the case of wasps the paper is flexible, and in that of hornets it is very brittle and fragile. Nest placement depends upon the requirements of the individual species. They are placed directly on trees, on the ground, within the ground (e.g. German wasp [*Vespula germanica*]), and cover provided by human buildings is frequently used.

Here, too, a division of labour exists in the colony, similarly to that of the European honeybee.



Family: **SCOLIIDAE**

There are 3 species in the Czech Republic. This family includes some of the largest and most prominently coloured species of Aculeata and Hymenoptera in general. The basic coloration is black, with yellow or potentially red markings. Biology is similar to that of flower wasps (Tiphiidae).

They lay eggs individually on paralysed larvae of large beetles developing in the soil, especially larvae of scarabs (Scarabaeidae), which they pursue into the substrate. The larva lives as an ectoparasite until it consumes all consumable parts. Then it pupates in a cocoon.

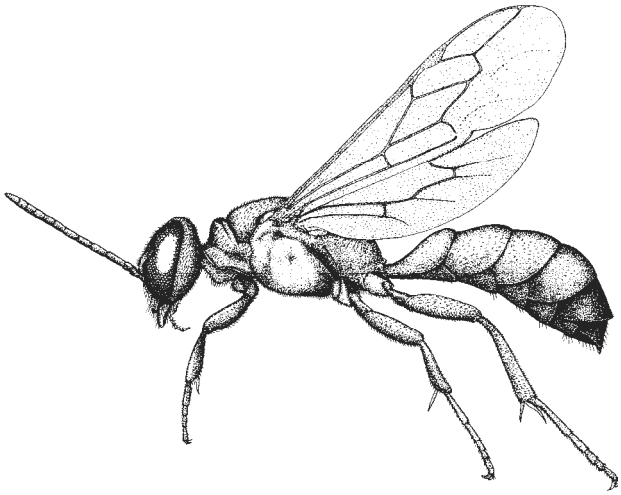
Superfamily: *APOIDEA*

Family: **AMPULICIDAE**

There are only 2 species in the Czech Republic. Slender, frequently strongly metallic species, with markedly developed mandibles.

Adults feed on haemolymph of their hosts, i.e. cockroaches (especially Blattodea: Ectobiidae). An adult paralyses the host with its stinger and places it into a prepared chamber (openings in wood created by other insects are used most frequently). The larva gradually consumes the host.

Family: **SPHECIDAE**



A very diverse group, body size of between 3 mm (*Spilomena* genus) and 50 mm (*Sphex* genus). Morphologically they are very difficult to distinguish from bees, but biologically they are well discernible.

Sphecidae feed their larvae with paralysed insects (imagos and larvae of the orders Coleoptera, Diptera, Hymenoptera and Lepidoptera) and spiders, while bees feed their larvae only with pollen and nectar. Due to their providing parental care, the number of eggs laid is relatively small and most frequently ranges around 10.

From similarly living spider wasps (Pompilidae) they differ by their short prothorax and shorter hind legs. Antennae have 12 segments in females and 13 segments in males. Eyes are large and frequently kidney-shaped.

Females of those species that dig galleries have strongly spiked basal segments of the tarsi. This apparatus is absent in species that do not dig. Abdomen sometimes has a significant stem, and at other times it is set normally. Hairs of the imago are sparse, and only the facial part of the head often bears thick, silvery shiny hairs.

Larvae live carnivorously on stores of paralysed food prepared by the female. They develop either on a single prey of larger size or are provided with larger number of smaller species (the more usual case). Prey differs by various species, but for each species it is limited to a relatively small range of species. Rarely, only a single species of prey is hunted (e.g. the European beewolf [*Philanthus triangulum*] hunts only the European honeybee). The prey is paralysed but alive, and thus it does not rot for one or two weeks, and many times significantly longer. After its capture, it is transported to a nest that mostly has been prepared in advance. After filling the nest with food, an egg is placed on one of the pieces of prey and the opening is closed off. Certain species, however, replenish the food for the growing larva, and thus a single female can service several burrows. Burrows are located in various places: in the ground, wood openings, galleries in wood, branches, stems, etc. Ground burrows with a single chamber are most typical, or branching galleries with several chambers, as well as galleries in old wood, branches and stems of plants where the gallery chambers are placed in a line next to one another, but separated by various materials.

After the larval development is complete, which usually takes less than 14 days, the larva creates a cocoon within which it subsequently pupates. Most frequently, it overwinters as a grown larva in a cocoon, or in certain species as an imago.

Imagos live almost exclusively upon easily available nectar and pollen.

Examples:

- *Ammophila sabulosa*. Its typical biotopes are sandy, sunlit roads. It is active in the warmest daytime hours (11 a.m.–3 p.m.) and vanishes when even a small cloud appears. It hunts non-hairy caterpillars. Already before the hunt, an earthen gallery several centimetres long is dug and resealed. Paralysed prey is often transported from afar, placed in front of the burrow and the gallery is opened. Then the female will recede into the gallery, dragging the caterpillar behind it, place the egg onto it, leave the gallery and seal it. Usually, 10 such nests are established. The grown larva makes a cocoon, but pupates only shortly before hatching. There is apparently only one generation per year.

Family: **CRABRONIDAE**

Formerly a subfamily of the family Sphecidae, with which they also share biology. Their most frequent hosts are representatives of the order Diptera.

Examples:

- In species of genus *Bembix*, eggs are laid into a gallery before the prey is brought in, and food stocks (similarly to certain other species) are continuously replenished.
- *Philanthus triangulum* (European beewolf) is a specialized hunter of bees. It is a black-and-white species, 12–16 mm long. Males are smaller and with different markings on the forehead than the females. They only hunt if the temperature exceeds 25°C. The bee is usually unable to defend itself. An incision is made into the membranous part behind the prey's front coxa. Before the paralysed prey is transported into the nest, the attacker usually pushes out and licks the

sweet contents of the crop. Oftentimes, the bees are hunted solely for this purpose. The nest consists of a corridor in the ground up to 1 m long with branches the size of pigeon eggs. Usually, three paralysed bees are placed into each and one egg laid on them. There are usually 5–7 chambers in one gallery, and such nest is built 1–2 times per year. This ratio of food provided corresponds to the general principle that in species feeding their larvae with paralysed prey, about three times the predator's weight of prey is necessary for development of a single larva. The number of paralysed items of prey is therefore dependent on their size (more if they are smaller, fewer if they are larger, and, in case of *Philanthus*, the prey size is about equal to that of the predator [thus the three bees]). Development is very rapid – after approximately 3 days from laying the eggs a larva hatches, it completes its development in just 5 days, cocoons, but usually only pupates the next summer. As they have very specific requirements for nesting (and those are usually only fulfilled in the immediate vicinity of an existing nest), nests are often found together. Thus, in rare cases local overpopulation can occur and this can pose a threat to beekeeping.

- Fly hunting is a speciality of, for example, *Mellinus arvensis*, which is attracted by human excrement (or rather by the numbers of flies seeking them), and of *Oxybelus*, which flies to its nest with flies pinned to the stinger and held by the hind legs.
- Species of the genus *Nysson* are kleptoparasites in nests of other Sphecidae (especially Sphecidae of the genus *Gorytes*).

Family: **APIDAE** (bees)

There are 700 species in the Czech Republic. The largest abundance of species is in warm and dry steppe areas. It is not easy to differentiate bees from Sphecidae, although biologically the two groups are quite different. While larvae of Sphecidae feed solely on animal food, larvae of bees eat plant food composed of a mixture of nectar and pollen.

Body size is 1.5–40 mm, usually around 10 mm. In coloration, shades of brown are prevalent, yellow and red markings are also frequent, and rarely metallic coloration also occurs. Bees are usually strongly haired, and the occurrence of feather-wise branched hairs is typical (this characteristic, however, is less prominent in bees that have switched to a kleptoparasitic way of life). In males and females, the metatarsus is long, flat and hairy on the internal side, which is a characteristic not found in Sphecidae, but that is developed also in kleptoparasitic bees, which can be easily confused with Sphecidae due to their sparse hairs and frequently also their coloration. Wings are always developed. Sexual dimorphism is developed in various degrees and it is reflected in size, abdomen structure, number of antennal segments (males 13 segments, females 12 segments) as well as in other characteristics of the antenna, formation of the eyes, mandibles, legs (especially forelegs), etc.

All bees feed on pollen and nectar. Most plants are allogamous and are to a larger or lesser degree dependent on pollination by insects, with bees playing the largest role. Pollen and nectar are only collected by adults, while individual groups of bees prefer certain groups of plants, which is very strongly reflected in proboscis length (the longest on bumblebees). Pollen is usually collected by the feather-wise branched hairs using the forelegs and middle legs, processed and moved to a storage place. According to the placement of the storage place, bees can be divided into two groups:

- **Leg-collecting bees** – pollen is transported on strongly haired legs, which is most significant in social bees, where baskets and brushes are developed on hind legs (most bees).
- **Belly-collecting bees** – pollen is stored on the sides of the propodeum (e.g. *Andrena*), and on the underside of the abdomen (e.g. *Halictus* and *Megachile*).

Nectar is usually transported in the crop and later regurgitated either into the cell with the developing larvae, or into a storage cell where honey is produced. The nectar is used as food for both the larvae and at least partially for the adults; pollen mixed with nectar is only consumed by larvae.

According to type of parental care, bees can be essentially differentiated as

- **solitary,**
- **subsocial,**
- **eusocial, or**
- **kleptoparasitic.**

Solitary lifestyle – The overwhelming majority of bees live as just one female caring for her own offspring. Parental care consists of constructing the nest and acquiring stores of pollen jelly for the development of the larva. They nest in galleries dug in the ground, in stems, wood and various cavities, in gastropod shells, and certain species also build several cells placed freely on the surface. Some species, however, build their nests for so long that when the construction is finished, the first offspring already are hatching and thus two generations have a relationship between one another. This is how species with a tendency to common nesting exist, such that at a suitable location there occur very numerous colonies of separate but closely neighbouring hives (e.g. in *Anthophora parietina*).

In certain species, there occurs a transition to a social lifestyle (large numbers of closely neighbouring nests, often with a common exit). In certain other species, workers hatch and provide care for the laid eggs and larvae, i.e. the situation is already similar to that of bumblebees. Such bees are called **subsocial**.

Eusocial bees constitute by far the smallest number of all known species of the world fauna. These bees build one-year or even permanent colonies with a specialized cast of sister workers, together caring for the mother's offspring. Workers care for the mothers' eggs and build the nest from wax scales secreted on abdominal segments. With the exception of parasitic bumblebees, all social bees have baskets and brushes on the hind tibiae.

In the Czech Republic, the following species live eusocially:

- several species of the subfamily Halictinae (form one-year colonies),
- bumblebees of genus *Bombus* (in the conditions of the Czech Republic, single-year colonies), and
- European honeybee (*Apis mellifera*) (permanent colonies).

There are about 400–500 bumblebees (genus *Bombus*) known from around the world, but only about 28 species in Central Europe. They are very difficult to differentiate, as they are highly variable in coloration. In warmer areas, bumblebee nests are more permanent (lasting several years) and can contain even multiple queens. In the temperate zone, however, the colony dies in the autumn and only the fertilized female overwinters somewhere in moss pads or among tree roots in the ground. In spring, they appear on blossoms and establish nests. They level the surface and cover it with wax, constructing a small comb with ca 6 eggs. They regularly cover the walls of the cell with a honey solution and secretions of the salivary glands (food for larvae). For this purpose, they sometimes open and then close the walls of the cells. The larvae inside gnaw on the cell wall containing pollen, thus increasing the internal volume, and finally pupate in irregularly neighbouring cocoons. Shortly, small females with underdeveloped reproductive organs emerge. They enlarge the nest and bring new food, build up food stocks (even inside of abandoned cocoons). All is arranged irregularly, covered with a wax layer on the outside, and in aboveground nests also with a sufficient layer of moss or plant stems. The wax is secreted by both the queen and the workers (in contrast to the European honeybee where only workers do so). Eventually, the nest is populated by up to several hundred individuals. In high summer, males hatch from unfertilized eggs. They fly following specific courses saturated with their scents. Copulation occurs both in the air during these flights and inside the nest. At night, there is always one individual sitting at the entrance into the nest, serving as a fan, blowing fresh air into the nest with its wings. Temperature in the nest is relatively constant and ranges around 30 degrees. In autumn, with decreasing temperature, the workers attack each other, killing one another with their stingers and the nest dies out. In Czech conditions, thermal insulation of the nest is insufficient, stored food negligible, and the number of individuals too small. Strong hairiness makes bumblebees a hardy species, active even in low temperatures, and thus they can frequently be encountered in the far north of Lapland (i.e. 10 degrees beyond the Arctic Circle). This northernmost species (*Bombus hyperboreus*) cannot even raise workers, and therefore only males and females are represented in their populations, thus secondarily passing to solitary life. Similarly, certain species also occur high in the mountains. These northern and mountainous species usually have red colour. For certain plants (e.g. clover) the presence of bumblebees is absolutely necessary for pollination.

Closely akin to bumblebees (and phylogenetically arising from them) there exists a small group of kleptoparasitic species of the genus *Bombus*. Their hairs are more or less regular and more upright (bushier), females have no basket developed, and the tibiae are more regularly haired. These species are tolerated in bumblebee nests, feed off their stored food, and lay eggs into the bumblebees' combs. As females of these species are mutually very intolerant, in each nest there can be only one female of the parasitizing species. Therefore, the host species is weakened, but its existence is not endangered. These parasitic bumblebees are very strongly chitinous and thus protected from the stingers of the host. Individual species are strongly specialized on their hosts and many times are also very similar to them. A typical example is seen in the species *Bombus lapidarius* and the parasitizing *Bombus rupestris*.

The last group of social bees are the species of the genus *Apis* with the best known being *Apis mellifera*. This is also the only European representative of this genus, as the other species range in Asia. This species has long been used and kept by

humans. Cave paintings showing the gathering of honey from wild bees are over 9,000 years old, and beehives are depicted in the Egyptian pyramids.

Kleptoparasitically living bees do not collect food for their offspring, but use the stored food of solitarily living bees. These "parasitic" (or "cuckoo-like") bees constitute one-quarter to one-third of all known species. They lack the collecting apparatus as well as the strong hairs typical for bees, frequently display bright colouring, and are visually similar more to Sphecidae. Their behaviour is also very different. They usually move restlessly among the hives of other bees and wait for an opportunity to lay their eggs into the host's nest. Their larvae develop faster than do those of the host, consume the collected provisions, and the larva of the host species dies of insufficient food. Much more frequently, however, the egg of the host species or the larva is eaten by the larva of the parasitic species. Nevertheless, the main objective of these species is to get to the food, not to prey. These species entirely lack the ability to build hives, and the associated lower development of mental capabilities also is reflected in smaller brain size.

In Central Europe, bees overwinter according to species in the stage of imago, pupa or larva. Females of species building nests and of social species spend the nights in their structures. Males of solitary bees and both sexes of kleptoparasitic ones spend the night on dry stems and the like, where they hold on firmly with their mandibles and assume a typical position with their legs pulled up.

Bees are of immense importance as pollinators of agricultural crops and thus also have great economic importance.

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