Comenius University in Bratislava, Faculty of Natural Sciences

BENTHIC INVERTEBRATES AND THEIR HABITATS

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Benthic invertebrates and their habitats
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Front cover photos:
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Publication without language correction.
Publisher: Comenius University in Bratislava

ISBN 978-80-223-4462-3

2017

Contents

Introduction

This publication brings a basic information about commonly occurring groups of aquatic macroinvertebrates in running and standing waters. It is designed for students of Biology, Environmental Sciences, Ecology and for everybody interested in freshwater life.

In the first part of this textbook there is a brief overview of taxonomic system of aquatic macroinvertebrates and Classification of running and standing water habitats. The second part consists of a benthic invertebrates characteristics and their habitat preferences. At the end of the book, you can find a glossary explaining terminology used in the text, and an appendix containing pictures of some freshwater habitats and invertebrates.

Attached digital determination key can serve as a field guide and as an effective tool for rapid assessment of water environment quality, calculating Biological Monitoring Working Party (BMWP) index. This index is adapted in many countries in the world and it is in conformity with requirements of the European Water Framework Directive (2000/60/EC). The BMWP scores for macroinvertebrate families are listed in the attached Table 1-2.

This publication is the result of the project Benthic invertebrates and their habitats supported by the Cultural and Educational Grant Agency of the Slovak Republic (KEGA), No 015UK-4/2017 and the Scientific Grant Agency of the Slovak Republic (VEGA), No 1/0119/16. Pictures and background details used in the determination key were provided by Dr. Thomas Korte and Sebastian Elsemann in the international project AquaWis, supported by Deutsche Bundesstiftung Umwelt (DBU) in 2008.

Benthic invertebrates – system

Kingdom: Animalia – animals
I. Subkingdom: Parazoa

Phylum: Porifera
Class: Demospongiae
Order: Haplosclerida
Family: Spongillidae

2. Subkingdom: Agnotozoa
3. Subkingdom: Eumetazoa
Clade: Protostomia

Phylum: Cnidaria
Class: Hydrozoa
Order: Hydrida
Family: Hydridae
Family: Olindiasidae

Phylum: Platyhelminthes
Class: Turbellaria
Order: Tricladida
Family: Planariidae
Family: Dendrocoelidae
Family: Dugesiidae

Phylum: Kamptozoa (Entoprocta)
Family: Barentsiidae

Phylum: Tentaculata
Class: Bryozoa
Order: Plumatellida
Family: Cristatellidae
Family: Fredericellidae
Family: Lophopodidae
Family: Paludicellidae
Family: Plumatellidae

Phylum: Mollusca
Class: Gastropoda
Family: Neritidae
Family: Viviparidae
Family: Thiaridae
Family: Bithyniidae
Family: Hydrobiidae
Family: Valvatidae
Family: Acroloxidae
Family: Lymnaeidae
Family: Physidae
Family: Planorbidae

Class: Bivalvia
Family: Unionidae
Family: Corbiculidae
Family: Sphaeriidae
Family: Dreissenidae

Phylum: Annelida
Class: Polychaeta
Family Ampharetidae
Family Nerillidae
Family: Aelosomatidae

Class: Clitellata
Subclass: Oligochaeta
Family: Naididae
Family: Lumbriculidae
Family: Haplotaxidae
Family: Glossoscolecidae
Family: Proppapidae
Family: Enchytraeidae
Family: Lumbricidae
Subclass Hirudinida
Order: Rhynchobdellida
Family: Glossiphoniidae
Family: Piscicolidae
Order: Arhynchobdellida
Family: Hirudinidae
Family: Haemopidae
Family: Erpobdellidae

Phylum: Nematomorpha
Class: Gordioida
Order: Gordea
Family: Gordiidae

Phylum: Arthropoda
Subphylum: Chelicerata
Class: Arachnoidea
Order: Araneida
Family: Cybaeidae
Order: Acarina
group: Hydracarina

Subphylum: Crustacea
Class: Branchiopoda
Order: Anostraca
Family: Branchipodidae
Family: Chirocephalidae
Family: Streptocephalidae
Order: Notostraca
Family: Triopsidae
Order: Laevicaudata
Order: Spinicaudata
Order: Anomopoda
Order: Onychopoda
Order: Cnetopoda
Order: Haplopoda
Class: Maxillopoda
Class: Ostracoda
Class: Malacostraca
Order: Bathynellacea
Family: Bathynellidae
Superorder: Peracarida
Order: Mysida
Family: Mysidae
Order: Amphipoda
Family: Corophiidae
Family: Gammaridae
Family: Niphargidae
Order: Isopoda
Family: Asellidae
Family: Janiridae

Order: Decapoda
Family: Astacidae
Family: Camparidae

Subphylum: Tracheata
Class: Entognatha
Order: Colembolla

Class: Insecta
Order: Ephemeroptera
Family: Siphlonuridae
Family: Ameletidae
Family: Ametropodidae
Family: Baetidae
Family: Behningiidae
Family: Isonychiidae
Family: Oligoneuridae
Family: Arthropleidae
Family: Heptageniidae
Family: Leptophlebiidae
Family: Palingeniidae
Family: Potamanthidae
Family: Polymitarcyidae
Family: Ephemeridae
Family: Ephemerellidae
Family: Caenidae

Order: Odonata
Suborder: Zygoptera
Family: Lestidae
Family: Calopterygidae
Family: Platycnemididae
Family: Coenagrionidae
Suborder: Anisoptera
Family: Aeshnidae
Family: Gomphidae
Family: Corduliidae
Family: Cordulegastridae
Family: Libellulidae

Order: Plecoptera
Family: Taeniopterygidae
Family: Nemouridae
Family: Capniidae
Family: Leuctridae
Family: Perlodidae
Family: Perlidae
Family: Chloroperlidae

Order: Hemiptera
Suborder: Heteroptera
Family: Gerridae
Family: Veliidae
Family: Hebridae
Family: Hydrometridae
Family: Mesovellidae
Family: Corixidae
Family: Aphelocheiridae
Family: Naucoridae
Family: Nepidae
Family: Notonectidae
Family: Pleidae

superOrder: Neuropterida
Order: Megaloptera
Family: Sialidae

Order: Neuroptera
Family: Osmylidae
Family: Sisyridae

Order: Coleoptera
Suborder: Myxophaga
Family: Sphaeriusidae
Suborder: Adephaga
Family: Gyrinidae
Family: Haliplidae
Family: Noteridae
Family: Dytiscidae

Suborder: Polyphaga
Family: Hydrophilidae
Family: Hydraenidae
Family: Scirtidae
Family: Elmidae
Family: Dryopidae
Family: Limnichidae
Family: Heteroceridae
Family: Psephenidae
Family: Chrysomelidae
Family: Curculionidae

Order: Hymenoptera
Family: Agryotypidae

Order: Trichoptera
Suborder: Annulipalpia
Family: Philopotamidae
Family: Ecnomidae
Family: Polycentropodidae
Family: Psychomyiidae
Family: Hydropsychidae
Suborder: Integripalpia
Family: Glossosomatidae
Family: Hydroptilidae
Family: Rhyacophilidae
Infraorder: Brevitentoria
Family: Molannidae
Family: Leptoceridae
Family: Odontoceridae
Family: Beraeidae
Family: Sericostomatidae
Infraorder: Plenitentoria
Family: Goeridae
Family: Limnephilidae
Family: Brachycentridae
Family: Lepidostomatidae
Family: Phryganeidae

Order: Lepidoptera

Family: Pyralidae

Family: Acentropidae

Order: Diptera

Family: Tipulidae

Family: Cylindrotomidae

Family: Limoniidae

Family: Pediciidae

Family: Psychodidae

Family: Ptychopteridae

Family: Blephariceridae

Familyo: Dixidae

Family: Chaoboridae

Family: Culicidae

Family: Thaumaleidae

Family: Ceratopogonidae

Family: Chironomidae

Family: Simuliidae

Family: Anisopodidae

Family: Stratiomyidae

Family: Tabanidae

Family: Athericidae

Family: Rhagionidae

Family: Empididae

Family: Dolichopodidae

Family: Syrphidae

Family: Sciomyzidae

Family: Ephydridae

Family: Scatophagidae

Family: Muscidae

Freshwater habitats

Running waters

1. **Springs (crenal)**
   a. Lowland and submountain springs
   b. Mountain and alpine springs
   c. Thermal and mineral springs

2. **Mountain and submountain streams and rivers (rhithral)**
   a. Mountain streams (epirhithral)
   b. Submountain streams:
      i. Submountain brooks (metarhithral)
      ii. Submountain rivers (hyporhithral)

3. **Lowland rivers (potamal)**
   a. Lowland brooks
   b. Main lowland stream and arms (eupotamal)
   c. Blind arms (parapotamal)
   d. Dead arms (plesiopotamal)

4. **Artificial or impoverished streams**
   a. Canals
   b. Ditches
   c. Regulated rivers

5. **Periodical running waters**
   a. Kryal stream
   b. Intermittent streams

Standing waters

1. **Lakes and water reservoirs**
   a. Mountain and alpin lakes (tarns)
   b. Lowland lakes and arms
   c. Water reservoirs
   d. Fishponds
   e. Gravel pits

2. **Another standing waters**
   a. Swamps
      i. Fens
      ii. Peat bogs
   b. Periodical standing waters
   c. Telms

Characteristics of benthic macroinvertebrates

Flatworms - Platyhelminthes

TURBELLARIA (FLATWORMS)

■ **Distribution:** They are distributed around the world, most are marine and benthic, but some also inhabit fresh water and moist temperate and tropical terrestrial habitats. The class has approximately 1303 aquatic species. In Slovakia 13 species in three families (Planariidae, Dendrocoelidae, Dugesiidae) have been recorded. They are common in running and standing waters.

■ **Characteristic:** Turbellaria are bilaterally symmetrical animals, they generally locomote by coordinated waves of cilia on a secreted mucus trail, though some species can swim by rhythmic muscle contractions. All are hermaphrodites and they are famous for their ability to regenerate if divided by cuts across their bodies. All our species are carnivorous, either preying on smal invertebrates (crustaceans, molluscs or worms) or protozoans.

Flatworm *Crenobia* (*Planaria*) *alpina* from the Family Planariidae has typical short auricles on head, two eyes and black body colour. It is common in cold springs and mountain streams with maximal water temperature about 12 – 14 °C. Flatworm *Polycelis felina*, with long auricles and numerous eyes on the head circumference, occurs also in cold mountain streams, with maximal water temperature ranged about 16 – 17 °C. Sometimes it inhabits also mountain lakes.

Dendrocoelum lacteum is the most common species from the Family Dendrocoelidae. It has two eyes and white or pinkish colour. It occurs mainly in rivers, but sometimes in lakes. At the beginning of winter individuals aggregate and copulate. They produce the cocoons at the turn of winter, in water temperature of approximately 10 °C.

In running water of Slovakia, the most common occurring species belong to the Family Dugesiidae, especially *Dugesia gonocephala* can be find almost in all submontain streams. It has triangular head with two eyes. Majority of non-indigenous flatworms in European stream comes from North America. For example, *Dugesia tigrina* (individuals have triangular head, two eyes and strongly spotted body) was introduced to Europe from North America by aquarists.

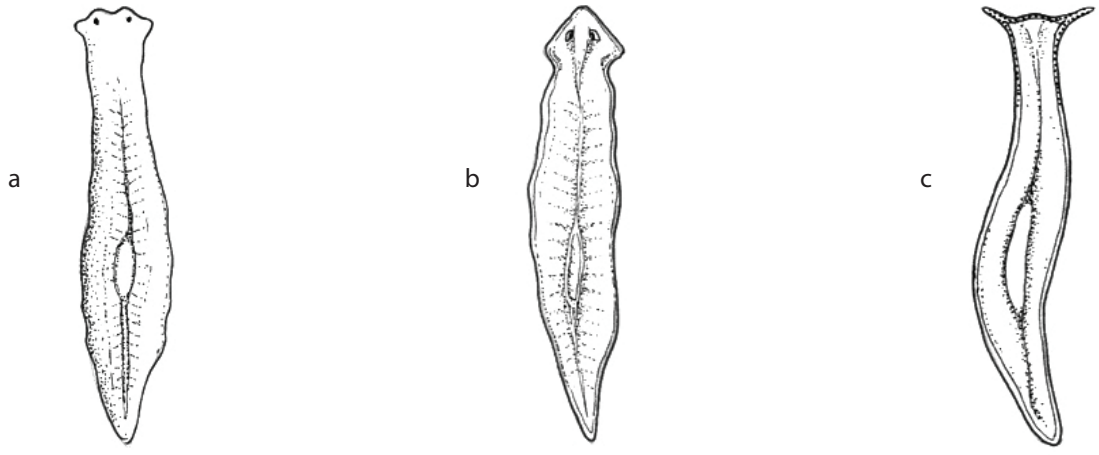

Fig.1 Flat worms habitus: a) Dendrocoelidae, b) Dugesiidae, c) Planariidae

Molluscs - Mollusca

GASTROPODA (FRESHWATER SNAILS)

■ **Distribution:** The freshwater snails and limpets are common in ponds, streams, marshes and lakes. In Slovakia, 51 species belonging to 10 families are registered in Malacofauna database.

■ **Characteristic:** Most species feed on algae or dead plant matter. They use radula in feeding – it is a special organ covered with small „teeth" (denticles). Radula morphology is an important tool for species identification. The species living in running water have higher oxygen requirements and they breathe with gills (mostly). Species *Bythinella austriaca*, *Ancylus fluviatilis*, *Theodoxus fluviatilis*, *Orderix labiata* occur mainly in running waters. Rheophile freshwater limpet *Ancylus fluviatilis* is abundant in streams with rocky bottom, where it lives on the stones. Nerite species *Theodoxus fluviatilis* is abundant in main channel of Danube river, whilst *Theodoxus danubialis* occurs rare in lower stretch of Danube near Komarno. Common bladder snail – *Physa fontinalis*, an aquatic pulmonate gastropod mollusc (breathing with lungs), is a rare species occurring between aquatic vegetation in slowly running and standing water. Similar water environment is also inhabited by a very rare gastropod *Bathyomphalus contortus*.

In lakes and ponds we can also find species breathing with lungs e.g. *Planorbarius corneus*, *Planorbis planorbis*, *Acroloxus lacustris*, *Lymnaea stagnalis*, *Valvata*, *Galba truncatula*, *Stagnicola*. Acute Bladder Snail *Physella acuta* is a non-indigenous species, which comes from Mediterranean area, and we can find it in small aquatic habitats of Danube floodplain. An invasive species is also a minute New Zeland mud snail *Potamopyrgus antipodarum*.

BIVALVIA (FRESHWATER MUSSELS)

■ **Distribution:** The bivalves are a most successful class of invertebrates found in aquatic habitats throughout the world. A large number of bivalves are found in the intertidal and sublittoral zones of the oceans, less species are known from freshwater habitats. In Slovakia 30 species belonging to 4 families live.

■ **Characteristic:** Most Bivalvia are filter feeders - the water is drawn into the shell from the posterior ventral surface of the animal, passes upwards through the gills and doubles back to be expelled just above the intake.

Autochtonous *Anodonta* species belong to most frequent big bivalve molluscs in rivers and standing water in Slovakia. The shell of genus *Anodonta* is a little slighter, what is the difference between them and genus *Unio*, which has a very solid shell. In Slovakia the genus *Unio* includes 3 species: *Unio crassus*, thick shelled river mussel, is a species recorded in Annex of Council Directive 92/43/EEC on the Conservation of

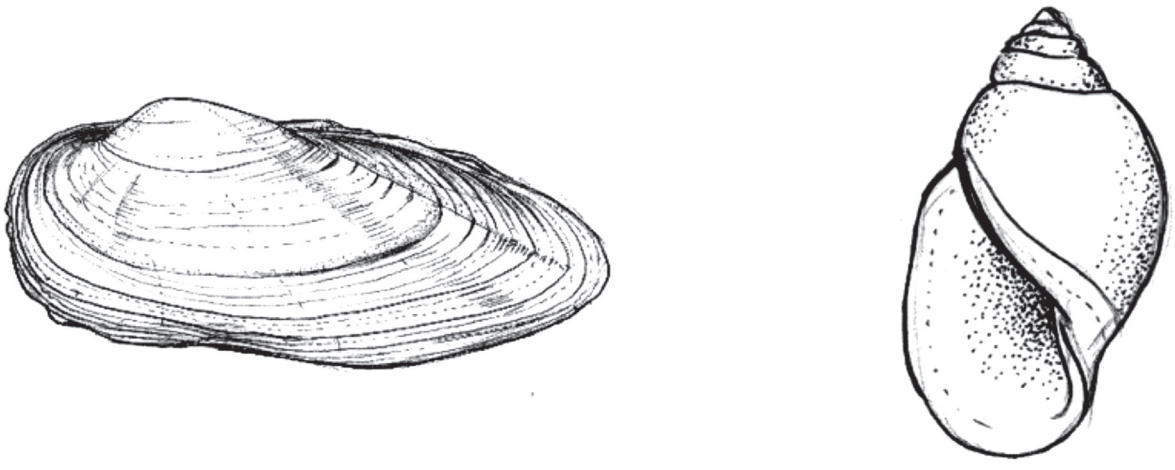

Fig. 1 Molluscs habitus – Bivalvia (left) a ulitníka – Gastropoda (right).

natural habitats and of wild fauna and flora (Habitats Directive). It is a species that declined during the 20th century everywhere in Europe due to deteriorating water quality, habitat fragmentation and host fish limitation. The most common species is painter´s mussel *Unio pictorum*, occurring in lowland streams and rivers. In Slovakia, *Pisidium* species are the smallest bivalves. They are very small or minute freshwater clams, only several millimeters large. Species of the genus *Sphaerium* have shells reminding cherrystone. They occur in stagnant and slowly running lowland waters. Non-indigenous species *Dreissena polymorpha*, *Synanodonta woodiana* and *Corbicula fluminea* were brought to our country by shipping transport or by birds. The zebra mussel *Dreissena polymorpha* is a small freshwater mussel. It was originally native to Ponto-Caspian region, and it extended to European rivers, where it creates clusters on submerged objects. The shells of invasive species *Corbicula fluminea* we can find in large numbers in Danube River near Chlaba village. Big shells of Asian species *Synanodonta woodiana* can be observed in Danube, and in lower stretches of Ipeľ and Hron River.

Ringed Worms - Annelida

OLIGOCHAETA (RINGED WORMS)

■ **Distribution:** Oligochaeta is a subclass of animals in the phylum Annelida, which is made up of many types of aquatic and terrestrial worms. Around 1100 freshwater and 600 marine species are known in the world. In Slovakia approximately 124 species belonging to the 11 families occur. The families Naididae, Enchytraeidae, Haplotaxidae, Lumbriculidae and Lumbricidae, are best known.

■ **Characteristic:** Oligochaetes usually have well-segmented body with few setae (chaetae) or „bristles" on their outer body surfaces. Oligochaetes feed primarily on detritus and algae and are important in energy flow in water, because most of the species are detritophagous. Genus *Tubifex* and *Limnodrilus* turnover during 24 hours huge quantities of mud, which exceeds their weight 4-6 times. Species of the genus *Chaetogaster* are predators. Aquatic oligochaetes are important food for fish and larger invertebrates. Several species, especially in the subfamily Tubificinae, are adapted to the life in the habitats with very low oxygen content, some of them (e.g. *Tubifex tubifex*, *Lumbriculus variegatus*) are able to survive without oxygen for a long time (up to several weeks). The worms can survive in environment with low oxygen concentration by waving hemoglobin-rich tail ends to exploit all available oxygen and can exchange carbon dioxide and oxygen through their thin skins, similar like the frogs. They can also survive in heavily organically polluted environment, where most of other species cannot live. By forming a protective cyst and lowering its metabolic rate, *Tubifex tubifex* can survive drought and food deficiency. Oligochaetes are key components of the benthic communities for many freshwater and marine ecosystems. From the subfamily Naidinae, the species *Stylaria lacustris* occurs typically in lakes and water dams. *Eiseniella tetraedra* is a stagnicolous species showing an overwhelming preference for wet habitats. It occurs in ponds, lakes, streams, rivers springs and looks like common earthworm (*Lumbricus terrestris*). Species of the Family Lumbriculidae occur mainly in cold water.

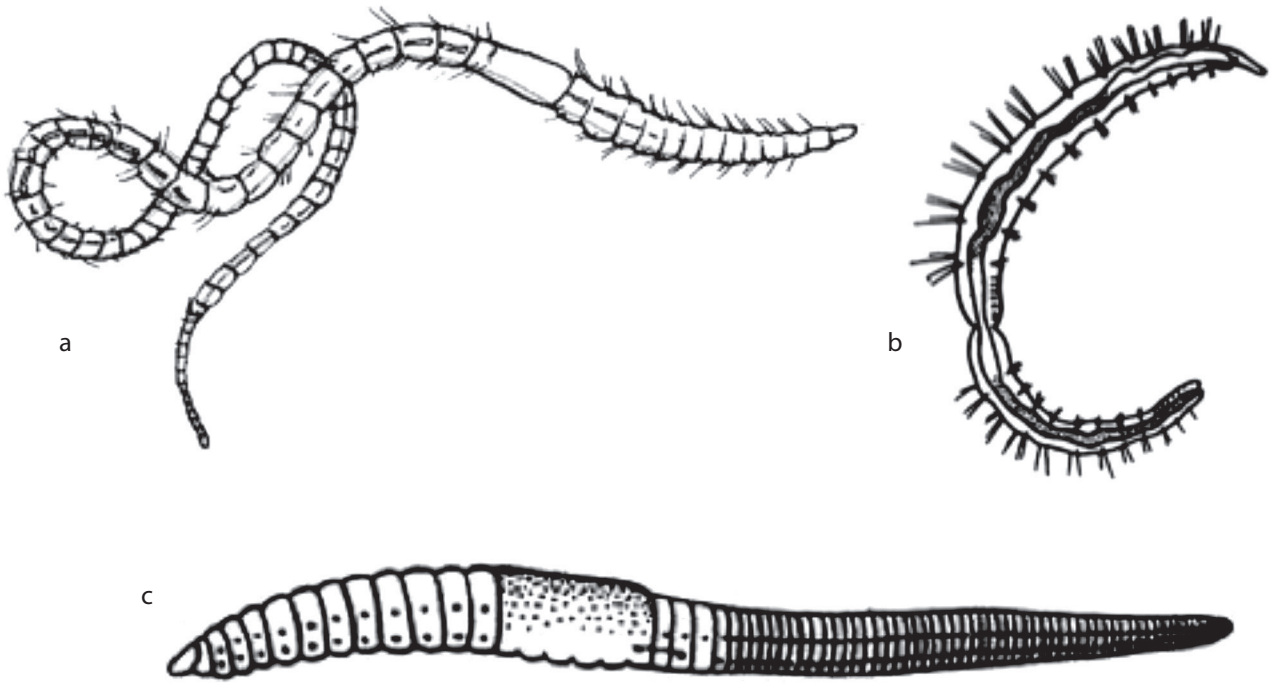

Fig. 1 Ringed worms habitus: a.) Tubificinae, b.) Naidinae, c.) Lumbricidae.

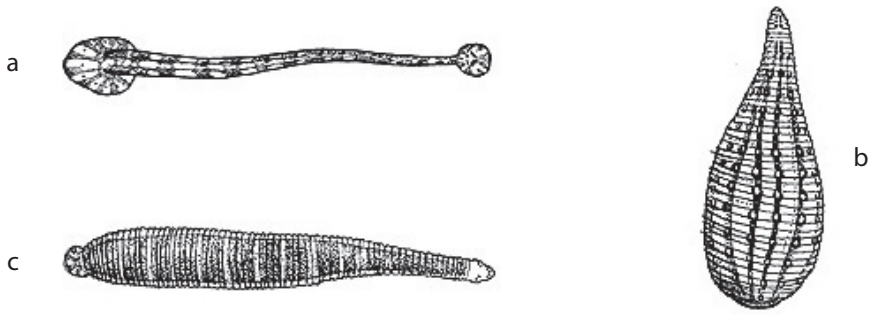

Fig. 1 Leeches habitus: a) Piscicolidae, b) Glossiphoniidae, c) Erpobdellidae.

HIRUDINIDA (LEECHES)

■ **Distribution:** The majority of leeches live in freshwater environment, while some species can also be found in terrestrial and marine environmen. Almost 700 species of leeches are currently recognized, approximately 100 of which are marine, 90 terrestrial and others are freshwater taxa. In Slovakia, 5 leech families occur: Glossiphoniidae, Erpobdellidae, Piscicolidae, Haemopidae, Hirudinidae.

■ **Characteristic:** They have two suckers at each end. Their bodies are much more solid, because secondary body cavity (coelom) is dense with connective tissues. Leeches do not have bristles and the external segmentation of their bodies does not correspond with the internal segmentation of their organs. Leeches can be either predatory or parasitic.

Fish leech *Piscicola geometra* is a fish parasite, which occurs in lowland running and standing water and it has very high oxygen consumption. Species from Family Glossiphoniidae are mollusc and oligochaete parasites. Species *Glossiphonia heteroclitta* is a transparent, lightly coloured ectoparasite of molluscs. Freshwater leech *Hellobdella stagnalis* is an aquatic predator, which mainly feeds on immature stages of freshwater arthropods, annelids and snails. In Slovakia, Family Haemopidae is represented by horse-leech *Haemopis sanquisuga*. Despite the name, it does not attack horses because it cannot bite mammalian skin at all. This species can be quite large, reaching up to 16 cm. Their colour is greenish or brown-black. They are very common in standing or slowly running water and it can be often found also under stones near water stream. They feed on smaller animals such as midge larvae and snails. European medicinal leech *Hirudo medicinalis* is the only one bloodsucking leech occurring in Slovakia and it sucks the blood of mammals. The orange/red stripes on dorsal side of the body are very typical (occasionally they can lack this pattern). Preferred habitats of this species are muddy freshwater pools and ditches with rich growing aquatic vegetation. In running water, *Erpobdella octoculata* and *Erpobdella vilnensis* from Family Erpobdellidae are very abundant. *Dina punctata* is non-indigenous species coming from western Europe, which can be found in Danube and its small tributaries.

NEMATOMORPHA (HORSEHAIR WORMS)

■ **Distribution:** About 300 freshwater species in 21 genera and four species in one marine genus of the Nematomorpha or horsehair worms are known to date. In Slovakia approximately 15 species occur, the most common are *Gordionus violaceus* (parasitic on Carabidae) and *Parachordodes tolosanus* (parasitic on smaller beetle species like *Calathus* and some small species of Family Carabidae).

■ **Characteristic:** Nematomorpha are a class of parasitoid animals superficially similar to nematode worms in morphology, hence the name. They range in size in most species from 50 to 100 centimeters long and can reach in extreme cases up to 2 meters, and 1 to 3 millimeters in diameter. Horsehair worms can be discovered in wet environment such as watering troughs, swimming pools, streams, puddles, and cisterns. The adult worms are free living, but the larvae are parasitic on beetles, cockroaches, mantids, orthopterans, and crustaceans.

Arthropoda

Crustacea

■ **Distribution:** Crustaceans are a group of invertebrates consisting of approximately 67,000 species distributed worldwide. They range in size from 0,1 mm (*Stygotantulus stocki*) to 3,8 m (*Macrocheira kaempferi*). Most crustaceans are aquatic animals. The most of them live in marine environment, where they are predominant group of arthropods. They occur also in freshwater habitats and a few groups have adapted to life on land (terrestrial crabs, terrestrial hermit crabs and woodlice). Decapoda, Isopoda, Amphipoda and Mysida are groups of the macrozoobenthos in Slovakian water bodies (Mysida are not included in the determination key).

■ **Characteristic:** They are distinguished from other groups of arthropods by the possession of two pairs of antennae and more than four pairs of biramous limbs. Crustaceans have exoskeleton, that they moult by growing.

ISOPODA (WATER HOG LICE)

They live in aquatic and terrestrial habibats. Isopods are flattened dorsoventrally, they lack an obvious carapace, which is reduced to a „cephalic shield" covering only the head. The first thoracic segment fused with the head to cephalothorax. The seven free segments of the thorax bear a pair of unbranched limbs. *Asellus aquaticus* (water hoglouse) is a common freshwater crustacean spread throughout of the temperate zone in standing and slowly running water. The male is about 13 mm long, female approximately 8 mm. The colour is mottled brown, blending in well with its environment. It is a common benthic dweller, living amongst rooting debris of leaves. It is able to tolerate moderately polluted water.

AMPHIPODA (FRESHWATER SHRIMPS)

Amphipoda are crustaceans with no carapace and with laterally compressed bodies. They are mostly marine animals, but we can find them almost in all types of aquatic environments. The thorax and abdomen are usually quite distinct and bear different types of legs.

Genus *Gammarus* involves 5 our indigenous species, the most abundant is *Gammarus fossarum*, which occurs in submountain streams. It is omnivorous and belongs to the shredders.

Gammarus roeseli is very common in warmer and sometimes also moderately polluted water. It lives in stagnant or slowly flowing water in lowland and submountain regions. It is most abundant in autumn when the food offer is the highest.

Dikerogammarus is relatively frequent genus, inhabiting Danube and lower stretches of bigger Danube tributaries. *Echinogammarus* is a rare invasive taxon in Danube, which expands to Europe from the Ponto-Caspian region.

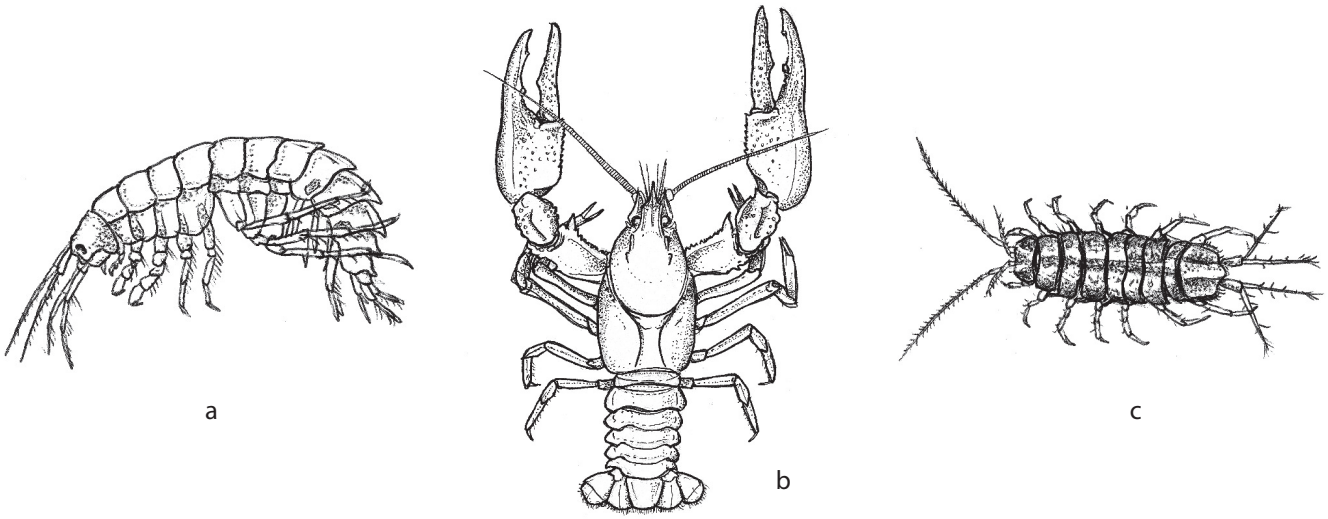

Fig. 1 Crustacea habitus a) *Gammarus roeselii*, b) *Astacus* , c) *Asellus aquaticus*.

DECAPODA (CRAYFISH)

The order Decapoda is estimated to contain nearly 15,000 species, which means they are the most numerous group of crustaceans. As the name Decapoda implies, they have ten legs. In our territory Decapoda are represented by crayfish species in streams, ponds or lakes. You can know them by large nippers on first thoracic limbs.

Austropotamobius torrentium (Stone crayfish) – is the smallest crayfish species in Slovakia. The body length is up to 12 cm, more often less than 10 cm. Its colour is brown, olive green, beige or light brown, occasionally orange or red. It is usually associated with relatively short stretches in the headwaters of small, upland streams with plenty of refuges, although it occasionally occurs in wide, lowland rivers. *Austropotamobius torrentium* is not very tolerant of environmental change. The saw-tooth appearance on the central ridge of the antennal scale is unique and coupled with the absence of spines on the shoulders of the carapace behind the cervical groove make determination relatively straightforward. The underside of the chelae is never red. Rostrum is triangular with smooth borders converging towards base of small triangular acumen, one pair of post-orbital ridges.

Astacus astacus (noble crayfish) – body length is usually less than 15 cm, but can reach 18 cm in total length. Variable coloring from reddish-brown, beige or black, also brilliant blue and red varieties are known. Chelae usually have the same colour as the body, underside smoother and red to dirty brown. Carapace exhibits various degrees of granulation, particularly on the sides. *A. astacus* has two pairs of post-orbital ridges, posterior pair may by indistinct. This species inhabits streams, rivers, lakes, ponds and reservoirs where shelter availability is high. It makes simple burrows in clay and earth banks. It is usually not found in pools with a muddy bottom, although it can thrive in earthen culture ponds, where it may burrow extensively into the banks.

Astacus leptodactylus (narrow-clawed crayfish) – the morphology of the carapace is very diverse, varying from egg-shaped to pear-shaped. Length usually reaches up to 15 cm, occasionally up to 20 cm. The colour is very influenced by aquatic environment. Dominant colour is honey-brown or oil-green, but it can vary from green or grey to dark brown or almost black. Blue varieties are also known. *A. leptodactylus* is indigenous to the Ponto-Caspian Basin but it has spread to occupy most European countries. It is tolerant to low oxygen concentration, low water transparency and changes of temperature. Populations of the *A. leptodactylus* inhabit both brackish and fresh waters - canals, rivers and lakes across Europe.

Pacifastacus leniusculus (Signal crayfish) – males can grow up to 16 cm in length from tip of rostrum to the end of telson, females up to 12 cm, larger individuals are occasionally recorded. Colour is bluish-brown to reddish brown, occasionally light- to dark-brown. Underside of chelae is red in color. Chelae robust, smooth on both surfaces, two widely-spaced tubercles on inner side of fixed finger with shallow incision between them, with white-turquoise patch on top of junction of fixed and moveable finger. In Europe non-indigenous species were introduced from California to Sweden in 1959 and released in 1960 in an attempt to find a species to boost stocks of crayfish. After this event populations of indigenous species *A. astacus* were severely depleted by crayfish plague. Later it was introduced also to other European countries. Nowadays it is known also from our territory, where it emerged from the Austrian crayfish culture. *P. leniusculus* is more tolerant of adverse environmental conditions than most indigenous crayfish species in Europe. It is eurythermic species, particularly tolerant to higher salinity. In Europe it inhabits similar environments like all indigenous species. However, it survives well mainly in culture ponds. It constructs burrows under rocks or in river and lake banks. *Pacifastacus leniusculus* is very active migrant, fast spreading up and down of the rivers.

Orconectes limosus (spiny-cheek crayfish) as a member of another family it differs from previous species. Chelea are moderate and the fixed finger a little shorter than the moveable finger. Body colour is pale or dark brown or olive-green, tips of chelae are orange with black band visible on underside, which is never red to dirty-brown. Blue coloured specimens are also known. A typical transverse brown-red band is present across each abdominal segment, the body length up to 12 cm. It is non-indigenous species in Europe. First it was introduced in 1890 from USA to north-eastern Germany. O. limosus is now one of the commonest non-

indigenous crayfish species in Europe. It is known from more than 20 European countries. *O. limosus* can be found in all types of water bodies in the lowlands, including soft-bottomed, silty, turbid and muddy waters in moderately wide to large streams and large rivers, polluted canals and river harbors, as well as organically enriched ponds and lakes.

Insecta

EPHEMEROPTERA (MAYFLIES)

■ **Distribution:** Mayflies are one of the oldest known insects that have appeared during the Lower Carboniferous. The world fauna comprises approximately 3,200 described extant species, Slovak mayfly fauna consists of app. 120 species belonging to 16 families. Nymphs (larvae) inhabit principally running waters; some taxa prefer stagnant waters.

■ **Characteristic:** Mayflies are hemimetabolous insects; life cycle includes 4 stages: egg, nymph, subimago, and imago. They are exceptional among insects by molting from the subimago (semi-adult) state to imago (adult). In some genera, e.g. *Palingenia*, only males develop to imago. Females are ready to mate as subimagines. Mayfly adults have a fragile body 3 – 35 mm long (excluding cerci), with two pairs of transparent wings, although some representatives are dipterous. Subimagines are easily distinguishable from imagines by opalescent, non-transparent wings. Adults live for a short time (several hours or days). Imaginal mouthparts are vestigial. Adults do not feed; their alimentary canal is filled with air. The only purpose of their brief lives is to reproduce. Adults swarm above or closely to water. Males fly in groups effectuating characteristic rising and falling courtship dance. Females flying into the crowd of males are gripped by male from below and mated. In some species a considerable proportion of females reproduce by parthenogenesis. From unfertilized eggs only female nymphs hatch. Females produce usually 400 – 3000 eggs, although the lowest numbers are around 100 and highest 12,000 eggs. Females of species developing in streams fly upstream before laying the eggs. By this compensation flight they counteract the drifting of their eggs and larvae above all. Some species are ovoviviparous

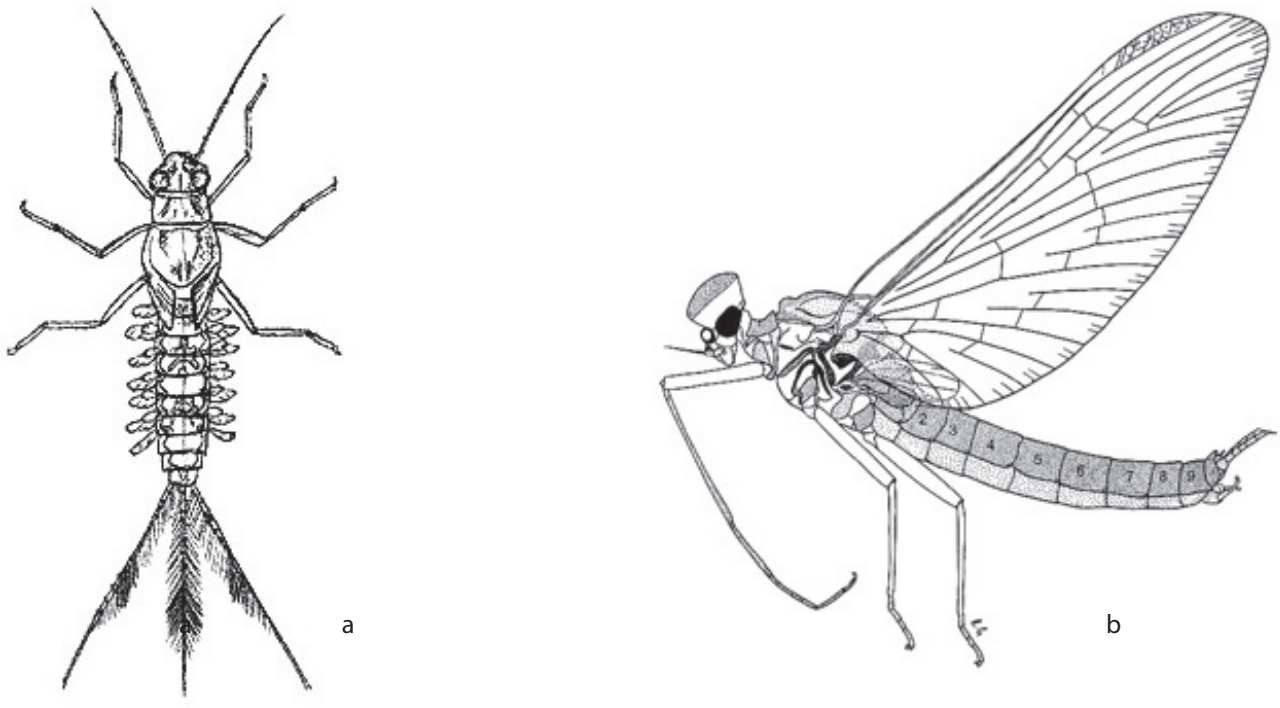

Fig. 1 Mayflies habitus: a) larvae b) adult.

(e.g. *Cloeon dipterum*). Nymphs molt 10 – 50 times during their development lasting for 0.5 – 3 years. Length of larval development is strongly affected by water temperature and can vary considerably even in one population. Nymphs respire through a series of tracheal leaf-like, filamentous or combined gills. They usually have seven pairs of gills, situated laterally or dorsally on the abdomen, accessory gills are rarely on mouthparts and coxae. They feed mostly on plant food, especially algae and detritus – small particles of organic matter in various stages of decomposition covered by microbial films, therefore belong to scrapers and detritophagous collectors, only very few species are predators (in central Europe *Baetopus tenellus*). Mayfly nymphs are important food for fish and larger predators from aquatic invertebrates, adults are common prey of birds and spiders. Mayfly nymphs are very useful bioindicators, therefore they are important group for standardized freshwater monitoring methods. Nymphs have different shape according to different environments they adapted to.

Ephoron virgo lives in lowland (potamal) rivers. Larvae burrow into the fine sediment. This species used to be very common, but disappeared from many rivers in 20th century as a consequence of pollution and river regulations. Adults form huge swarms, similarly to other lowland burrowing genus *Palingenia*. Larvae develop for 3 years in clay bottom where they burrow U-shaped tunnels. The genus *Oligoneuriella* prefers places with strong currents in submountain hyporhithral and metarhithral streams. Species from genus *Siphlonurus* are inhabitants of standing waters and back arms of unpolluted submountain and lowland streams. Larvae from the family Ephemerellidae have plate like tracheal gills. They are common in all types of streams, seems to prefer stands of filamentous algae. Larvae of *Potamanthus luteus* from the fam. Potamanthidae develop in warmer lowland rivers (potamal). Some species from the fam. Caenidae prefer standing waters; larvae are less demanding on oxygen supply in water, while others live in streams. The species from the large fam. Baetidae inhabit lotic and lenitic habitats and feed on particulate organic matter while others are grazers and scrapers of biofilms. Larvae from the fam. Ephemeridae burrow in fine sediments. Species of the fam. Leptophlebiidae inhabit flowing and standing waters. The most important genera of the fam. Heptageniidae: *Epeorus*, *Ecdyonurus*, *Rhithrogena* and *Heptagenia* are showed in the key with their characteristic morphological features. Larva of *Epeorus assimilis* is characterized by their flattened body with two caudal filaments, while another heptagenids have three caudal filaments. Larvae of the genus *Ecdyonurus* may be diagnosed by the presence of large, posteriorly projecting pronotal extensions. Larvae of the genus *Rhithrogena* are characterized by ventral friction disk formed by the 1st pair of abdominal gills. Larvae of the genus *Heptagenia* inhabit submountain and lowland rivers. Heptageniidae occur in clear flowing waters from high mountains to lowlands. Most species live in mountain and submountain streams, however members of the genus *Heptagenia* are typical for larger potamal streams.

PLECOPTERA (STONEFLIES)

■ **Distribution:** Stoneflies are a small order of hemimetabolous insects: appromimately 3,500 species have been described so far in the world. Asian stonefly diversity is much greater than European and North American. The least species occur in tropical Africa. In our country, app. 120 species are known, mainly in mountaine and submountaine streams. They do not occur in standing waters.

■ **Characteristic:** Fossil records of stoneflies extend back to the early Permian. The name Plecoptera, derived from the Greek "pleco" meaning folded and "ptera" meaning wing. They fold them flat over their back. Stoneflies are generally not strong fliers, and some species are entirely wingless. Larvae (or naiads) and adults have long paired cerci projecting from the tip of their abdomens. They have long antennae; weak, chewing mouthparts; reduced and non-functional by the most species. Larvae feed on coarse organic matter (leaves) or fine organic matter (detritus, Leuctridae, Nemouridae) and some of them are predators (Perlidae, Perlodidae, Chloroperlidae), species of the genus *Brachyptera* feed on epilithic algae (grazers). Larval development takes 1- 4 years. Stoneflies are excellent indicator of flowing waters.

From seven families occurring in Europe, they are presented taxa of the family Perlidae – our largest stoneflies living in mountain and submountain streams. They need a high content of oxygen and they are predators.

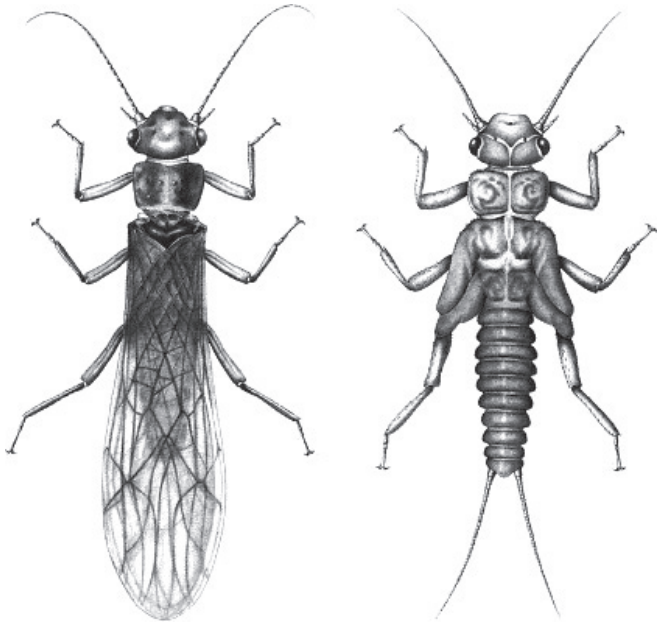

Fig.1 Stoneflies habitus: a) adult - fam. Nemouridae, b) larva - fam. Nemouridae. (upravené podľa Tierno de Figueroa, 2000).

Stoneflies of the Perlodidae family do not have branching gills from leg bases and live in submountain or temporary streams. In such streams we could find detritophagous species of the family Leuctridae and Nemouridae, as well. Chloroperlidae nymphs are characterize with having quite short legs and shortened cerci. Some of the adults appear more yellow than they do green but they are. They belong to the indicators of springs and clean waters. The most tolerant species to pollution is *Nemoura cinerea*.

ODONATA (DRAGONFLIES, DAMSELFLIES)

■ **Distribution:** The order Odonata consists of three suborders: Anisoptera (dragonfly - 6 families in Europe), Zygoptera (damselfly - 4 families in Europe) and Anisozygoptera. The third suborder, Anisozygoptera is represented by two species, one occurs in Himalaya Mountains and another one in Japan. Although only one family is recent, fossil evidence of 10 extinct families indicates considerable early diversity within this suborder. Worldwide, there have been described about 6,000 species of dragonflies. They are distributed from the tropics, where the greatest numbers and diversity occur, to the tree-line in Polar regions. In Slovakia, 69 species have been found till now.

■ **Characteristic:** Odonata is an old hemimetabolous order of insects. The fossil dragonfly *Meganeura monyi*, which lived about 300 million years ago, had a wingspan of 70 cm. Fossil records are known from France and England. Characteristic feature of all the larvae is modified labium - mask. Larvae catch prey by rapid protraction of an extendable mask which folds under the head and thorax.

Damselflies – Zygoptera

Damselflies are smaller, all four wings are near equal in size and shape. When at rest, most species hold their wings along the length of their abdomen with exception of the species of the family Lestidae. Larvae (also called nymphs or naiads) have 3 flat, leaf-like caudal lamellae at the top of the abdomen, used for respiration and for locomotion. *Platycnemis pennipes* (Platycnemidae) is widespread in running waters. In our country live two species of the family Calopterygidae: *Calopteryx splendens* and *Calopteryx virgo*. The pond damselflies Coenagrionidae live mostly in standing water. Males are usually more brightly coloured than females, mostly blue with exception of *Pyrrhosoma nymphula* (Large Red Damsel). Females can be brown, olive or similar to males. *Coenagrion ornatum* is included in

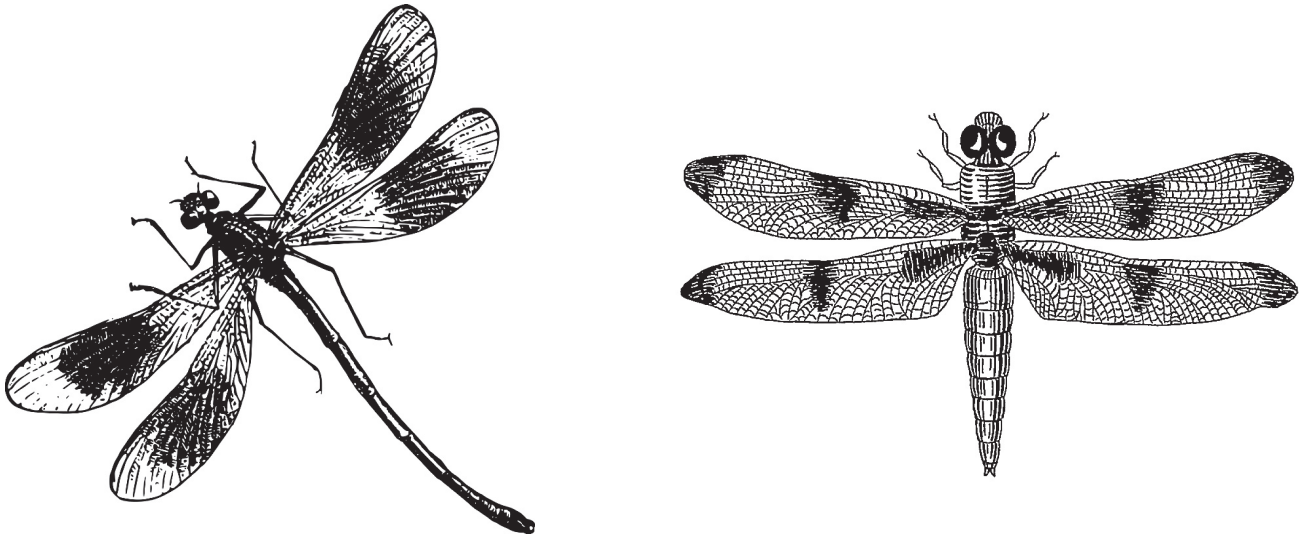

Fig. 1 Odonata adults: Zygoptera (left) and Anisoptera (right).

Annex II of the European Habitats Directive and thus all its habitats should be preserved from any kind of alteration in the European members countries.

Species of the family Lestidae prefer temporal standing waters. Therefore, they have rapid development. *Sympecma fusca* and *Sympecma paedisca* (Lestidae) overwinter as an adult. *Sympecma fusca* is common taxa, *Sympecma paedisca* was recorded in our country in 1981, for the last time.

Dragonflies – Anisoptera

Dragonflies are larger than Zygoptera with dissimilar wing pairs, hind wings are broader at the base. While at rest, the wings are usually spread. Larvae of the suborder Anisoptera differ from other aquatic insects by having internal gills associated with the rectum. Water is circulated in and out of the anus by muscular contractions of the abdomen. This rectal gills mechanism doubles as a jet propulsion system.

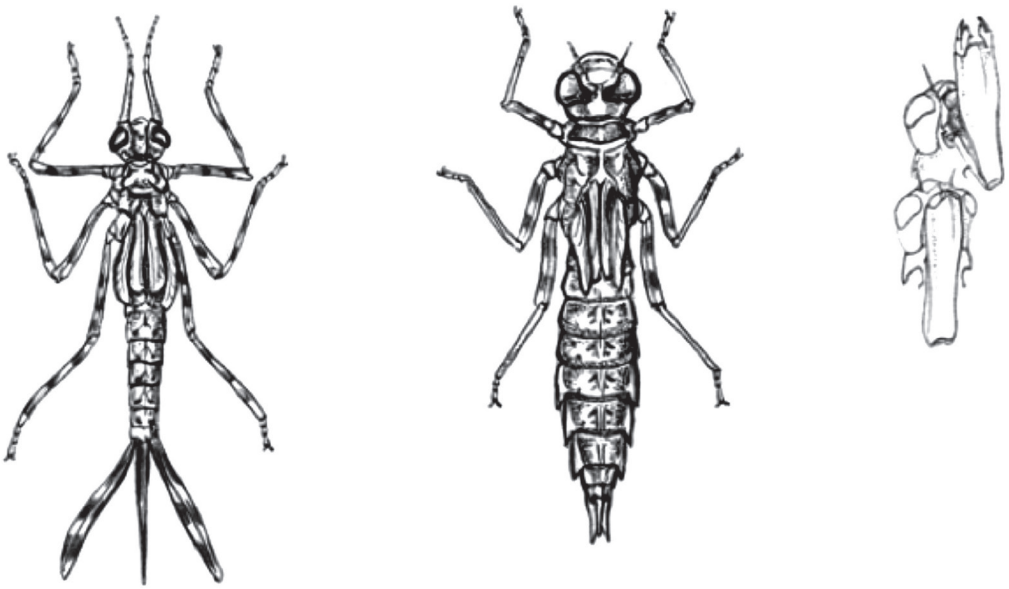

Fig. 2 Odonata larvae: Zygoptera (left), Anisoptera (centre), mask (right).

A sudden, powerful contraction of the abdomen will expel a jet of water and thrust the insect forward, which is a quick way to escape from predators. Dragonflies are very good flyers, the top speed for a dragonfly is between 30 and 60 km/h. Some species of dragonflies are territorial, with males that defend territories of suitable sites. In these species, males are often brightly coloured. In central Europe, species of five families live: Aeshnidae, Gomphidae, Cordulegastridae, Corduliidae, Libellulidae. Common worldwide spread genera of the family Aeshnidae are *Aeshna* and *Anax*. Species of the family Gomphidae live mostly in flowing waters and species of the family Cordulegastridae occur in springs and small submountain streams. The largest species in Europe is *Cordulegaster heros*, of which the female can 97 mm long. *Cordulegaster heros* is listed on Annexes II of the Habitats Directive. It occurs in small submountain streams, where their larvae develop from 4 to 5 years. There are 22 species of the family Libelullidae resident in Slovakia in five genera: *Libellula, Orthetrum, Crocothemis*, *Sympetrum* and *Leucorrhinia*. Umbrella and flagship species of the genus *Leucorrhinia* prefer fens and peat bogs.

HETEROPTERA AQUATICA (WATER BUGS)

■ **Distribution:** True bugs (Heteroptera) are among the largest groups of insects on Earth, there are nearly 40,000 species of true bugs in the world, 8 % of them are aquatic and semi-aquatic.

■ **Characteristic:** True bugs belong to hemimetabolous insects, order Hemiptera. True bugs have sucking mouthparts, they suck plant or animal juices. The fore-wings are differentiated into a thickened basal area and a membranous apical area.

Aquatic and semiaquatic bugs consist of 2 infraorders: Nepomorpha and Gerromorpha. **Nepomorpha** have their antennae often hidden in concavity, not visible from above, middle and hind legs are often flattened and they live under the water surface. Infraorder Nepomorpha comprises six families in our country: Nepidae, Corixidae, Naucoridae, Notonectidae, Pleidae, Aphelocheiridae. Only Corixidae suck plant juices (are phytophagous and omnivorous), the others aquatic bugs are zoophagous. In our region, two species belong to the family Nepidae: water scorpion *Nepa cinerea* and the water stick insect *Ranatra linearis*. They uses their front legs for trapping of

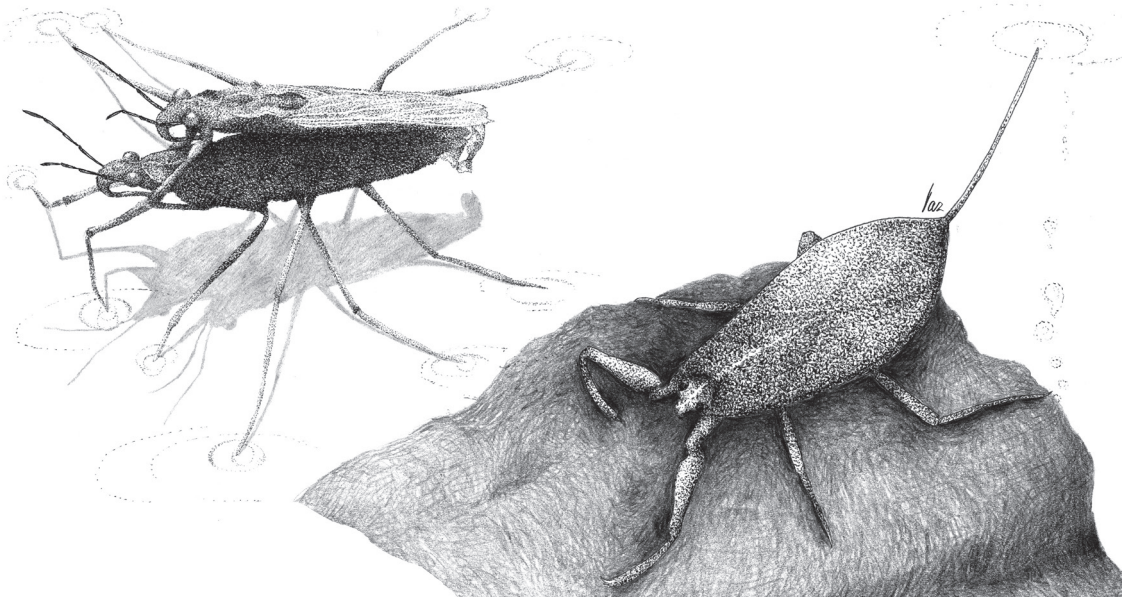

Fig. 1 Water bugs habitus: Gerromorpha (*Gerris*) (left) and Nepomorpha (*Nepa cinerea*) (right) (Z. Pazderková).

a suitable prey. The breathing tube (like snorkel) protrude above water that allows them to breathe atmospheric oxygen. Both bugs prefer shallow water among vegetation in ponds, gravel-pits. *Nepa cinerea* can be sometimes found in shallow slow-moving streams.

Water boatmen (Corixidae) prefer algal and filamentous blue-greens, diatoms and the microscopic fauna living on the bottom. In our condition bugs live in standing waters and are good indicators of organic pollution. Their body is well adapted to swimming, strong hind legs, which resemble small paddles are used like oars. *Ilyocoris cimicoides* is the only representative of the Naucoridae family, has broad and dorso-ventrally compressed body. It feeds on insects fallen in the water but they can attack warm-blooded vertebrates including man, as well. This bug spends a lot of time hidden in dense vegetation in muddy pond shallows.

In Europe, there is a single species of the family Pleidae (small backswimmers), *Plea minutissima*, widely found in vegetated standing waters. *Plea minutissima* swim in the inverted position like Notonectidae. Small backswimmers feed on mosquito larvae and other small invertebrates.

In Europe, family Aphelocheiridae is represented by one species *Aphelocheirus aestivalis*, the only benthic bugs. Aphelocheirids live on gravel-sand bottom in the river rapids and calm. They have relatively wide ecological valence but because of having plastron respiration they prefer aerated water. It is red-listed in some European countries.

Notonectidae (backswimmers) are represented with the most common genus *Notonecta*. They swim upside down through the water and grab insects and other benthic invertebrates and small vertebrates too. Backswimmers live in shallow ponds and pools with few plants. They can disperse easily to new habitats because they fly well.

Antennae of **Gerromorpha** are well developed, visible from above, their movement is characteristic above water surface, they use hydrofuge (water-repellent) hair piles on the legs and abdomen to avoid breaking the surface film. Gerromorpha comprise 5 families: Veliidae, Mesoveliidae, Gerridae, Hebridae a Hydrometridae, all species are predaceous.

Larvae and adult of family Veliidae and Mesoveliidae inhabit fresh water streams where they catch prey. Water bugs of the family Gerridae have reduced forelegs but these are highly efficient for catching and holding prey. They prefer standing waters from small pools to lakes, they can be found on slow-flowing waters too. Small members of the family Hebridae are semiaquatic and live among moss. Hydrometridae prefer still water where they can be found moving slowly across the surface of the water or on nearby vegetation.

MEGALOPTERA (ALDERFLIES)

■ **Distribution:** The alderflies is a group of small, dark-bodied megalopterans. There are about 300 species in the world. In Europe, there is only one genus *Sialis* with 4 described species. They live in running as well as standing waters and they are most common in Australia.

■ **Characteristic:** Adult sialids lack ocelli on the head capsule and have entirely or predominantly blackish body and wing colouration. Sialid larvae are characterized by

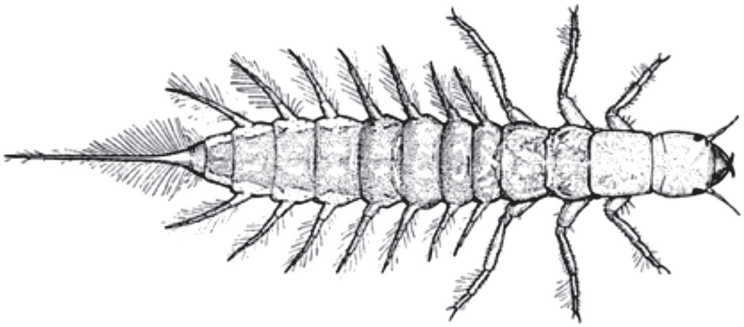

Fig. 1 Larva, Sialidae, *Sialis* (according to Ross, 1973).

an abdomen with seven pairs of lateral tracheal gills and a single (i.e., unpaired) median terminal filament. They are holometabolous: life cycle is complete: egg, larva, pupa and adult. Alderfly larvae are predators with large jaws projecting forward. Alderflies feed on small aquatic invertebrates, such as snails, isopods, and insects. They live on the pond bottom in silty, vegetation rich environments (*Sialis lutaria*) or another species (*Sialis morio*, *Sialis fuliginosa*) live in streams and river arms.

NEUROPTERA - PLANIPENNIA

■ **Distribution:** Plannipenia are distributed all over the world, they are known about 7,000 species, in Slovakia 91 species (terrestric + aquatic), with only two families the Sisyridae and the Osmylidae, their species live semi-aquatic.

■ **Characteristic:** Larvae of the majority of Planipennia are terrestrial as in *Myrmeleon*, the ant lion. However, some like *Sisyra* are aquatic and parasitic in the freshwater sponge, *Spongilla*. General features of the larvae of Planipennia are the forward extended, curved and pointed mandibles and maxillae, which are so arranged as to form between them at each side a food tube up which the hemolymph of their prey is drawn. The only species found in our country is *Sisyra terminalis*. Adults of *Sisyra terminalis* seems to prefer overhanging boughs of oak tree for egg laying. There are only three larval stages, larvae of third instar swim away from the sponge to the shore.

Osmylidae are a small family of the net-winged insect order with only one species *Osmylus fulvicephalus*. Semi-aquatic larvae live in mosses at the edge of the stream with dense vegetation on their banks. Larvae are characteristic by long mandibles and maxillae which form long stylet like tubes. The body bears many setae and the abdomen terminates in a pair of finger - like processes covered with hooks.

COLEOPTERA AQUATICA (AQUATIC BEETLES)

■ **Distribution:** The Coleoptera is a huge order, of which the majority of members are terrestrial. However, there are still a great deal of aquatic species - about 12,500 worlwide, in Slovakia about 350 species.

■ **Characteristic:** Suborder Adephaga comprises 4 families: Haliplidae, Noteridae, Dytiscidae and Gyrinidae. Polyphaga are mostly terrestric, from aquatic families there are living in our region species of the family Curculionidae, Donaciidae, Helodidae, Psephenidae, Elmidae, Spercheidae and Hydraenidae.

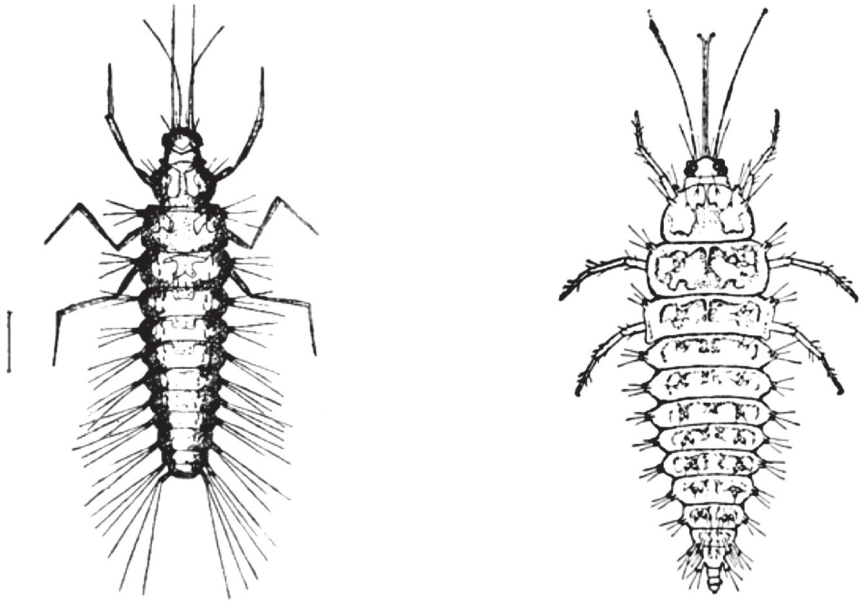

Fig. 1 Plannipenia habitus: larvae of Osmylus fluvicephalus (left) and Sysira (right), (© 2009 public domain, https://bugguide.net).

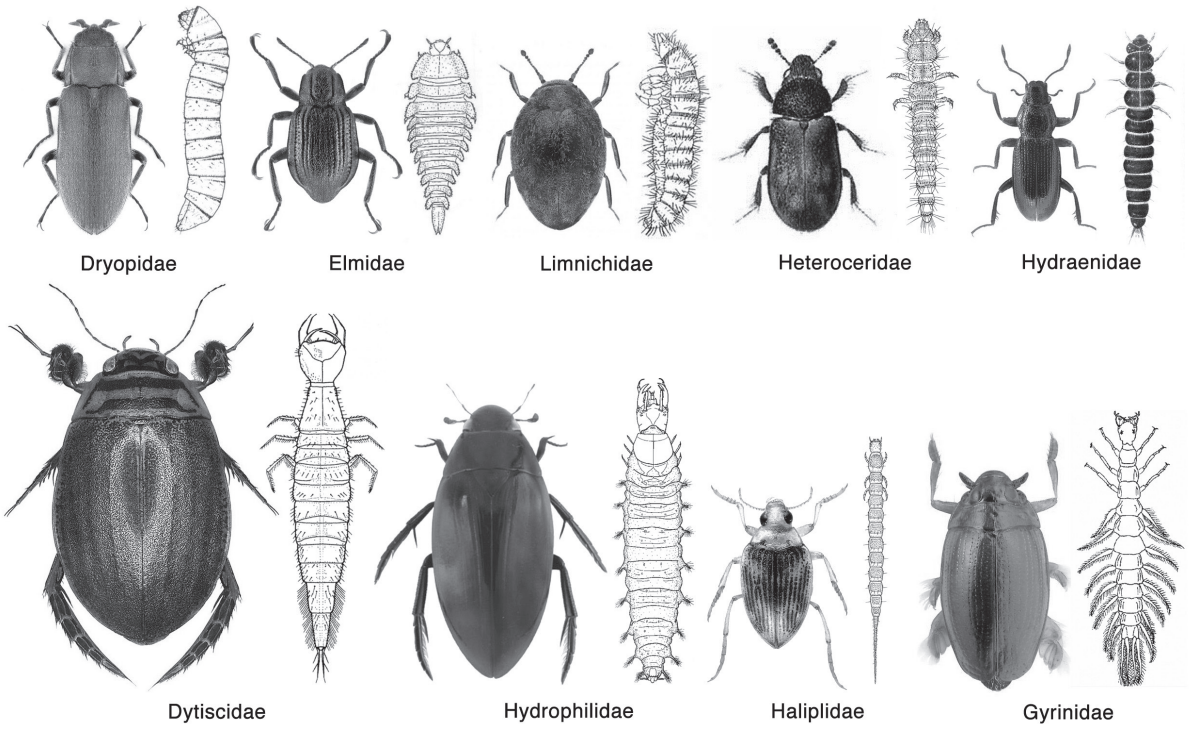

Fig. 1 Aquatic beetles habitus (Beutel & Leschen Eds., 2016, source: Internet, update).

Mouthparts of larvae are biting, mandible a maxilla use for grasping and cheving, legs are absent or there are 3 pairs of jointed legs on thorax. Aquatic beetles breathe by various means: using spiracles or gills (Gyrinidae), tapping into submerged plants with hollow stems (Chrysomelidae), using a siphon located at the tip of the abdomen to draw in surface air (Dytiscidae), storing air in the sub-elytral cavity and between the metacoxal plates or as a bubble beneath the elytra or as a plastron (thin layer of oxygen around the abdomen – Dryopidae, Elmidae).

Dryopidae – larvae are scrapers, occur in standing waters. Adult beetles tend to walk along the botoom, larvae are semi-aquatic.

Larvae and adults of the fam. Elmidae inhabit riffles of running waters on rocks or dead wood. Elminae larvae and adults live together under water, they are fully aquatic and need well-oxygenated water. They feed on algae and detritus, e.g. they are mostly grazers and collectors.

The largest family of aquatic beetles, the fam. Dytiscidae comprises true aquatic beetles, living mostly in vegetation zone along the edges of ponds, lakes, pools, some (*Noterus*) burrow in mood. Their body is adapted for swimming, with swimming hairs on hind legs by adults or with long legs by larvae. This predaceous diving larvae and adults breathe surface air.

Adults of the Gyrinidae are commonly known as whirligig beetles with eyes divided into dorsal and ventral part. The ventral part of the eye is used for vision above the water while the dorsal part is used for seeing below the water surface at the same time. Adults of Gyrinidae species inhabit the water surface in both lotic and lentic habitats. They occur at the edges of small lakes, in ponds, in slow flowing brooks and rivers. Larvae spend most of their life crawling on the bottom or sometimes swimming and acquire oxygen from the water through abdominal gills. Adult and larvae are predators.

Adults and larvae of the Haliplidae family occur amongst aquatic vegetation in ponds and lakes or in slow flowing rivers and brooks. They are shredders and piercers.

Hydrophilidae adults feed on plants or decaying plant matter and larvae are predators, feeding on snails, worms, small crustaceans and insect larvae. They occur in slow till fast moving streams (*Laccobius*, *Berosus*) or in shallow, still waters such as ponds, dams. Great Silver Water Beetle

Hydrophilus piceus is one of the largest water beetles (app. 50 mm).

Hydraenidae adults could be determined according to 9-segmented antennae with 5-segmented club. They live in moss or algal accumulations, dead leaves and twigs in littoral zone of streams, rivers, pools and ponds. Adults are mostly grazers and larvae predators.

Aquatic Curculionidae and Donaciinae from the fam. Chrysomelidae occur in stagnant and slow moving water in submerged vegetation, they are herbivorous shredders. Adults feed on leaves while larvae burrow into stems and roots feeding on the internal plant tissues.

TRICHOPTERA (CADDISFLIES)

■ **Distribution:** This order includes more than 15,000 recent as well as extinct species. So far in Slovakia approximately 175 species have been recorded, occupying every type of flowing and standing waters. They are assigned to 18 families, the most common taxa of which, occurring mainly in running waters, are described here in more detail.

■ **Characteristic:** Caddisflies belong to the order of insects undergoing a complete metamorphosis, meaning having a stadium of pupa in their development. The adults resemble butterflies; however, their wings are covered with hairs (from the Greek word thrichos = hair and ptera = wings → Trichoptera) and they do not have a proboscis, but rather vestigial mouth parts.

Larvae of case-making caddisflies (suborder Integripalpia) resemble caterpillars with chewing mouthparts. The primary axis of the head is ata 90° angle to the primary axis of the body.

Caseless caddisflies (suborder Annulipalpia) have chewing mouthparts, the axis of which is the elongated axis of the body.

Bodies of caddisfly larvae end with abdominal prolegs with anal claws, being an adaptation to strong water currents. They have 5-7 developmental stages (instars) and typically complete their life cycles in a single year. They belong to various feeding guilds, for example passive filter feeders (genus *Hydropsyche*), predators (families Polycentropodidae, Rhyacophilidae), grazers and scrapers of algae and shredders (family Limnephilidae). At the apex of the labium the larvae have silk glands, which produce strands used for net construction or they use it as a glue for case construction.

In Slovakia the family Rhyacophilidae includes 14 species of the genus *Rhyacophila* – caseless predaceous caddisflies occurring in fast-flowing waters, tolerating slight organic pollution. Living larvae are usually green in colour.

Species of the family Glossosomatidae are small case-making shredders and scrapers of clean submountain and mountain streams.

The larvae of the family Hydroptilidae, representing the smallest caddisflies (up to 8 mm), are relatively less studied. They occur in running waters.

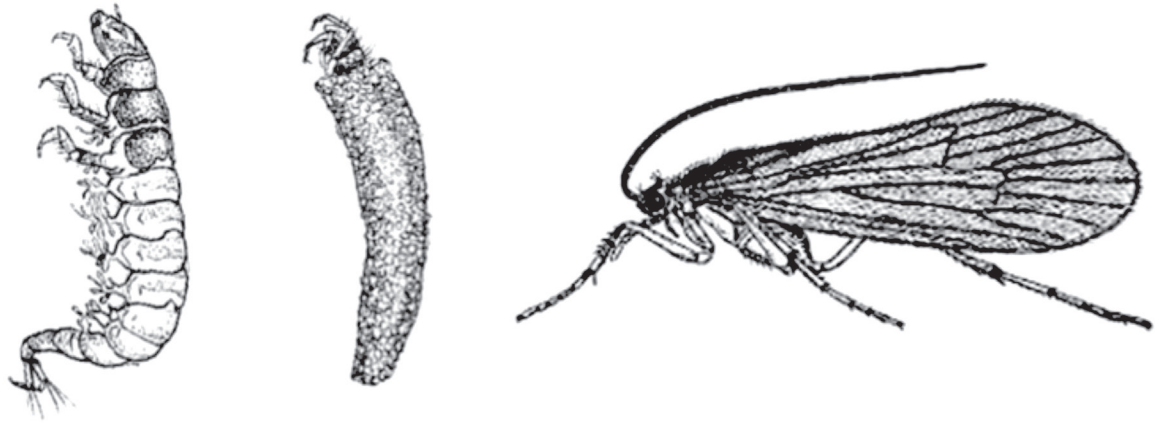

Fig. 1 Caddisflies habitus: a) *Anulipalpia* larvae b) *Integripalpia* larvae, c) adult.

The Philopotamidae are also relatively small caseless caddisflies (up to 22 mm), occurring in colder clean-flowing waters. They have a highly sclerotised head and the first thoracic segment, and capture their prey in nets.

Another family of caseless caddisflies capturing their food in the nets is the Hydropsychidae family. The species occur in flowing waters, which might be organically polluted, providing them with a high amount of food.

The caseless caddisflies of the family Polycentropodidae construct their cases among the stones of mainly lower-elevation streams, with the exception of the genus *Plectrocnemia*.

The larvae of the family Psychomyiidae grow up to 1 cm in length. They belong to algae scrapers, filter feeders, and species of the genus *Lype* feed on wood (are xylophagous).

The Brachycentridae build their cases, which are quadrangular by the genus *Brachycentrus*. They live in running waters of mountain and submountain areas and belong to various feeding types (grazers, filter feeders, predators).

The family Goeridae construct their cases entirely of rock fragments; some genera incorporate larger rock fragments laterally. They inhabit flowing waters and are detritophages, or grazers on periphyton.

The large family of Limnephilidae includes case-making species occupying the full range of aquatic habitats. The larvae of running-water species use mostly inorganic material for the construction of their cases, while the larvae of standing-water species use mostly organic material (e.g. leaves or shells of molluscs). The first two segments of thorax are dorsally sclerotised; sclerotisation of the third segment consists of 6 small plates. Species *Anabolia furcata* attaches longer twigs to its case to protect itself from predaceous fish. *Glyphotaelius pellucidus*, with the case composed of leaves, occurs in warmer standing waters. They belong to various feeding guilds.

Sericostomatidae, building their slightly curved cases from sand, inhabit submountain streams. They are considered to be indicators of relatively undisturbed sites.

Case-making larvae of the family Lepidostomatidae, reaching a length of up to 11 mm and found in running waters, tolerate slight organic pollution. The most common species, *Lepidostoma hirtum*, appears to feed as a scraper and shredder and occurs in running as well as littoral zones of standing waters.

DIPTERA (TRUE FLIES)

■ **Distribution:** The world fauna comprises over 150,000 species, most Diptera are terrestrial. In Europe, there are 3,592 aquatic or semiaquatic species belonging to 30 families. Slovak aquatic true flies fauna consists of app. 566 species belonging to 26 families. This order can be divided in 3 groups: Nematocera ("threadhorns") and Brachycera ("shorthorns") and Cyclorrhapha.

■ **Characteristic:** Diptera are holometabolous insects, stages include egg, larva, pupa, imago. Aquatic larvae breathe through a cuticula and spiracles, tracheal gills are developed only by the species of the family Blephariceridae. Life cycle is seasonal, mono- or bivoltine (development takes 1 year) and poly- or semivoltine (development takes more years). They feed on plant food, especially algae and detritus, there are many predators with obvious mounthparts. Larvae live in various types of habitats and they are important group of biological indicators for freshwater ecosystem assessment.

One of the largest group of Diptera are Tipulidae sensu lato known as the Tipulloidea. The Tipuloidea are considered to contain the families Cylindrotomidae, Limoniidae, Pediciidae and Tipulidae sensu stricto. Representatives of the family Tipulidae are known as "big mosquitos" but they do not bite. Larvae have a cylindrical shape of body, the head is usually partially retracted into thorax. The most distinctive feature is the spiracular disc that is used for taking breath from the air. It is situatedon the end of the abdomen and surrounded by 6 lobes, sometimes they cannot be developed well.

Some of them are inhabitants of swamps or moist soil. They occur in pools of running waters, as well (e.g. *Tipula maxima*, *Tipula lateralis* group). Tipulidae are shredders, although larvae of *Tipula saginata* and of *Tipula* subgenus *Savtshenkia* live in mountain brooks and feed on bryophytes. Tipulidae larvae are important prey to fish and birds.

Species of the family Limoniidae live in sand and silt on the edge of pools. Larvae have four or five lobes usually surrounded the posterior spiracles, but occasionally these

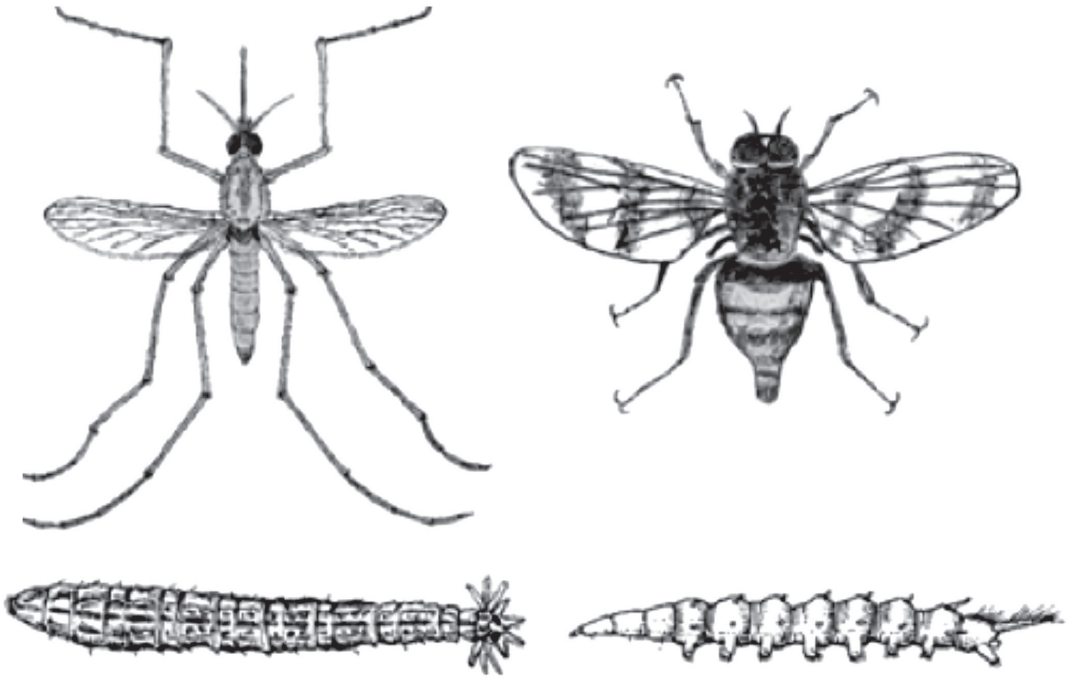

Fig. 1. True flies habitus: Nematocera: adult and larva (left), Brachycera: adult and larva (right).

lobes are absent. Some of the larvae (*Eloeophila*, *Hexatoma*) are carnivorous preying on small insect larvae and worms, another are detritophagous (*Scleroprocta*).

The Pediciidae larvae are hemicephalic and metapneustic, with a strongly fused head capsule and with only two lobes at the margin of spiracular field, some abdominal segments bear creeping welts (*Pedicia*, *Tricyphona*) or pseudopods (*Dicranota*). They are important predators on mites, oligochaetes, insect larvae. Larvae of the genus *Dicranota* occur in all types of not very polluted flowing and still waters.

The family Chironomidae (non-biting midges) are a family with global distribution. Larvae can be found in almost all aquatic and semiaquatic habitats. Some species are adapted to virtually anoxic conditions and they are dominant in polluted waters. The head capsule of larvae is complete, not rectractile. Larvae of some species *Chironomus spp.* are red in colour due to a haemoglobin and their ability to capture oxygen is further increased by their making undulating movements. Cold stenothermal larvae of the genus *Diamesa* inhabit harsh conditions in glacier brooks. Chironomid larvae belong to gathering and filtering collectors, predators, shredders and scrapers too. Larvae are most commonly found amongst benthic debris and aquatic vegetation but also in pools, sandy substrates, snag habitats, hygropetric seepages and muddy lake beds.

Female of black flies (Simuliidae) require a blood meal for maturation of the eggs, either before or after mating. These larvae occur in fast flowing waters where suitable conditions for respiration and filter-feeding are. These filtering collectors extract fine particulate matter from water therefore they tolerate a slight organic pollution. Larvae are characteristic with their head capsule with pair labral brushes and abdomen swollen in posterior portion, bearing circlet of spines and sucker for attachment. They occur in all parts of flowing waters and are indicators of stream zonation and morphological degradation.

Females of some species of the family Ceratopogonidae feed on blood like black flies, therefore ceratopogonid adults are commonly known as bitting midges. Larvae have complete head capsule (eucephal), not retractile into thorax. Live in mud, debris, rooting vegetation, water-filled tree rocks, slowly flowing parts of streams or in lakes. Larvae feed on detritus, fungi, algae or small invertebrates.

Blephariceridae can be easy identified to the family. Their body is dorso-ventrally flattened, cephalic division consists of head, thorax a 1st abdominal segment fused and ventral surface has 6 sucking disc. Larvae occur in cold submountain and mountain streams. They are sensitive to pollution, changing water level and therefore are good biological indicators. Larvae feed on microscopic algae on boulders and cobbles. Pupae have also been attached to the substrata till emergence from May to June.

Psychodidae known as moth flies because adult resembles a tiny moth. Each thoracic and abdominal segment of larvae is subdivided and bearing sclerotized plates and good developed head (eucephalic). They inhabit various habitats, some species live in clean mountain streams (e.g. *Berdeniella unispinosa*). Some species are tolerant to eutrophication and low oxygen level (*Psychoda*). Larvae are gathering collectors feeding on decomposing organic matter.

Family Ptychopteridae (phantom crane flies) larvae have long, telescopic breathing tube (for breathing atmospheric air) and good developed head. They live in polls of flowing waters in the fine substratum (mud, sand, silt) with organic material which is source of their nutrition. In Europe only genus *Ptychoptera* occurs.

Dixidae (meniscus midge) are good indicators of clean water. Species of the genus *Dixella* inhabit natural standing waters and species of the genus *Dixa* inhabit natural running waters. Their larvae maintain characteristic U shaped position in water surface. They are eucephalic, abdomen is bearing setose lobes.

Athericidae have robust predatory larvae with incomplete head capsule, paired prolegs present on abdominal segments, and lateral and dorsolateral tubercles on abdominal segments. Final instar larvae leave the water to pupate. Females of the species *Atherix ibis* lay their eggs on overhanging riparian vegetation, bridges or stones, so that newly hatched larvae can drop straight into the water. Therefore they are good indicators of permanent discharge.

Empididae - larvae of these relatively small predators live in mud and detritus or in algal mats and aquatic mosses in standing and flowing waters.

Tabanidae is a well-known group of haematophagous insects. The females of all the Central European species are blood-sucking, whereas the males are nectar feeders. Larvae of two genera could be distinguished according to prolegs. The larvae of the genus *Chrysops* have 3 pairs of prolegs on seven abdominal segments, the larvae of the genus *Tabanus* have 4 pairs of prolegs on seven abdominal segments. Larvae are predators of invertebrates such as oligochaetes and insects. They usually occur in shallow muddy regions of ponds and lakes, but are also found in deep pools, among submerged vegetation or near the banks of streams.

Larvae of the family Stratiomyidae have rough and strongly sclerotised integument. They live in springs (*Oxycera*), larvae of the genus *Stratiomys* occur in organic polluted eutroph standing waters. All larvae are saprophages.

The adults of the hoverflies (Syrphidae) often mimicking various aculeate Hymenoptera. Larvae are commonly known due to the telescopic breathing tube at the posterior end of the abdomen. This allowed them to breathe and survive in water that lacks oxygen. Larvae are gathering collectors feeding on organic tissue in the sediment of standing and slow-flowing waters.

Most larvae of the family Ephydridae are aquatic or semiaquatic, but some of them are adapted to extreme habitats such as alkaline or highly saline waters, hot springs or oil pools, whilst others develop in decomposing matter or are leaf miners. Larvae are characteristic by separated posterior spiracles, which could be spine-like.

Glossary

Aquatic

relating to water; living in or near water or taking place in water (derived from Latin aqua = water).

Terrestrial

the animals that live predominantly or entirely on land, as compared with aquatic animals, which live predominantly or entirely in the water

Macrozoobenthos = macroscopic benthic invertebrates (MZB)

the animals that live at the bottom of the water, and are visible. In some classification schemes, these organisms are larger than 1 mm; in another, the smallest dimension must be at least 0.5 mm. They include oligochaete worms, moluscs, flat worms, leeches, crustaceans and aquatic insects.

Aquatic insects live mainly in freshwaters. Some of them pass through ontogenetic development within few days while others need even several years. Most aquatic insects live in water only during larval stages, thus they form the temporary aquatic fauna, while some beetles and bugs live in water during whole their life. Oligochaetes, moluscs, flat worms, leeches, crustaceans live all of their life in water and belong to the permanent aquatic fauna.

Imago

the last stage an insect attains during its metamorphosis, the stage in which the insect attains maturity.

Larva

a distinct juvenile form many animals undergo before metamorphosis into adults.

Metamorphosis

a biological process by which an animal physically develops after hatching, involving a conspicuous and relatively abrupt change in the animal's body structure through cell growth and differentiation.

Life cycles

ontogenetic cycle describes the development of organism – from fertilisation to reproduction.

Hemimetabola

those insects which have an incomplete metamorphosis. Hemimetabolism or hemimetaboly, also called incomplete metamorphosis, is the mode of development of certain insects that includes three distinct stages: the egg, nymph, and the adult stage, or imago. These groups go through gradual changes; there is no pupal stage. The nymph often somewhat resembles the adult stage but lacks wings and functional reproductive organs.

Holometabola

are insects which go through distinctive larval, pupal, and adult stages. They undergo a radical metamorphosis, with the larval and adult stages differing considerably in their structure and behaviour. This is called holometabolism, or complete metamorphism.

Univoltine

referring to organisms having one brood per year.

Bivoltine

referring to organisms having two broods per year.

Multivoltine

referring to organisms having more than two broods per year.

Semivoltine

referring to organisms whose generation time is more than one year.

Species

is one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring.

From biological point of view, the species is a group of organisms, which can reproduce and deliver vital offspring. Any species does occur in specific region. Scientific name of species consists of the generic name (starts with upper case letter) and specific epitaph (always written in lower case).

Genus

is a low-level taxonomic rank used in the biological classification of living and fossil organisms, which is an example of definition by genus and differentia. Genera and higher taxonomic levels such as families are used in biodiversity studies, particularly in fossil studies since species cannot always be confidently identified and genera and families typically have longer stratigraphic ranges than species.

Genus is a higher systematic rank above species level. Related species with many common characters are arranged to the same species.

Family

a taxonomic rank. Other well-known ranks are life, domain, kingdom, phylum, class, order, genus, and species, with family fitting between order and genus.

Related genera are arranged into families. Family ad systematic category is on the rank above genus.

Order

a taxonomic rank used in the classification of organisms. Related families are grouped into orders.

Example:

Order: Trichoptera (caddisflies)

Family: Hydropsychidae

Genus: *Hydropsyche*

Species: *Hydropsyche pellucidula*

Taxon

is a group of one (or more) populations of organism(s), which a taxonomist adjudges to be a unit. Usually a taxon is given a name and a rank, although neither is a requirement.

Taxonomy

is the academic discipline of defining groups of biological organisms on the basis of shared Characteristic and giving names to those groups.

We prepare a list of invertebrates captured during the excursion, but it should be arranged in the table according the system from the lowest taxonomic rage to the higest one.

Example: we have found Oligochaeta, some aquatic insects, moluscs, Crustacea. The list will looks like:

1. Mollusca
2. Oligochaeta
3. Crustacea
4. aquatic insects (Insecta)

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Appendix 1

Water quality evaulation

Table 1: Score of benthic invertebrates for calculation of BMWP index (Barbour et al. 1999).

Family	Taxon	Score
Siphlonuridae	Ephemeroptera	10
Heptageniidae	Ephemeroptera	10
Leptophlebiidae	Ephemeroptera	10
Ephemerellidae	Ephemeroptera	10
Potamanthidae	Ephemeroptera	10
Ephemeridae	Ephemeroptera	10
Taeniopterygidae	Plecoptera	10
Leuctridae	Plecoptera	10
Capniidae	Plecoptera	10
Perlodidae	Plecoptera	10
Perlidae	Plecoptera	10
Chloroperlidae	Plecoptera	10
Aphelocheiridae	Heteroptera	10
Phryganeidae	Trichoptera	10
Molannidae	Trichoptera	10
Beraeidae	Trichoptera	10
Odontoceridae	Trichoptera	10
Leptoceridae	Trichoptera	10
Goeridae	Trichoptera	10
Lepidostomatidae	Trichoptera	10
Brachycentridae	Trichoptera	10
Sericostomatidae	Trichoptera	10
Astacidae	Decapoda	8
Lestidae	Odonata	8
Calopterygidae	Odonata	8
Coenagrioniidae	Odonata	8
Gomphidae	Odonata	8
Cordulegastridae	Odonata	8
Aeshnidae	Odonata	8
Corduliidae	Odonata	8
Libellulidae	Odonata	8
Ecnomidae	Trichoptera	8
Psychomyiidae	Trichoptera	8
Philopotamidae	Trichoptera	8

Family	Taxon	Score
Caenidae	Ephemeroptera	7
Nemouridae	Plecoptera	7
Rhyacophilidae	Trichoptera	7
Polycentropodidae	Trichoptera	7
Limnephilidae	Trichoptera	7
Neritidae	Mollusca	6
Viviparidae	Mollusca	6
Planorbidae	Mollusca	6
Hydroptilidae	Trichoptera	6
Unionidae	Mollusca	6
Corophiidae	Amphipoda	6
Gammaridae	Amphipoda	6
Platycnemididae	Zygoptera	6
Coenagrionidae	Zygoptera	6
Mesoveliidae	Heteroptera	5
Hydrometridae	Heteroptera	5
Gerridae	Heteroptera	5
Nepidae	Heteroptera	5
Naucoridae	Heteroptera	5
Notonectidae	Heteroptera	5
Pleidae	Heteroptera	5
Corixidae	Heteroptera	5
Haliplidae	Coleoptera	5
Hygrobiidae	Coleoptera	5
Dytiscidae	Coleoptera	5
Gyrinidae	Coleoptera	5
Hydrophilidae	Coleoptera	5
Clambidae	Coleoptera	5
Helodidae	Coleoptera	5
Dryopidea	Coleoptera	5
Elmidae	Coleoptera	5
Chrysomelidae	Coleoptera	5
Curculionidae	Coleoptera	5
Noteridae	Coleoptera	5
Hydropsychidae	Trichoptera	5
Tipulidae	Diptera	5
Simuliidae	Diptera	5
Pediciidae	Diptera	5
Ptychopteridae	Diptera	5
Planariidae	Turbellaria	5
Dendrocoelidae	Turbellaria	5
Baetidae	Ephemeroptera	4
Sialidae	Megaloptera	4
Piscicolidae	Hirudinida	4
Valvatidae	Mollusca	3
Hydrobiidae	Mollusca	3

Family	Taxon	Score
Lymnaeidae	Mollusca	3
Physidae	Mollusca	3
Planorbidae	Mollusca	3
Sphaeriidae	Mollusca	3
Bithyniidae	Mollusca	3
Glossiphoniidae	Hirudinida	3
Hirudinidae	Hirudinida	3
Erpobdellidae	Hirudinida	3
Asellidae	Isopoda	3
Chironomidae	Diptera	2
Oligochaeta	Oligochaeta	1

The BMWP score equals the sum of the tolerance scores of all macroinvertebrate families in the sample.

Table 2: Water quality evaluation on the basis of BMWP index

Score	Ecol. status	Water quality
≥100	high	Very good quality
100 - 71	good	Good quality
70 - 41	moderate	Fairly good quality
11 - 40	poor	Fair quality
0-10	bad	Poor quality

Appendix 2
Freshwater habitats

Fig. 1B Karst spring © Katarína Gregušová

Fig. 2B Karst spring © Katarína Gregušová

Fig. 3B Mountain stream © Andrea Rúfusová

Fig. 4B Mountain stream © Andrea Rúfusová

Fig. 5B Submountain brook © Eva Bulánková

Fig. 6B Submountain brook © Ferdinand Šporka

Fig. 7B Submountain river © Iľja Krno

Fig. 8B Lowland brook © Eva Bulánková

Fig. 9B Lowland river © Andrea Rúfusová

Fig. 10B Lowland river © Iľja Krno

Fig. 11B Lowland river – blind arm © Eva Bulánková

Fig. 12B Lowland river – dead arm © Iľja Krno

Fig. 13B Lowland river – dead arm © Tomáš Čejka

Fig. 14B Canal © Eva Bulánková

Fig. 15B Canal © Tomáš Čejka

Fig. 16B Regulated river © Jakub Cíbik

Fig. 17B Regulated river © Igor Kokavec

Fig. 18B Regulated river © Igor Kokavec

Fig. 19B Alpine stream (kryal) © Iľja Krno

Fig. 20B Intermittent stream © Eva Bulánková

Fig. 21B Alpine lake – tarn © Andrea Rúfusová

Fig. 22B Alpine lake – tarn © Fedor Čiampor

Fig. 23B Mountain lake – tarn © Iľja Krno

Fig. 24B Dead arm © Eva Bulánková

Fig. 25B Water reservoir (source: internet)

Fig. 26B Water reservoir © Andrea Rúfusová

Fig. 27B Fishpond © Jakub Cíbik

Fig. 28B Gravel pit © Eva Bulánková

Fig. 29B Fen © Tomáš Čejka

Fig. 30B Peat bog © Eva Bulánková

Fig. 31B Fen © Eva Bulánková

Fig. 32B Vernal pool © Eva Bulánková

Fig. 33B Vernal pool © Eva Bulánková

Fig. 34B Telm – phytotelm © Jozef Oboňa

Fig. 35B Telm – dendrotelm © Jozef Oboňa

APPENDIX 3

Freshwater invertebrates

Fig. 1A Turbellaria, Dugesiidae, *Dugesia gonocephala* © Matej Žiak

Fig. 2A Turbellaria, Planaridae, *Crenobia alpina*
© Ladislav Hamerlík

Fig. 3A Mollusca (Gastropoda), Planorbidae, *Ancylus fluviatilis*
© Ivan Kňaze

Fig. 4A Mollusca (Bivalvia), Unionidae, *Unio tumidus* © Matej Žiak

Fig. 5A Mollusca (Bivalvia), Unionidae, *Unio pictorum* © Igor Kokavec

Fig. 6A Mollusca (Bivalvia), Corbiculidae, *Corbicula* sp. © Igor Kokavec

Fig. 7A Mollusca (Bivalvia), *Synanodonta woodiana* © Igor Kokavec

Fig. 8A Mollusca (Gastropoda), *Radix* sp. © Igor Kokavec

Fig. 9A Oligochaeta, Tubificidae, *Limnodrilus* sp.© Matej Žiak

Fig. 10A Hirudinea, Erpobdellidae, *Dina punctata* © Matej Žiak

Fig. 11A Isopoda, Asellidae, *Asellus aquaticus* © Matej Žiak

Fig. 12A Anostraca, Chirocephalidae, *Eubranchipus grubii* (male) © Lukáš Merta

Fig. 13A Anostraca, Chirocephalidae, *Eubranchipus grubii* (female) © Lukáš Merta

Fig. 14A Notostraca, Triopsidae, *Lepidurus apus* © Lukáš Merta

Fig. 15A Notostraca, Triopsidae, *Triops cancrifirmis* © Lukáš Merta

Fig. 16A Amphipoda, Gammaridae, *Gammarus fossarum* © Matej Žiak

Fig. 17A Decapoda, Astacidae, *Austropotamobius torrentium* © Matej Žiak

Fig. 18A Ephemeroptera, Baetidae, *Baetis* sp. © Matej Žiak

Fig. 19A Ephemeroptera, Heptagenidae, *Ecdyonurus* sp. © Matej Žiak

Fig. 20A Ephemeroptera, Baetidae, *Baetis* sp. © Matej Žiak

Fig. 21A Odonata (Zygoptera), Calopterygidae, *Calopteryx virgo* © Matej Žiak

Fig. 22A Odonata (Anisoptera) Gomphidae, *Onychogomphus forcipatus* © Matej Žiak

Fig. 23A Odonata (Anisoptera), Aeshnidae, *Aeshna* sp. © Matej Žiak

Fig. 24A Odonata (Anisoptera), Cordulegastridae, *Cordulegaster bidentata* © Matej Žiak

Fig. 25A Odonata (Anisoptera), Libellulidae, *Sympetrum* sp. © Matej Žiak

Fig. 26A Odonata (Zygoptera), Lestidae, *Lestes sponsa* (male) © Matej Žiak

Fig. 27A Odonata (Zygoptera), Lestidae, *Sympecma fusca* (female) © Matej Žiak

Fig. 28A Odonata (Anisoptera), Libellulidae,*Orthetrum brunneum* (male) © Matej Žiak

Fig. 29A Odonata (Anisoptera), Libellulidae, *Sympetrum danae* (male) © Matej Žiak

Fig. 30A Odonata (Zygoptera), Platycnemididae, *Platycnemis pennipes*, oviposition © Ivan Kňaze

Fig. 31A Odonata (Anizoptera), Libellulidae, *Sympetrum* sp., coupling © Matej Žiak

Fig. 32A Plecoptera, Perlidae, *Dinocras cephalotes* © Matej Žiak

Fig. 33A Plecoptera, Perlodidae, *Isoperla sudetica* © Matej Žiak

Fig. 34A Plecoptera, Perlidae, *Perla marginata* © Matej Žiak

Fig. 35A Plecoptera, Perlodidae, *Perlodes microcephalus* © Matej Žiak

Fig. 36A Plecoptera, Taeniopterygidae, *Rhabdiopteryx navicula* © Matej Žiak

Fig. 37A Plecoptera, Perlodidae, *Acinopteryx dichroa* © Matej Žiak

Fig. 38A Plecoptera, Taeniopterygidae, *Brachyptera seticornis* © Matej Žiak

Fig. 39A Plecoptera, Perlidae, *Perla marginata* (exuvium) © Matej Žiak

Fig. 40A Plecoptera, Perlodidae, *Isoperla oxylepis* © Matej Žiak

Fig. 41A Plecoptera, Leuctridae, *Leuctra prima* © Matej Žiak

Fig. 42A Plecoptera, Perlidae, *Perla bipunctata* © Matej Žiak

Fig. 43A Heteroptera, Gerridae, *Gerris lacustris* © Matej Žiak

Fig. 44A Heteroptera, Hydrometridae, *Hydrometra* sp. © Matej Žiak

Fig. 45A Heteroptera,Nepidae, *Nepa cinerea* © Matej Žiak

Fig. 46A Coleoptera, Dytiscidae, *Dytiscus marginalis* © Matej Žiak

Fig. 47A Coleoptera, Dytiscidae, *Dytiscus marginalis* © Matej Žiak

Fig. 48A Trichoptera, Brachycentridae, *Brachycentrus montanus* © Matej Žiak

Fig. 49A Trichoptera, Hydropsychidae, *Hydropsyche* sp. © Matej Žiak

Fig. 50A Trichoptera, Limnephilidae, *Potamophylax* sp. © Matej Žiak

Fig. 51A Trichoptera, *Glossosomatidae* (cases) © Matej Žiak

Fig. 52A Trichoptera, Sericostomatidae, *Sericostoma* sp. © Matej Žiak

Fig. 53A Trichoptera, Odontoceridae, *Odontocerum albicorne* © Jakub Cíbik

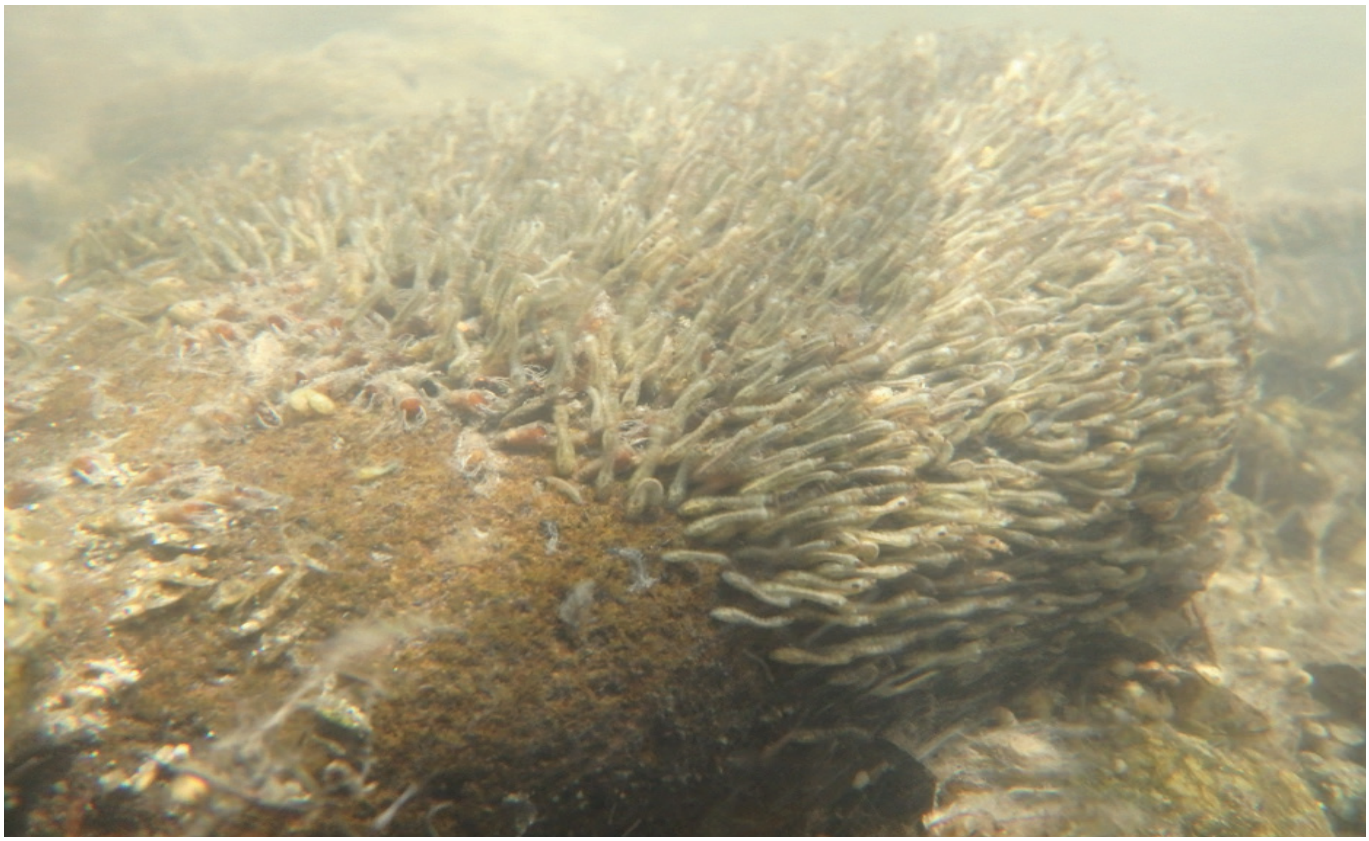


Fig. 54A Diptera, *Simuliidae* © Igor Kokavec

Fig. 55A Diptera, Tipulidae, *Tipula* sp. © Igor Kokavec

Fig. 56A Diptera, Tipulidae, *Tipula* sp. © Eva Bulánková

Fig. 57 A: Diptera, Blephariceridae, *Liponeuracinerascens* (larvae, pupa) © Ján Špaček

Fig. 58A Diptera, Simuliidae, *Prosimulium hirtipes* (larvae, pupa) © Ján Špaček

Fig. 59A Diptera, Psychodidae, Pericoma sp. (left) Dixidae, *Dixa submaculata* (right larva) © Ján Špaček

Fig. 60A Diptera, Chironomidae, Diamesa sp. (left larva), *Prodiamesa olivacea* (right larva) © Ján Špaček

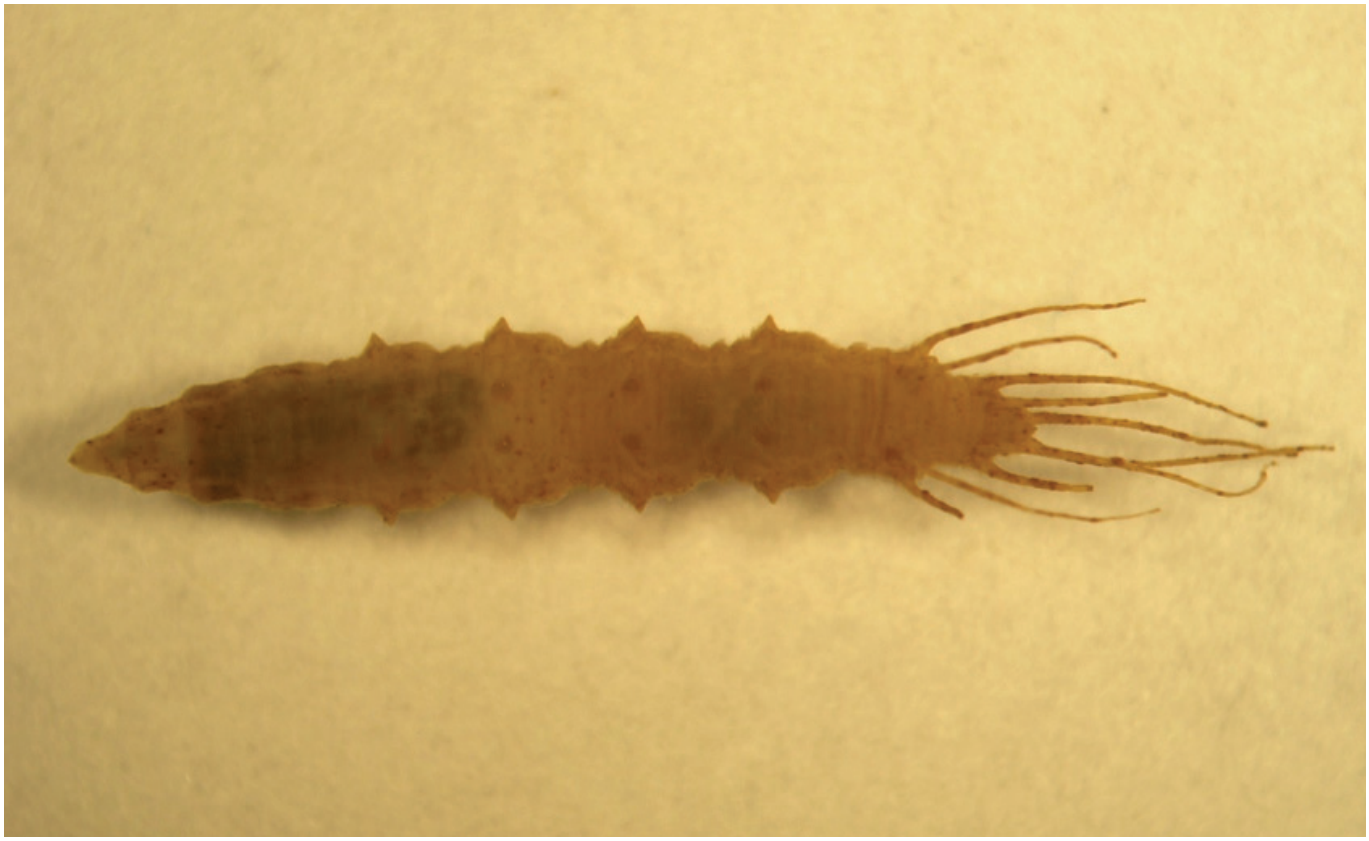


Fig. 61A Diptera, Athericidae, *Atrichops crassipes* (larvae) © Ján Špaček

Fig. 62A Diptera, Athericidae, *Atherix ibis* (pupa) © Eva Bulánková

Fig. 63A Lepidoptera, Pyralidae, *Parapoynx* sp.(larvae) © Ján Špaček

Appendix 4

Digital determination key of benthic macroinvertebrates

Digital determination key
Benthic macroinvertebrates

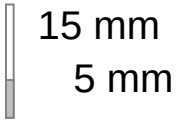
Enter

KEGA 015UK-4/2017

MINISTRY
OF EDUCATION, SCIENCE,
RESEARCH AND SPORT
OF THE SLOVAK REPUBLIC

Instructions

1. In determination key there are listed the most common organisms found in streams and rivers from lowland to mountain range. Organisms are determinable using binocular microscope with 10 x magnification.
2. In introductory table there are listed orders and classes with characteristic pictures showing the most important signs and terms. At the same time the name of the order or class stands for the shortcut to individual taxonomic group in the determination key. Otherwise press-button „ENTER“ is used to start determination procedure for all taxonomic groups.
3. Determination procedure: On every slide there are two or more options describing one determining sign. By clicking on the appropriate option user is switched to the next level in the key. Text linked with this function is **always coloured**. (It is important to click **only** on coloured text, because by clicking on any part of slide Power Point automatically switches to the next slide seriately). Determination is finished, when the appropriate option informs about genus or family, eventually other taxonomic level of the investigated organism, **at the same time is** not linked with press-button. Final answer is always underlined.
4. Pictures show characteristic signs, therefore they are important helper when taking decision.
5. On every slide there are press-buttons „BACK“ and „FINISH“. „BACK“ button returns to the previous level. „FINISH“ button ends the whole determination procedure and takes user to the introductory table.
6. Information about size: abscissa next to the picture of organism show its real size.
7. Length of the whole abscissa presents the maximal size of the organisms, while the grey part of the abscissa present the minimal size.

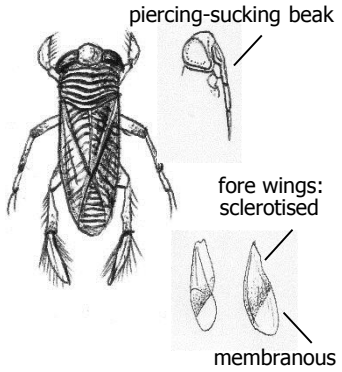


Size of the organisms is in range from 5 to 15 mm.

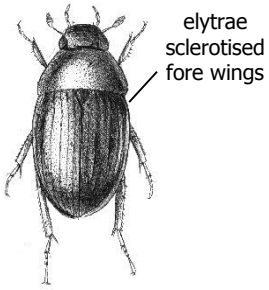
Enter

Back

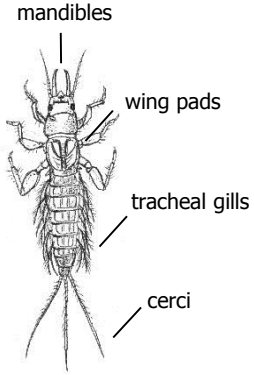
The most important characteristics of listed orders and classes



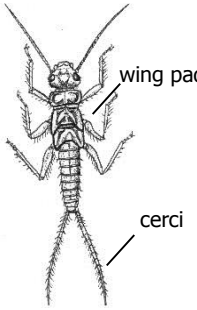
1: True bugs (Heteroptera)



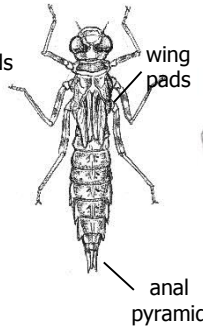
2: Beetles (Coleoptera)



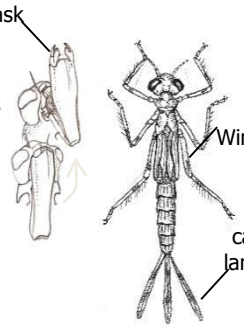
3: Larvae of mayflies (Ephemeroptera)



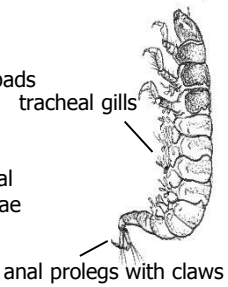
4: Larvae of stoneflies (Plecoptera)



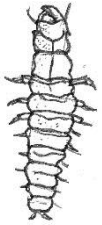
5: Larvae of dragonflies Odonata: Anisoptera)



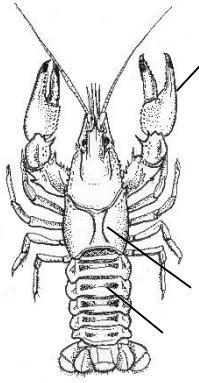
6: Larvae of damseflies (Odonata: Zygoptera)



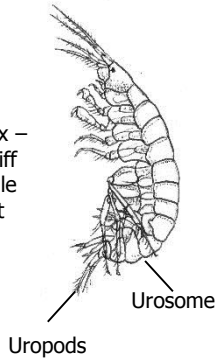
7: Larvae of caddisflies (Trichoptera)



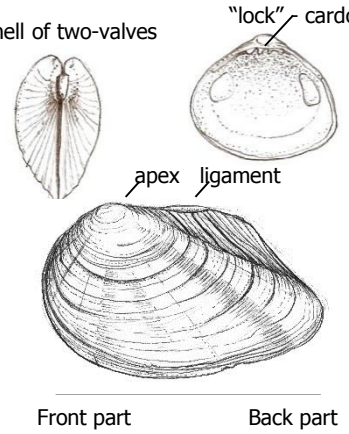
8: Larvae of beetles (Coleoptera)



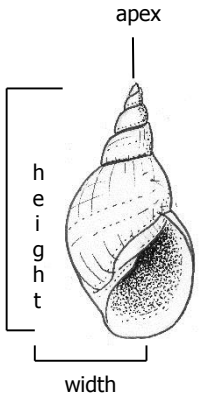
9: Crustaceans (Crustacea, crayfishes)



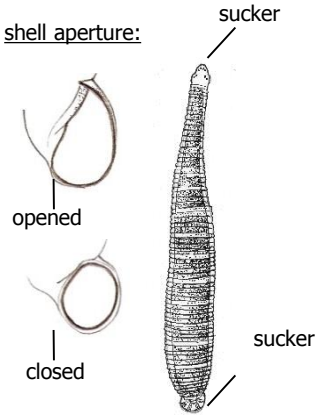
10: Crustaceans (Crustacea, freshwater shrimp, scuds)



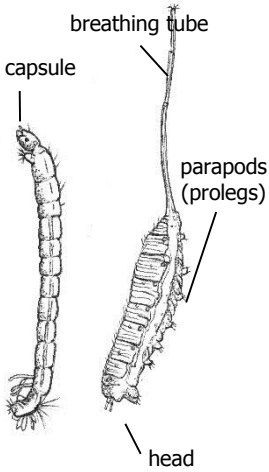
11: Freshwater mussels and clams (Bivalva)



11: Snails and limpets (Gastropoda)

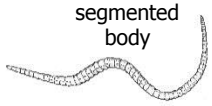


13: Leeches (Hirudinea)

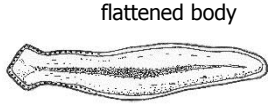


14-15: Larvae of true flies (Diptera)

16: Hairworms (Nematomorpha)



17: Worms (Oligochaeta)

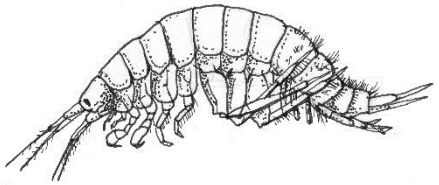


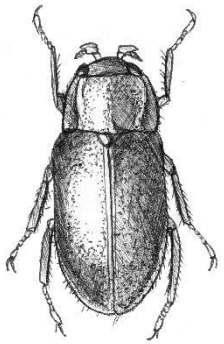
18: Flatworms (Turbellaria)

Instructions

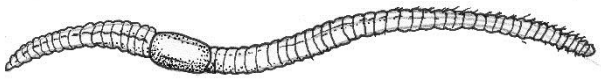
Enter

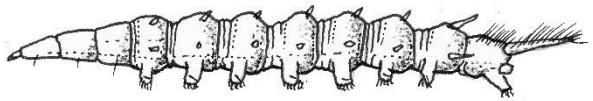
The macroinvertebrate with segmented (jointed) legs

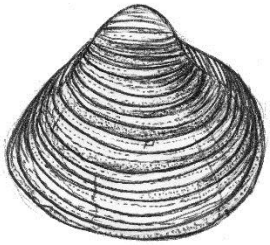


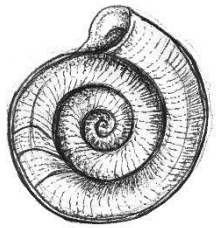


The macroinvertebrate does not have segmented legs

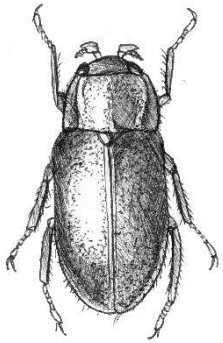




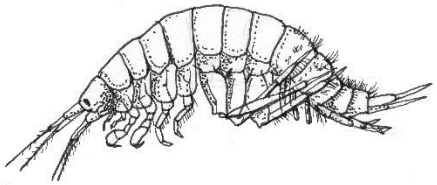




The macroinvertebrate has six legs



The macroinvertebrate has more than six legs



Finish

Back

Insect and its larvae

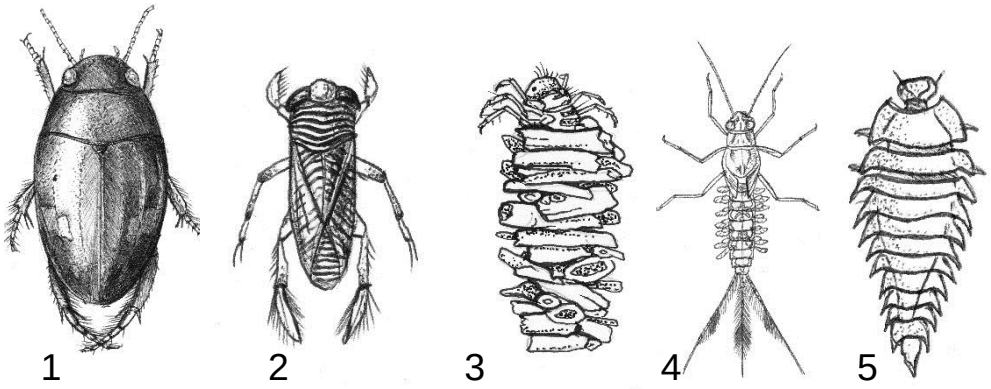
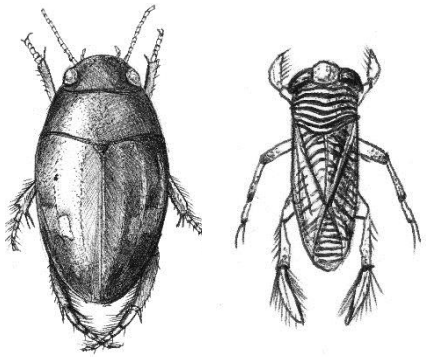
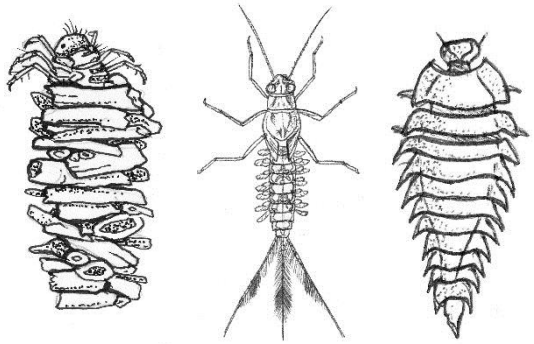


Fig. 1: adult of beetle, Fig. 2: water bug, Fig. 3: caddisfly larvae, Fig. 4: mayfly larvae, Fig. 5: beetle larvae

With fully developed wings



Without fully developed wings



Finish

Back

With three pairs of legs and fully developed wings: beetles (Coleoptera) and water bugs (Heteroptera)

Front part of the forewings hardened, hind part usually membranous (Figs. 1-5). They swim on the back, or move on the water surface: Heteroptera

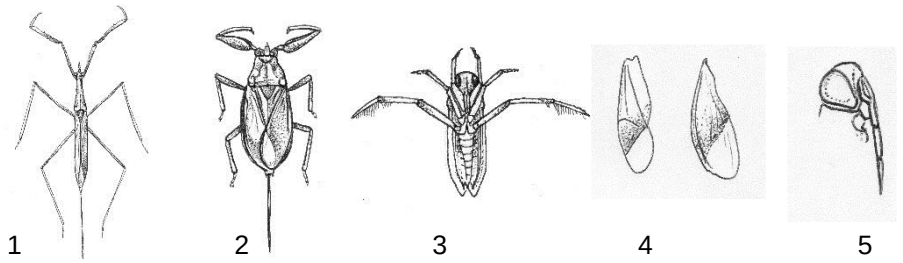


Fig. 1: Water scorpion *Ranatra linearis*, Fig. 2: water scorpion *Nepa cinerea*, Fig. 3: backswimmer *Notonecta* sp., Fig. 4: wing, Fig. 5: piercing-sucking beak

! Below the head *always* piercing-sucking beak, often raptorial forelegs (Fig. 2), some legs very long and thin (Fig. 1), sometimes with terminal abdominal breathing tube (Fig. 2)

Forewings are wholly hardened (chitinous) (Figs. 6-10): Coleoptera

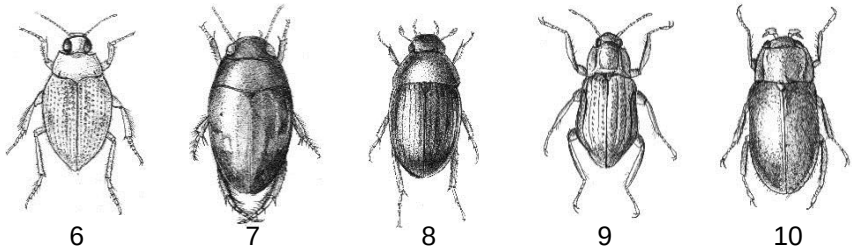


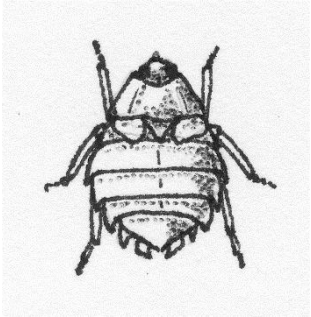
Fig. 6: Haliplidae, Fig. 7: Dytiscidae, Fig. 8. Hydrophilidae, Fig. 9: Elmidae, Fig. 10: Dryopidae

Finish

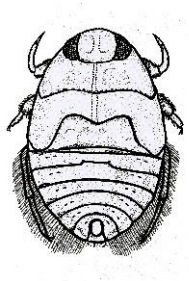
Back

True water bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

Flattened and rounded body *and* short wings - Benthic water bug *Aphelocheirus aestivalis* (Aphelocheiridae). Piercing-sucking beak reaches behind the forelegs, 6-8 mm.



Flattened and rounded body. Between vegetation, standing water.
Ilyocoris cimicoides (Naucoridae), 8-12 mm.



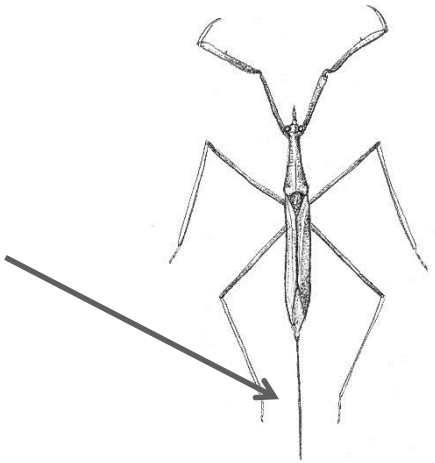
Body is not flattened and rounded with short wings

Finish

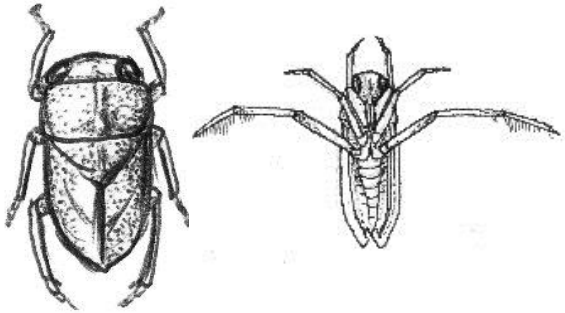
Back

Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

With long terminal abdominal breathing tube



Without long terminal abdominal breathing tube



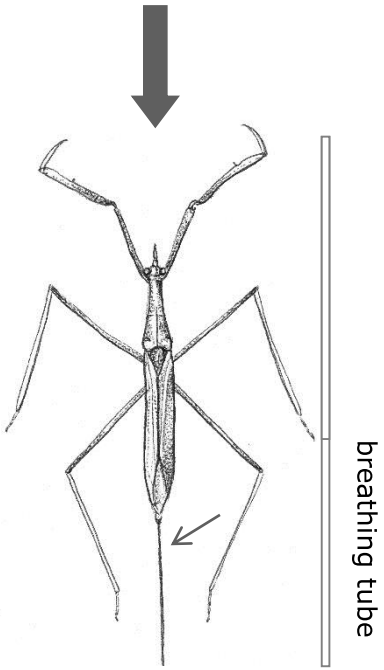
Finish

Back

Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

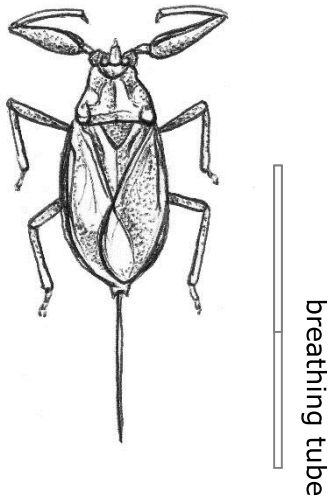
Body long and narrow?

Yes



Water scorpion *Ranatra linearis*
length 40 mm

No



Water scorpion *Nepa cinerea*
elongated oval body, length 22 mm

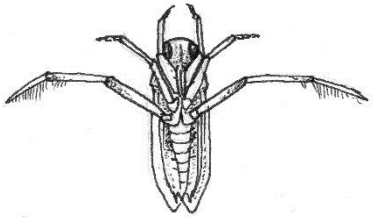
Fam. Nepidae

Finish

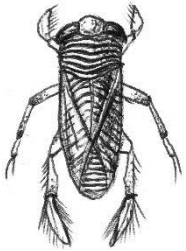
Back

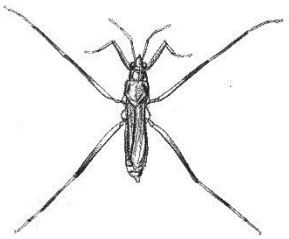
Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

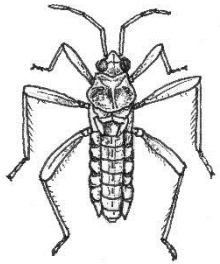
They swim on the back



They do not swim on the back







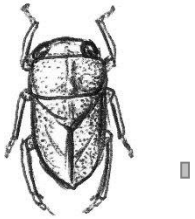
Finish

Back

Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

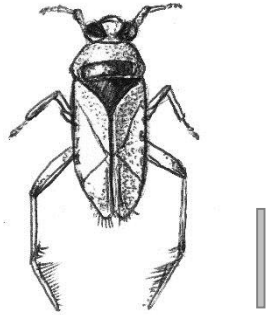
Body short, up to 2.5 mm?

Yes



Pygmy backswimmer *Plea minutissima*, (Pleidae)
body spherical, dorsal part strongly convex, 2-3 mm

No



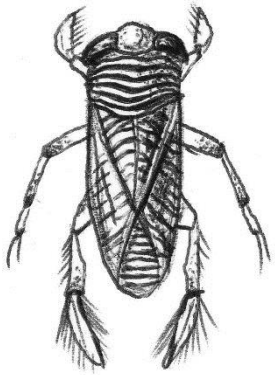
Backswimmer *Notonecta* sp. (Notonectidae), elongated body, 13-17 mm.

Finish

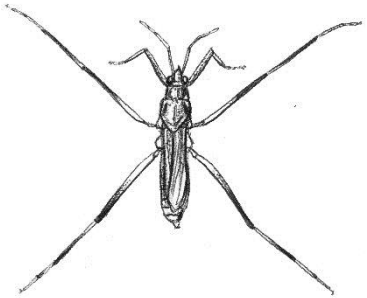
Back

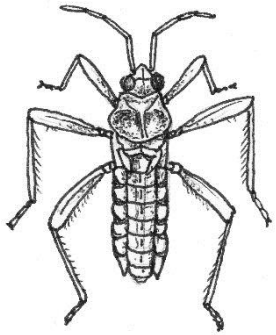
Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

Forelegs short and a paddle-like (be carefull: often only mid and hind legs are visible): water boatman (Corixidae),
5 -15 mm.



Forelegs long





Finish

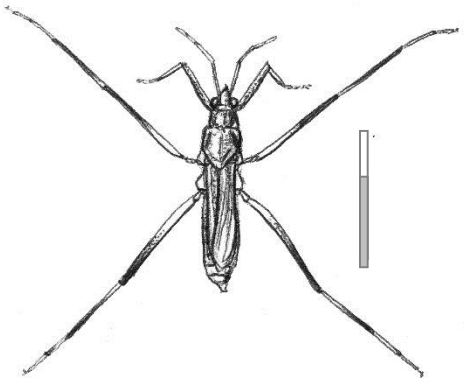
Back

Water true bugs (Heteroptera): always with piercing-sucking beak, front part of the forewings hardened (sclerotised), larvae with wing pad

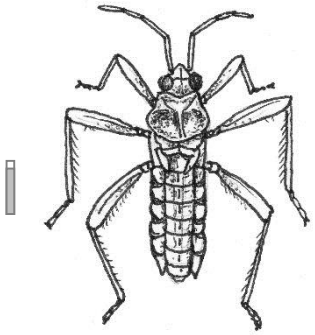
Moving on water surface?

Yes **No**

or



Water strider *Gerris* sp. Gerridae, 12-17 mm.



Broad-shouldered water strider *Velia* sp. (Veliidae), 6 – 7 mm.

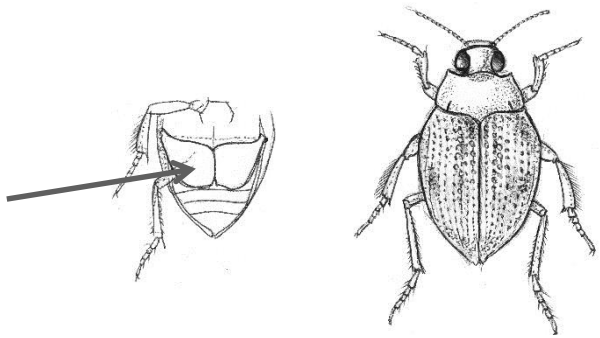
Other water true bugs

Finish

Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

Hind coxae expanded into gills covering abdominal segments
Crawling water beetle (Haliplidae), 2-3 mm



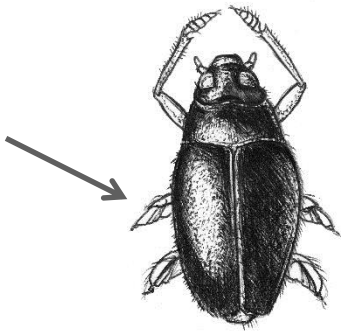
Hind coxae do not form gills

Finish

Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

They swim rapidly in circles. Mid and hind legs
Whirligig beetles (Gyrinidae), 5-7 mm.



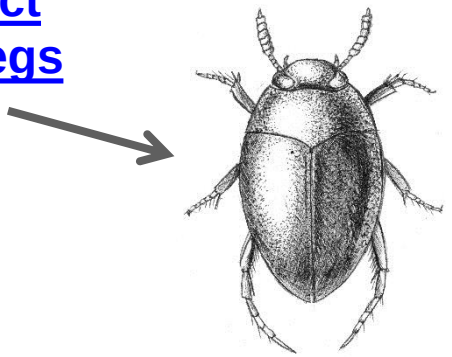
Other shape of mid and hind legs

Finish

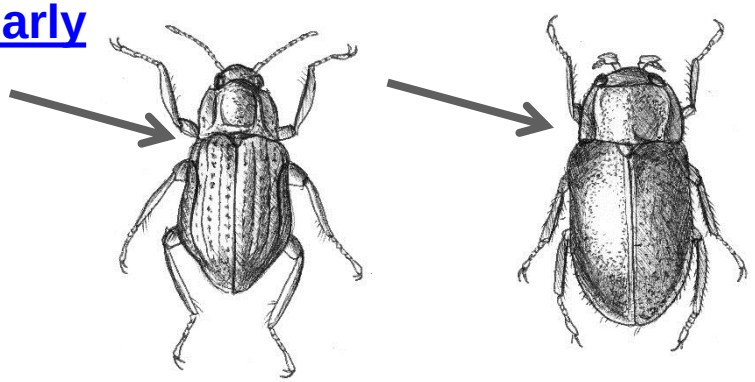
Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

Eliptic body, thorax and abdomen create compact unit, synchronized movements of two pairs of legs



Other shape of body, thorax clearly distinct from abdomen



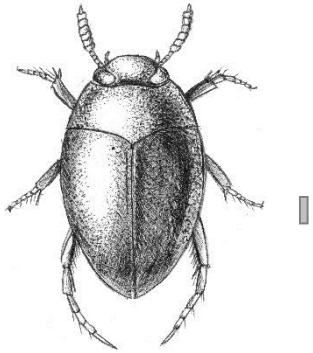
Finish

Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

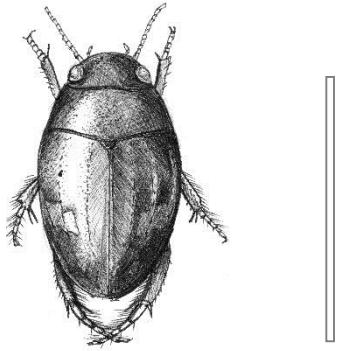
The last antennal segment wide-spread

Yes



Noteridae. Living on shore. The last antennal segment wide-spread. 3.5-4.5 mm.

No



Predaceous diving beetles (Dytiscidae). Antennal segments cylindrical, longer than their width, 2-35 mm.

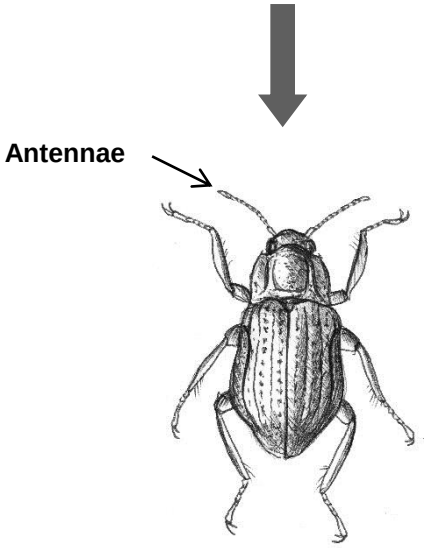
Finish

Back

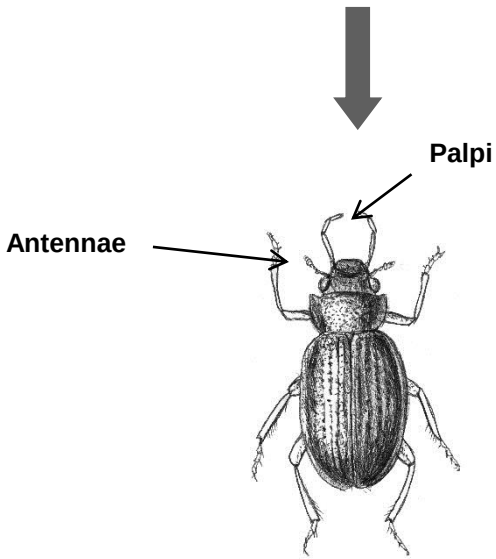
Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

Palpi shorter than antennae? Claws markedly large? Moving only by crowling?

Yes



No



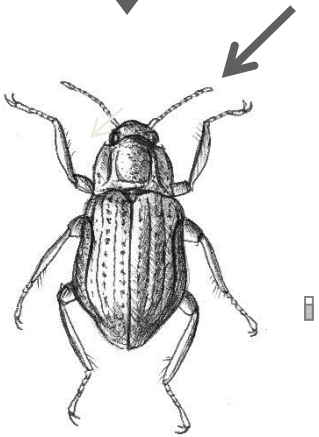
Finish

Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

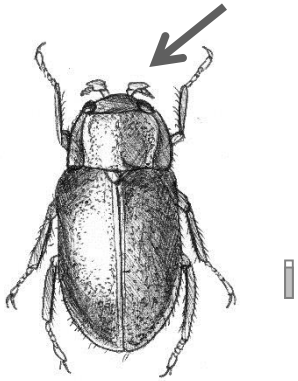
Antennae filiform?

Yes



Elmidae, filiform antennae, body not haired, 2-3 mm.

No



Dryopidae, short antennae with pectinate club, haired body, 4-5 mm.

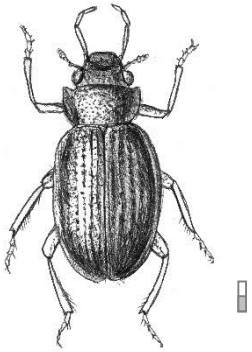
Finish

Back

Beetles - adults (Coleoptera): hardened sclerotised forewings protect and shelter the membranous hind wings

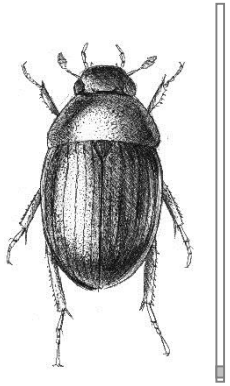
Pronotum wider in front part than in caudal part?

Yes



Hydraenidae, 5-segmented antennae, very long palpi, 2-4 mm.

No



Hydrophilidae, 3-segmented antennae, swimming with uncoordinated movements of legs, 1.5-50 mm.

Finish

Back

Animals with six legs; some with cases: larvae of mayflies, stoneflies, caddishflies, dragonflies, damselflies, beetles, Plannipenia – spongillaflies and osmylids, Megaloptera - alderflies

They DO NOT bear case. Wing pads visible (Fig. 1-5) OR **with 2 or 3 segmented filaments (cerci) (Figs. 1, 2)**

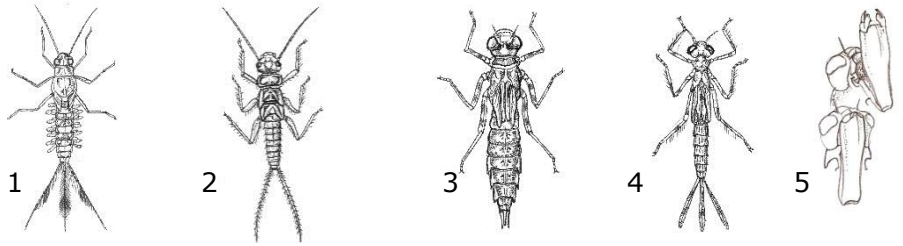


Fig. 1: mayfly, Fig. 2: stonefly, Fig. 3: dragonfly, Fig. 4: damselfly, Fig. 5: labium forming food capturing structure

They can bear case (Fig. 6). Wing pads not visible. Without 2 or 3 segmented tails (cerci) (Figs. 6 -10)

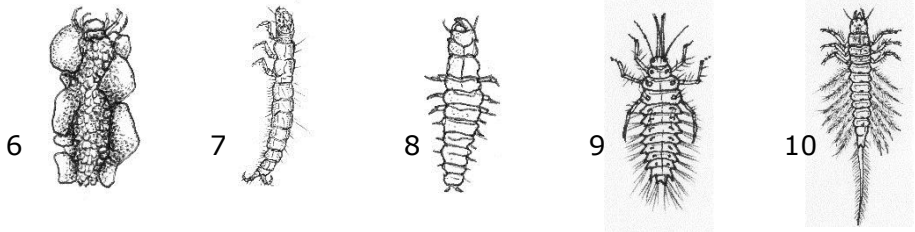


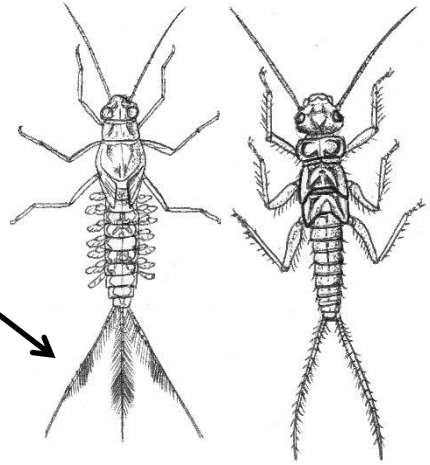
Fig. 6,7: caddisfly, Fig. 8: beetle, Fig. 9: Plannipenia, Fig. 10: alderfly

Finish

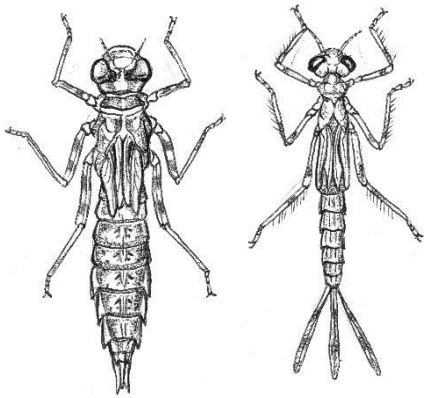
Back

Larvae of mayflies / stoneflies / dragonflies / damselflies

With caudal filaments



Without caudal filaments

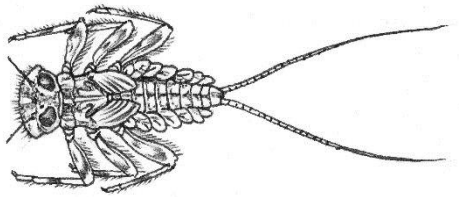


Finish

Back

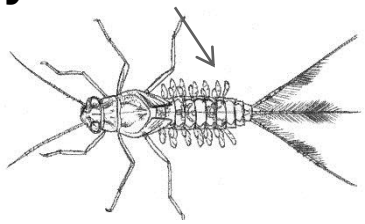
With six legs; wing pads *and* abdominal filaments - larvae of mayflies, stoneflies

Abdomen with oval tracheal gills AND two caudal appendages: mayfly (Ephemeroptera) *Epeorus* sp.

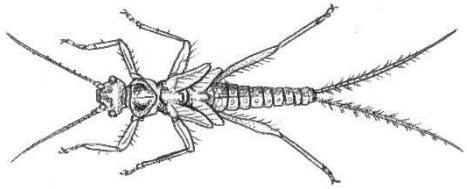


Abdomen with tracheal gills (oval or filamentous) AND three (only *Epeorus sp.* two caudal cerci) caudal cerci: mayflies (Ephemeroptera)

Appendages can be damaged while taking material!



Abdomen without tracheal gills AND two caudal cerci: stoneflies (Plecoptera)



Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

Tracheal gills feathery and form two branches

Other shape of gills

Finish

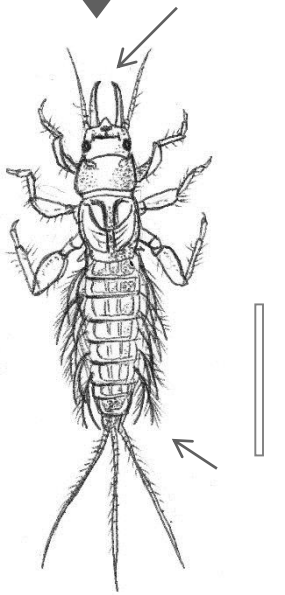
Back

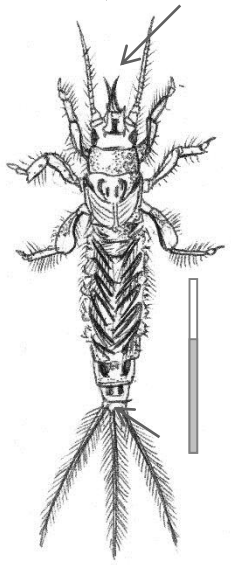
Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

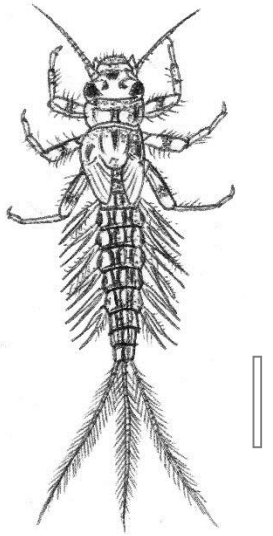
Mandibles visible

Yes

No







Ephoron virgo (Polymitarcidae), mandibles bend inwards, gills lie close to abdomen, 20 mm without cerci

Ephemera sp. (Ephemeridae), mandibles bend apart, gills are above abdomen 15-23 mm

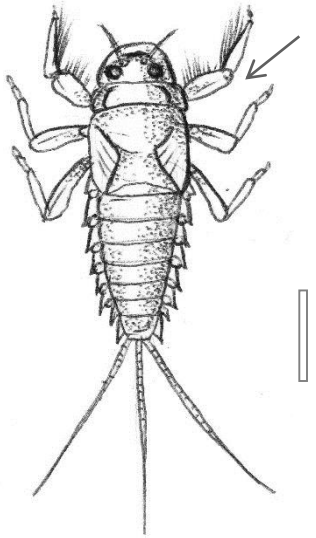
Potamanthus luteus (Potamantidae) gills stand apart the abdomen, 10-12 mm

Finish

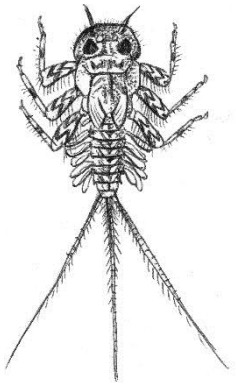
Back

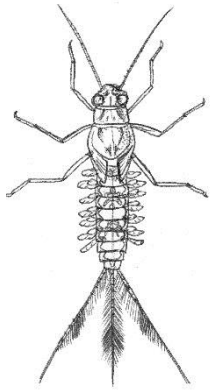
Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

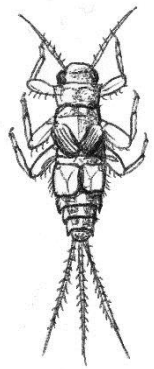
Forelegs with long hairs and tracheal gills small - *Oligoneuriella* sp., 12 mm.



Forelegs without long hairs and tracheal gills larger





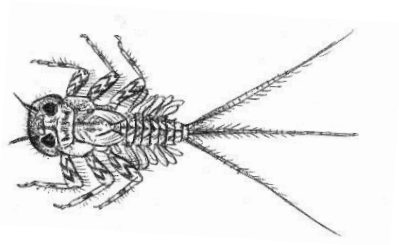


Finish

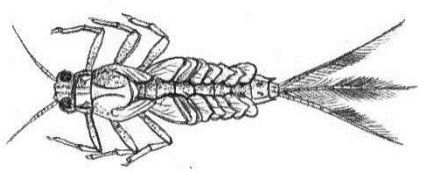
Back

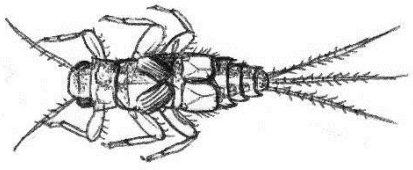
Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

Eyes on dorsal part of head, body flattened - Heptageniidae



Eyes placed lateraly, body not flattened

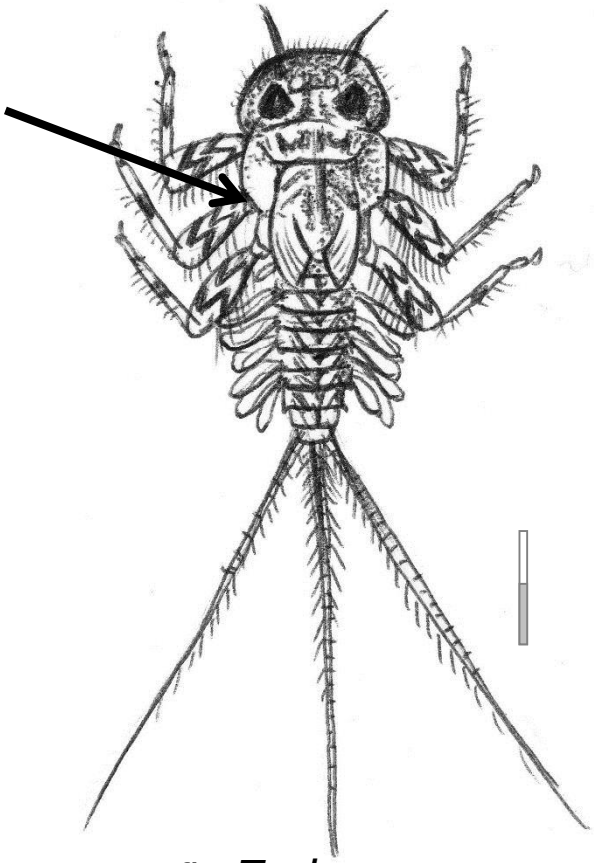




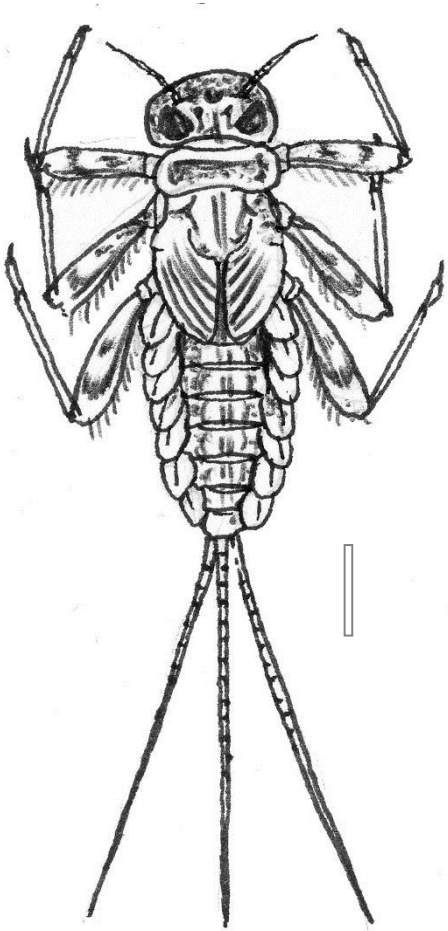
Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills



Mayfly *Ecdyonurus sp*. (Heptageniidae), pronotum with backward projections , 8-15 mm.



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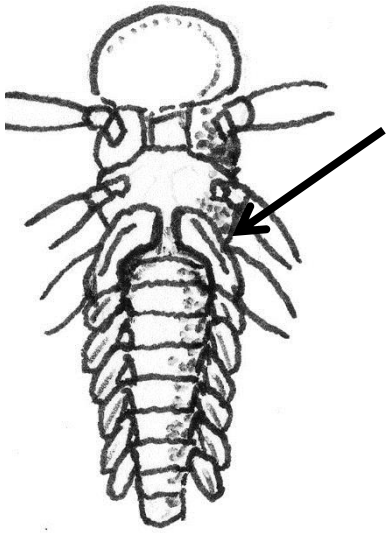
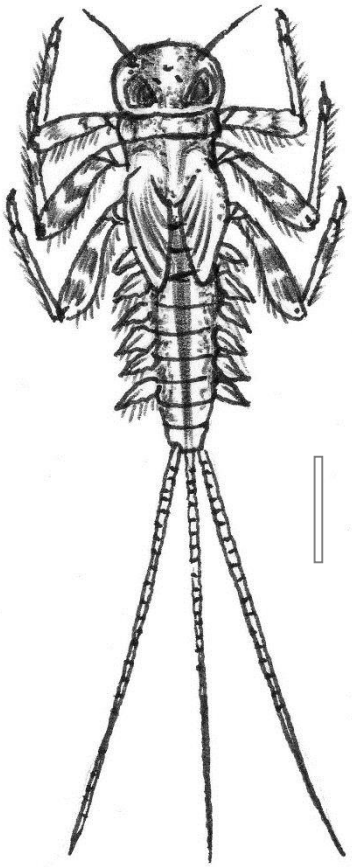


Rhitrogena sp. (Heptageniidae), first pair of gills large and meeting eatch other beneath the body, 8-12 mm.

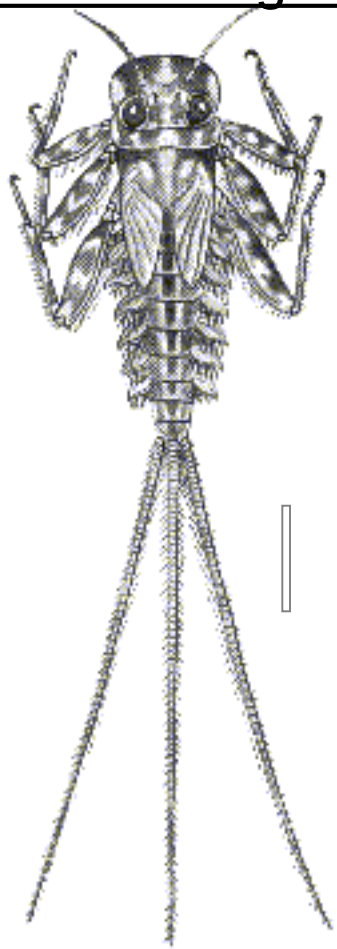
Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills



Heptagenia sp.
(Heptageniidae),
9 -14 mm, in larger rivers.



Electrogena sp.
(Heptageniidae), 8-14 mm,
cerci are longer than body, in
clear smaller streams.

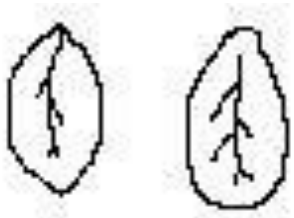
Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

Gills with two branches, each gill may have several branches

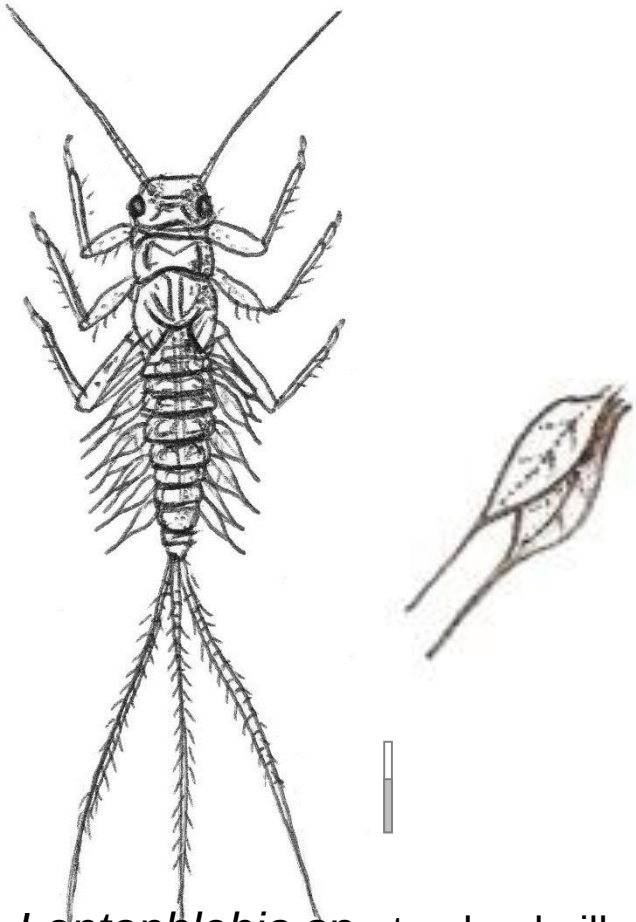
Gills plate-shaped



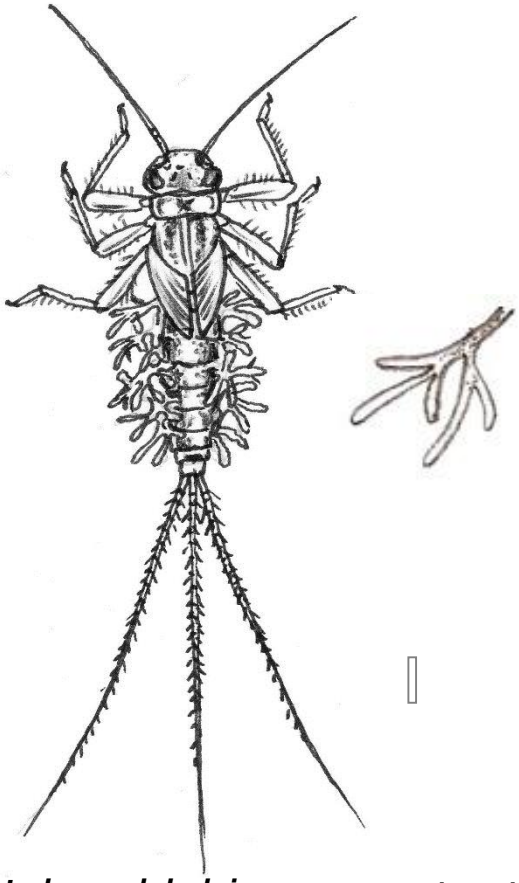
Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills



Leptophlebia sp., tracheal gills lanced, 7-12 mm.



Habrophlebia sp., tracheal gills consist of two branches, 5-6 mm.

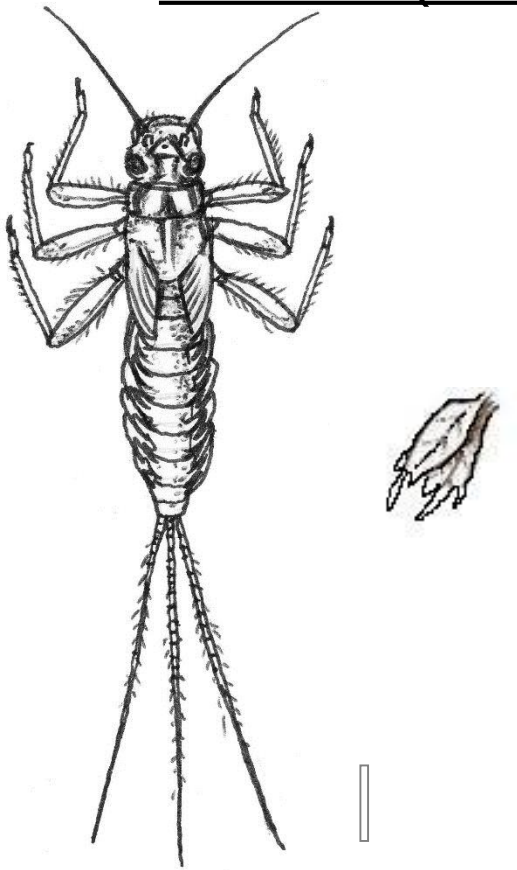
OR

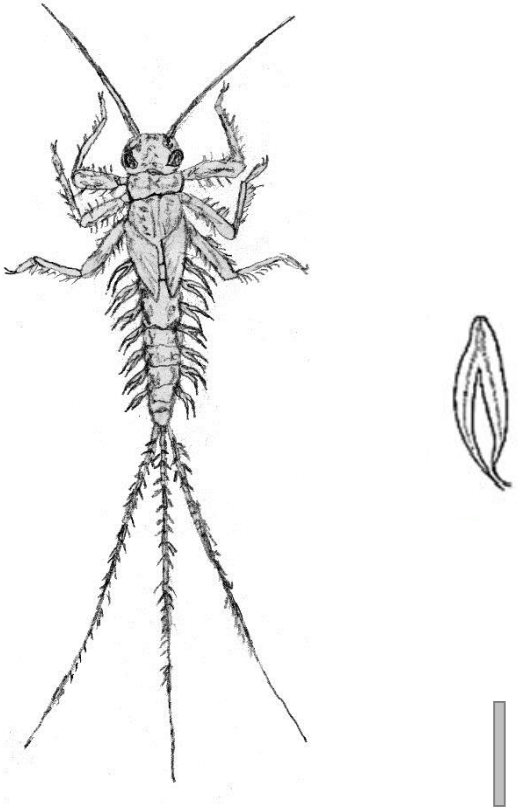
Finish

Fam. Leptophlebiidae

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills





Choroterpes picteti, gills with two plate-like branches with three peaks, 10 mm. Rare species.

Habroleptoides sp., furcate gills, 8-10 mm.
Paraleptophlebia sp., furcate gills, 9 – 12 mm.

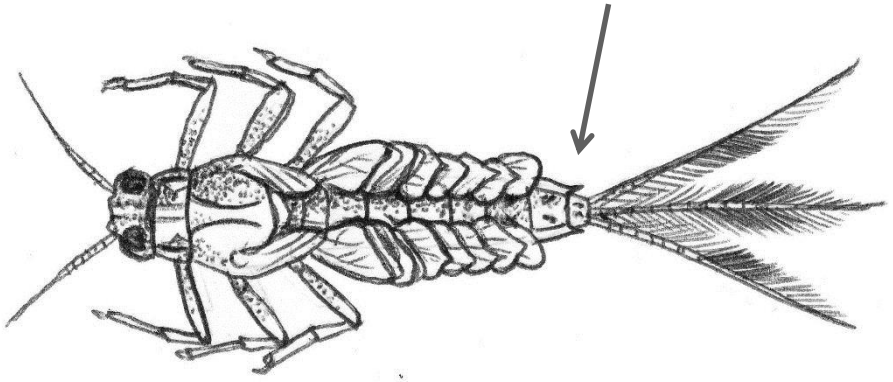
Fam. Leptophlebiidae

Finish

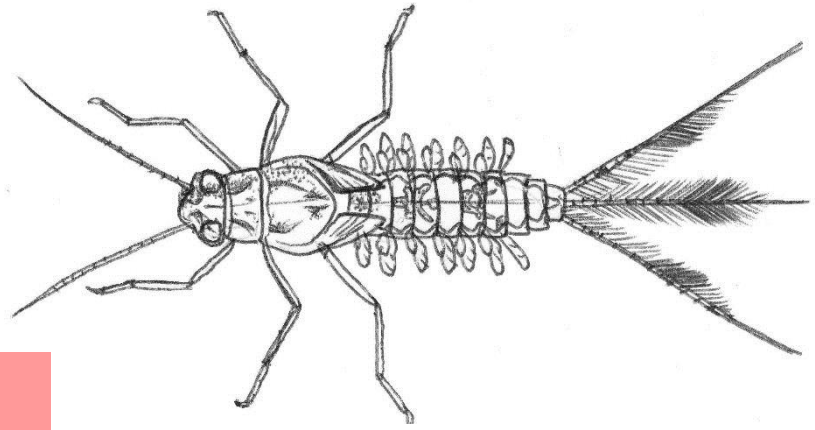
Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

The last abdominal segments with postero-lateral spines



The last abdominal segments without postero-lateral spines

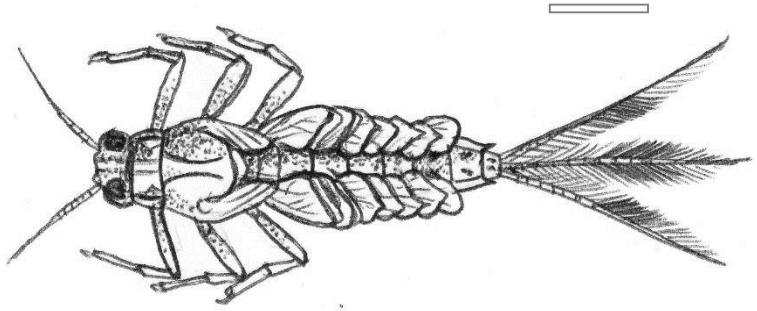


Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

Elongated body and triangle tracheal gills, at least 1st and 2nd gill consisting of two gills: mayfly *Siphlonurus* sp., 11-13 mm.



More robust body and tracheal gills not triangle

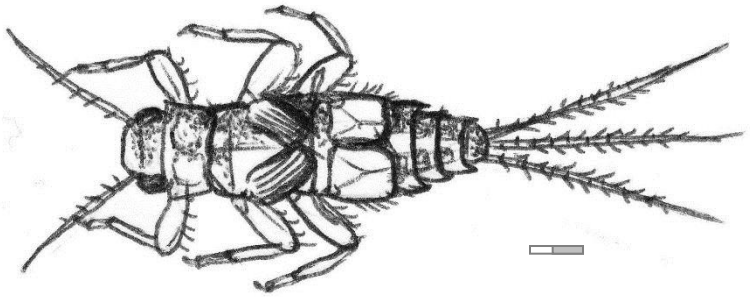
Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills

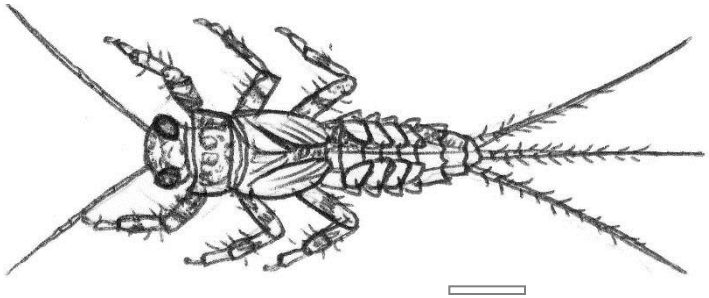
One pair of gills plate-like and markedly larger than other gills?

Yes



Caenidae, body rounded, 4-7 mm.

No

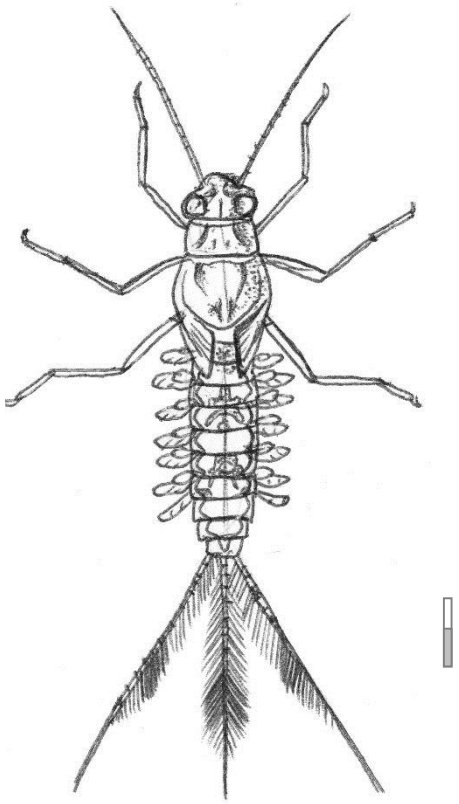


Ephemerellidae, 8-10 mm.

Finish

Back

Mayflies larvae (Ephemeroptera): with wing pads; three caudal filaments (cerci); lateral abdominal tracheal gills



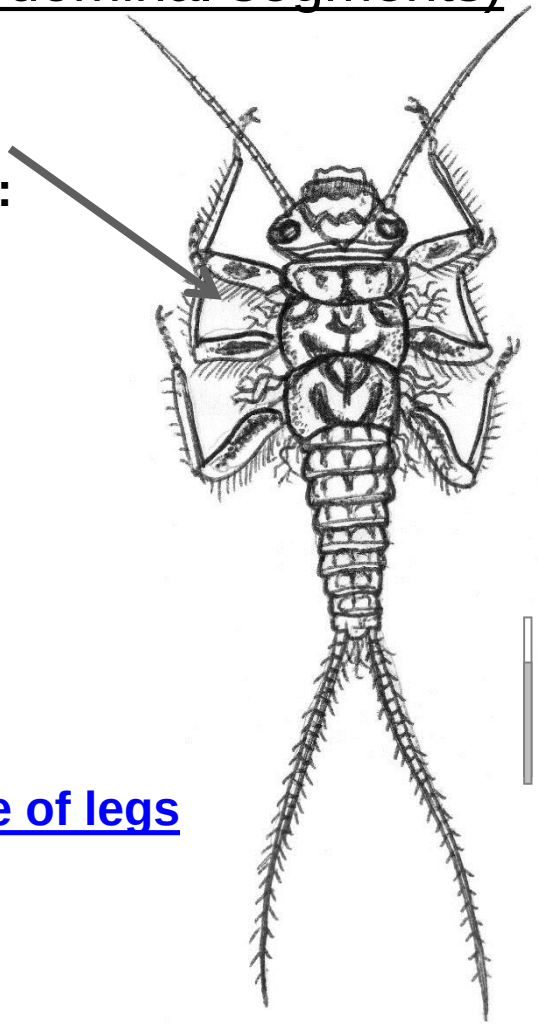
Baetidae, 5-9 mm. Without posterolateral spines on last abdominal segment.

Finish

Back

Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck; or gills are missing (gills never present on abdominal segments)

Gills on thoracic segments at the base of legs:
Perlidae, clear, distinct pattern on abdomen, lenght without filaments 16-22 mm.



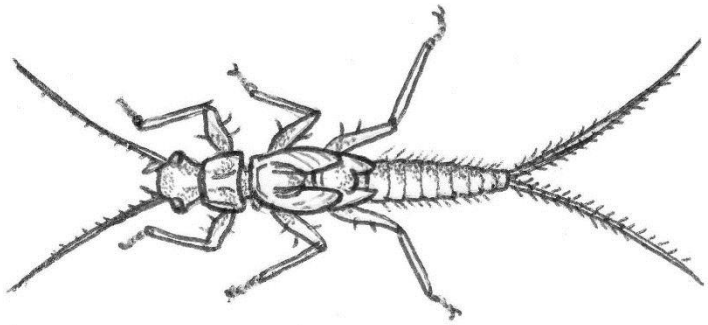
Without gills on thoracic segments at the base of legs

Finish

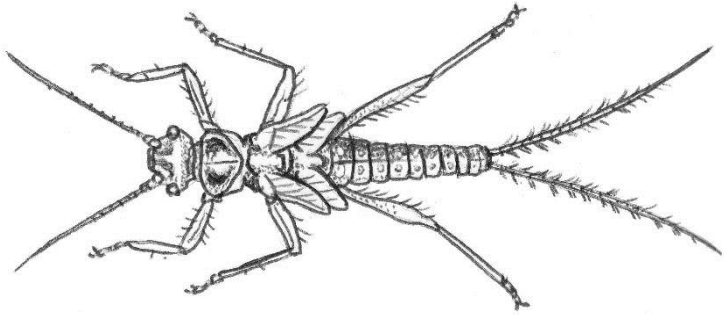
Back

Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck; or gills are missing (gills never present on abdominal segments)

Wing pads parallel with midline



Wing pads not parallel with midline **(divergent or convergent)**

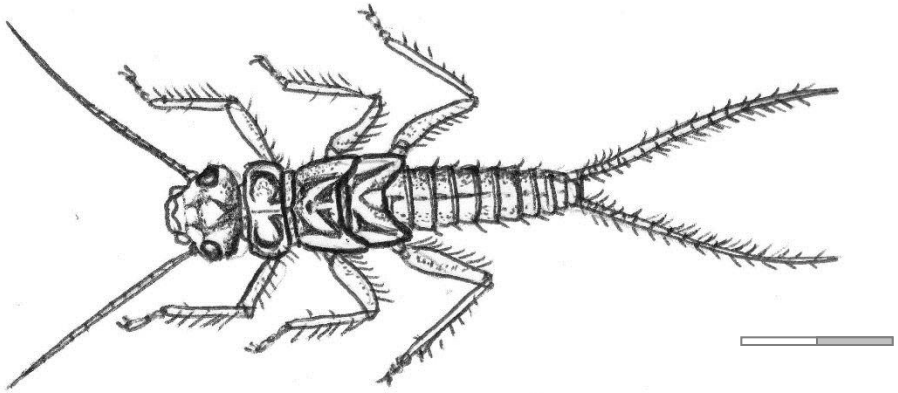


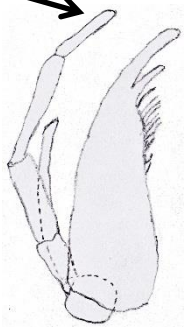
Finish

Back

Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck; or gills are missing (gills never present on abdominal segments)

Body with clear colour pattern: Perlodidae, larger species, with various yellow-brown colour, 10-20 mm. Last segment of palp normal size.





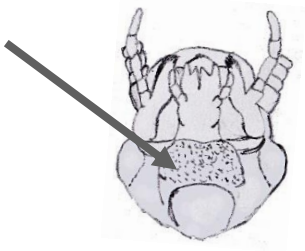
Small species uniformly coloured

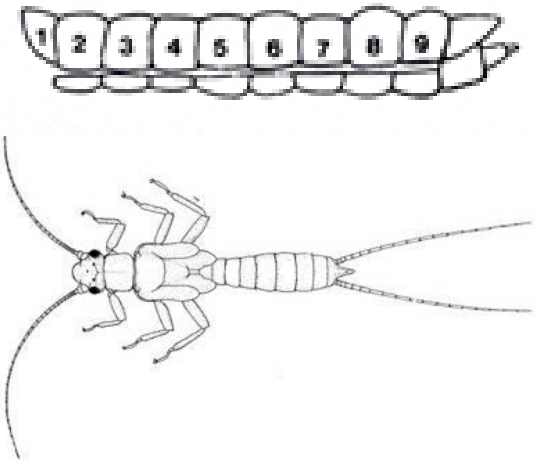
Finish

Back

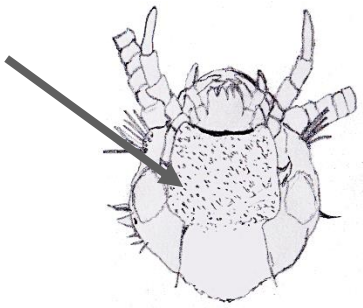
Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck; or gills are missing (gills never present on abdominal segments)

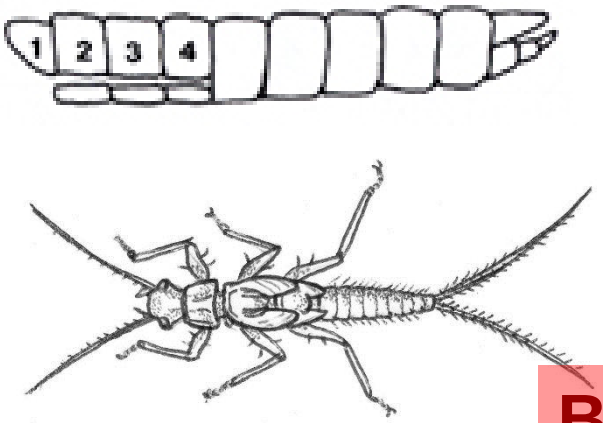
Abdominal segments 1-9 divided into sternum and tergum: Capniidae, brown colour, in gravel or detritus, 5-10 mm. Mentum small.





Only 1-4 abdominal segments divided into sternum and tergum: Leuctridae, snaky movements in water, moving through gravel substrates, mostly yellow colour, 5-8 mm. Mentum bigger, plate-like.



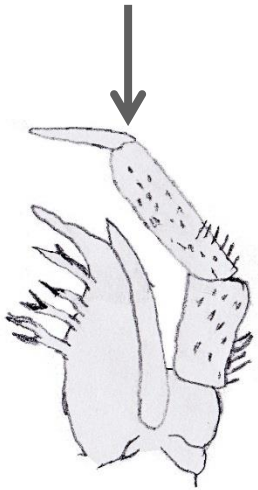


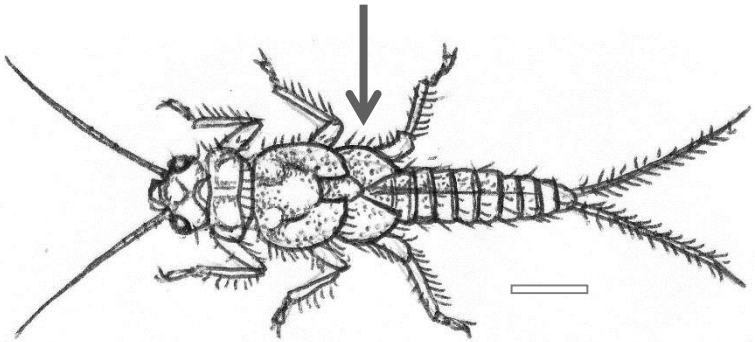
Finish

Back

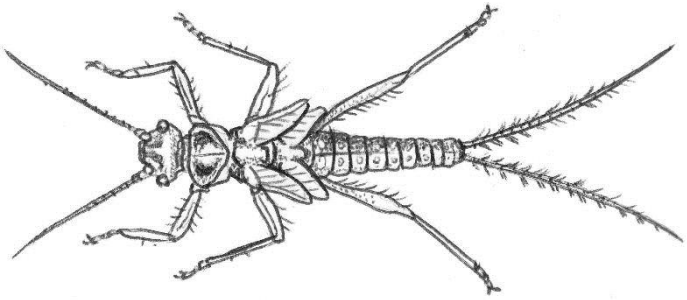
Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck or gills are missing (gills never present on abdominal segments)

Wing pads convergent: Chloroperlidae, edge of wing pads cheliform, 10 mm, last segment of palp reduced..





Wing pads divergent from midline

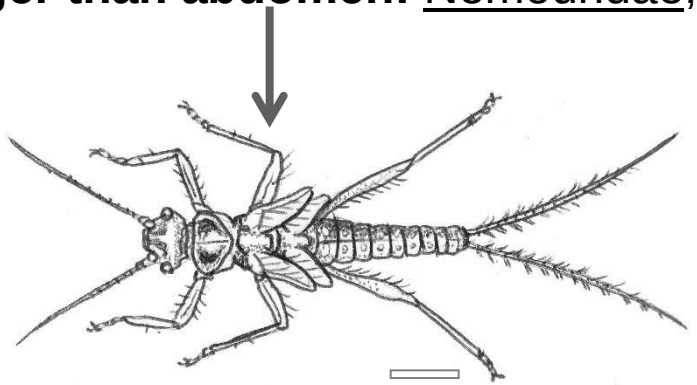


Finish

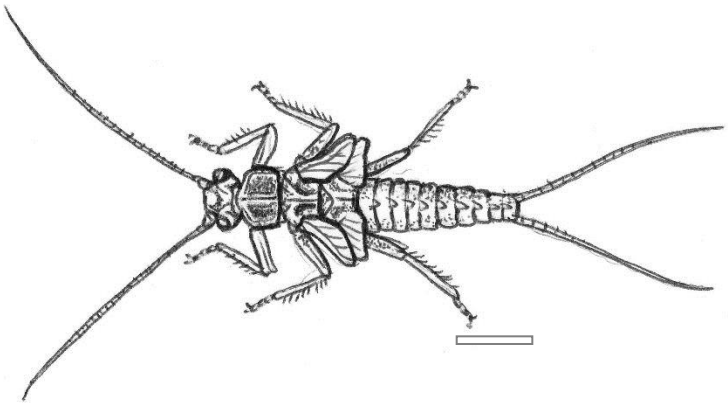
Back

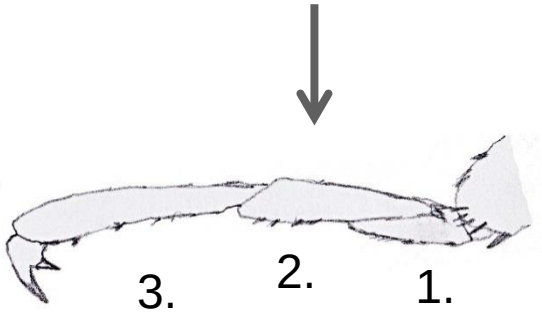
Stoneflies (Plecoptera): Wing pads / two caudal filaments (cerci) / branched or single gills on thoracic segments or neck; or gills are missing (gills never present on abdominal segments)

Hind legs longer than abdomen: Nemouridae, 6-9 mm.



Hind legs shorter than abdomen: Taeniopterygidae**,** 8-10 mm, second tarsal segment longer than first.



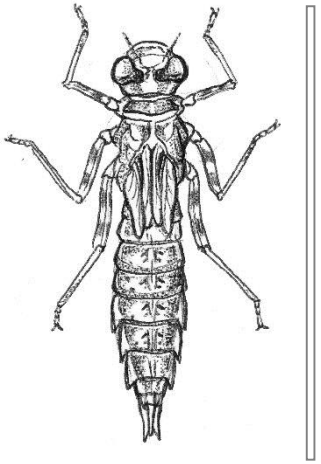


Finish

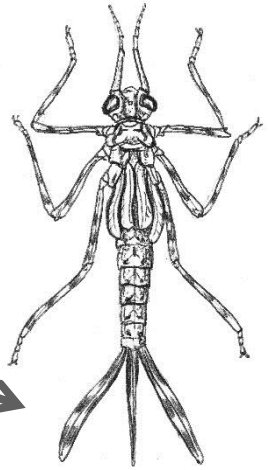
Back

Larvae of dragonflies / damselflies: (Odonata) with wing pads, three flat caudal leaves-like appendages or short pointed appendages (anal pyramid), labium in form of extendable mask-like or scoop-like appendage

Abdomen robust and flattened (> 4mm wide), with short pointed appendages (anal pyramid): dragonflies (Anisoptera), -60 mm.



Abdomen slender, ending with three leaf-like gills (caudal lamellae)

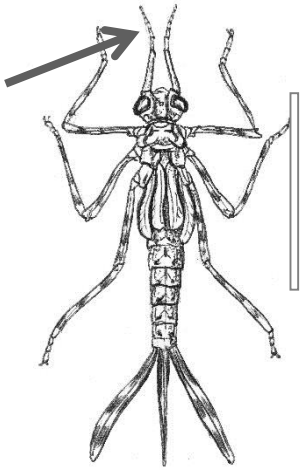


Finish

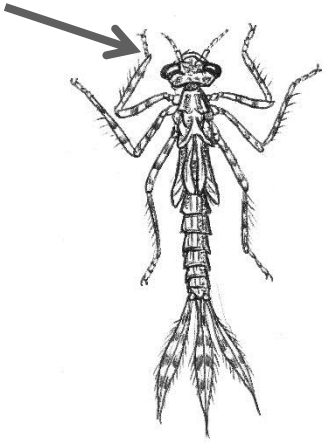
Back

Larvae of damselflies: (Odonata: Zygoptera) with wing pads, three flat caudal leaves-like appendages, labium in form of extendable mask-like or scoop-like appendage

First antennal segment much more longer than head: jewelwing damselfly (*Calopteryx* sp., Calopterygidae), 26 mm without appendages.



First antennal segment short



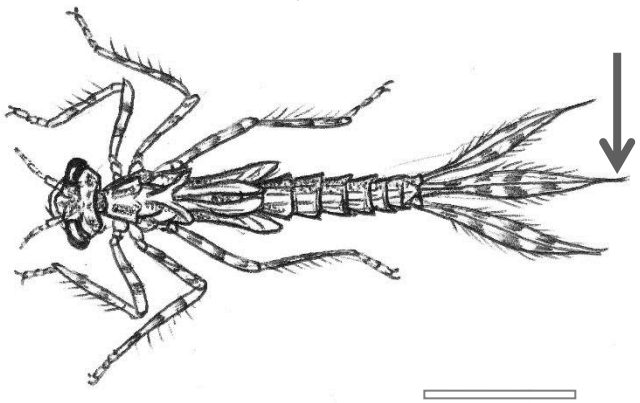
Finish

Back

Larvae of damselflies: (Odonata) with wing pads, three flat caudal lamellae, labium in form of extendable mask-like or scoop-like appendage

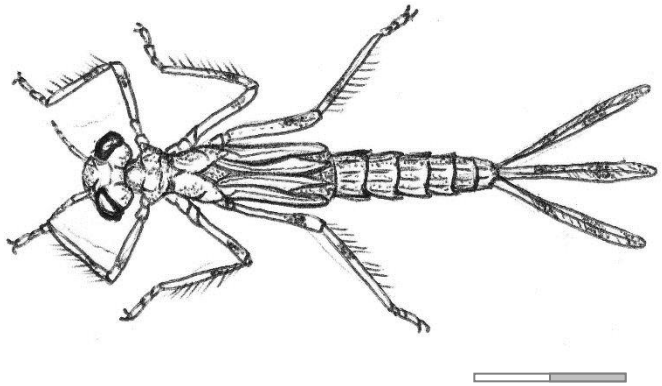
Caudal lamellae elongated into tips?

Yes



white-legged damselfly (*Platycnemis pennipes,* Platycnemididae), 20 mm.

No



other damselflies (Zygoptera), 10-20 mm.

Finish

Back

Larvae of damselflies: (Odonata) with wing pads, three flat caudal lamellae, labium in form of extendable mask

Branchings of the veins vertical?

Yes

Lestidae

No

Coenagrionidae

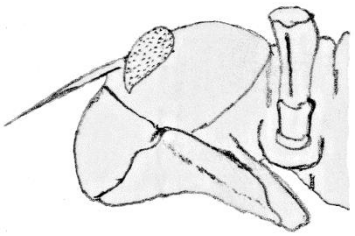
Finish

Back

Abdomen rounded and flattened (> 4mm wide), ended with anal pyramid: dragonflies (Anisoptera), 60 mm.

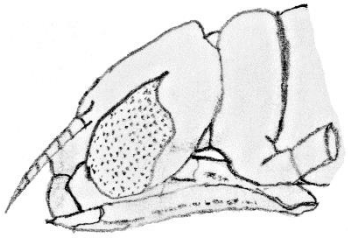
Mask spoon-like?

Yes



Corduliidae, Cordulegastridae, Libellulidae

No



Aeshnidae, Gomphidae

Finish

Back

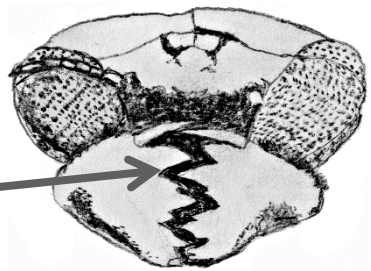
Abdomen rounded and flattened (> 4mm wide), ended with anal pyramid: dragonflies (Anisoptera), 60 mm.

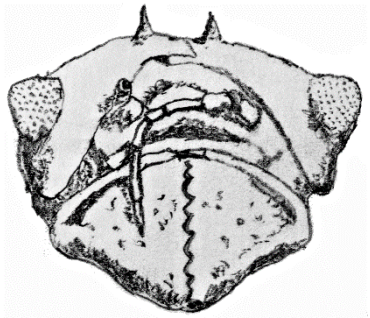
Labial teeth irregular ?

Yes

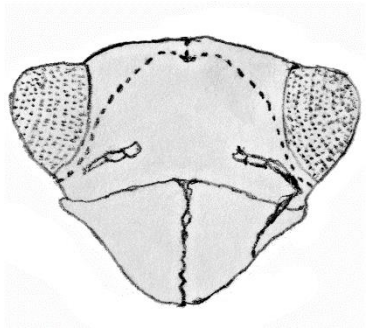
No

Cordulegastridae





Corduliidae
+ *Libellula depressa*



Libellulidae

Finish

Back

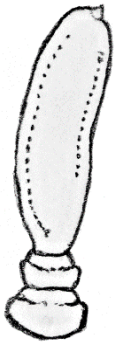
Abdomen rounded and flattened (> 4mm wide), ended with anal pyramid: dragonflies (Anisoptera), 60 mm.

Antennae with 6-7 segments?

Yes

Aeshnidae

No



Gomphidae

Finish

Back

With six legs; without wing pads; with *or* without cases: caddishflies, Plannipenia and beetle larvae

With two hooks on anal prolegs (= unjointed appendages *and* abdomen *always* soft. Some can bear cases (Figs. 1-7): Trichoptera larvae
(Maximal size up to m30 mm, if they are larger, than they belong to beetles)

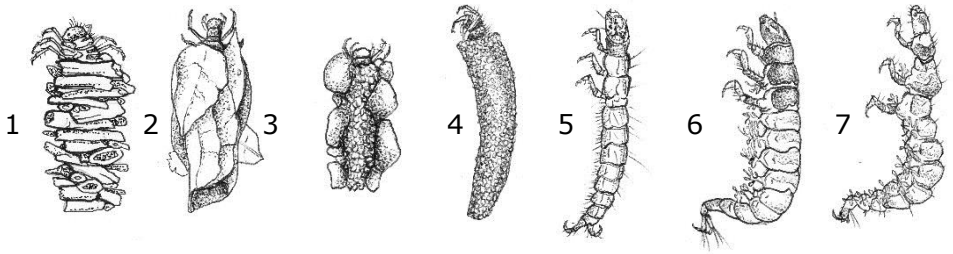


Fig. 1: Limnephilidae, Fig. 2: *Glyphotaelius* sp. (Limnephilidae), Fig.. 3: Goeridae, Fig.4: *Sericostoma* sp. (Sericostomatidae), Fig. 5: Polycentropodidae, Fig. 6: *Hydropsyche* sp. (Hydropsychidae), Fig. 7: *Rhyacophila* sp. (Rhyacophilidae)

Abdomen often sclerotised or hard; sometimes with appendages, without cases: larvae of beetles (Coleoptera), (Plannipenia) and **alderflies (Megaloptera)** (Figs. 8-12).

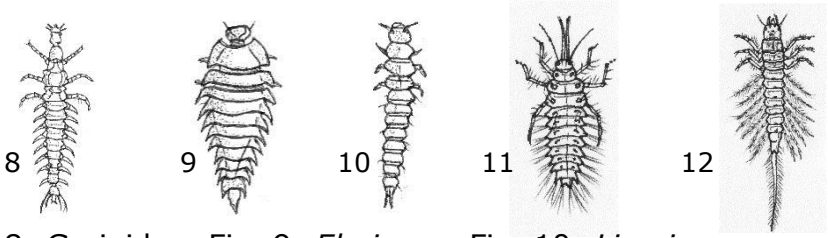


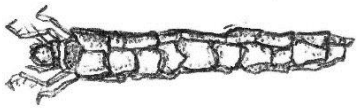
Fig. 8: Gyrinidae, Fig. 9: *Elmis* sp., Fig. 10: *Limnius* sp., Fig. 11: Plannipenia, Fig. 12: Megaloptera

Finish

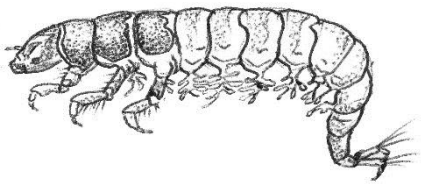
Back

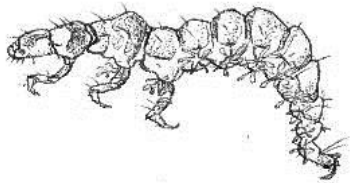
Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with *or* without cases

With cases from various material (sand, gravel, wood…)



Without cases



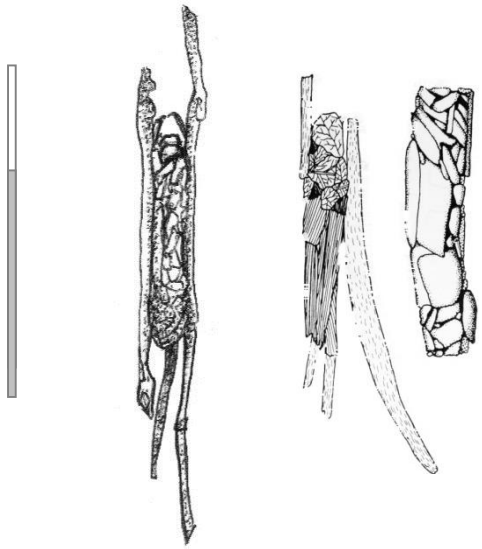


Finish

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Cases in front and on back strengthen and extended with two long twigs (markedly overhung the case): Limnephilidae, case without twigs 30 - 40 mm.



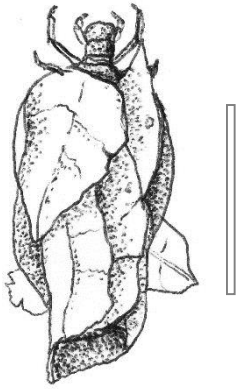
Other shape of case

Finish

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Case made from several large brown pieces of leaves stick together:
Glyphotaelius sp. (Limnephilidae), 25 mm.



Other shape of case

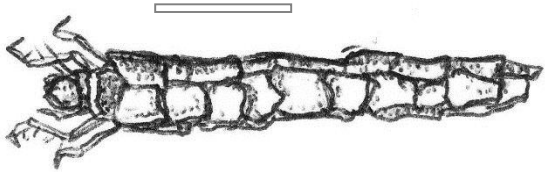
Finish

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

More or less square cross-section cases made from small pieces of leaves

or



Lepidostomatidae, square cross-section case from leaves.

Brachycentidae, case seems to be striped, 20 mm.

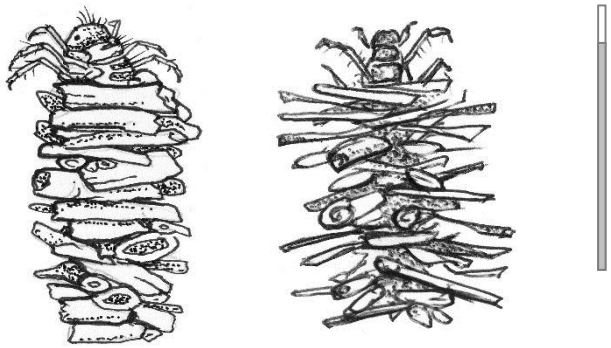
Other shape of case

Finish

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Cases from fragments of plants or pieces of wood (seems to be interlarded with them): *Limnephilus* sp., (Limnephilidae), 30-35 mm.



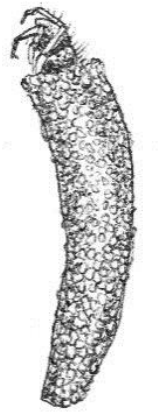
Other shape of case

Finish

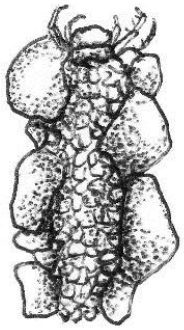
Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Smooth cases made from one kind of material



Cases made from various material

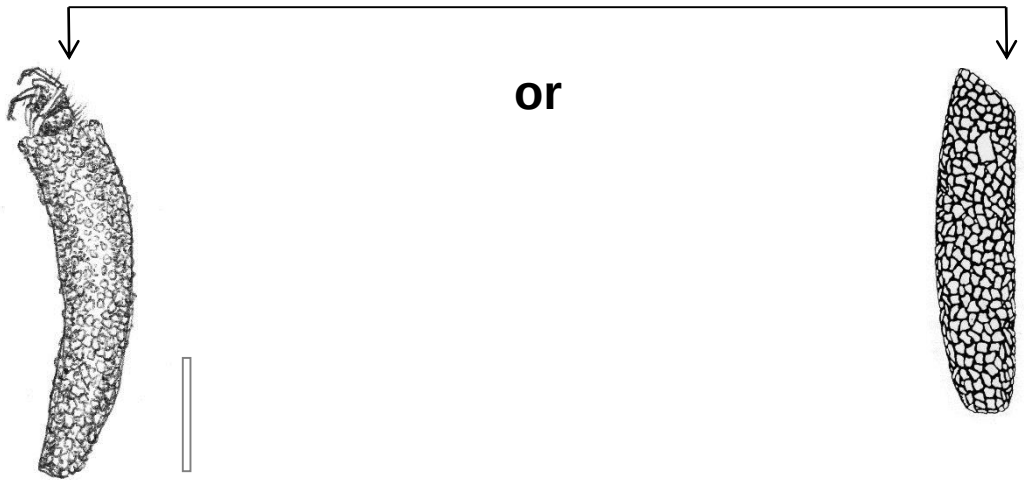


Finish

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Case is like curved tube made from almost same sized small stones



or

Sericostoma sp.,
(fam. Sericostomatidae) 15 mm.
Odontocerum albicorne, 16-8 mm.
(fam. Odontoceridae)
sand grains being attached to an inner silk tube

Potamophylax sp.,
(fam. Limnephilidae), case skew on the top and less curved as *Sericostoma.*

Finish

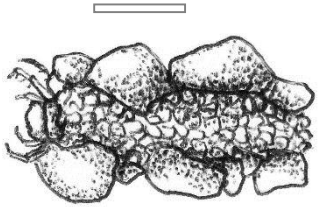
Other shape of case: larvae of other caddisflies

Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Not smooth cases, but rough, uneven, made from various material.

Cases made from small stones (sand), *only* beside sides larger stones overhang: larvae of family Goeridae, such as *Silo* sp., 10 – 12 mm.



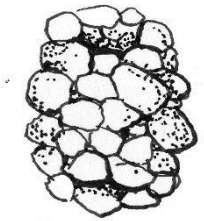
Other shape of case

Finish

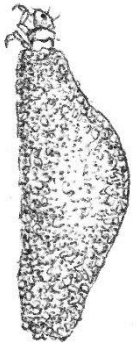
Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, with cases

Case convex on the upper part and flat on the bottom part, often found on rocks: Glossosomatidae, 10 mm.



Other shape of case: Hydroptilidae, cases made from sand grains and organic matter, compressed from the sides, 5 mm.

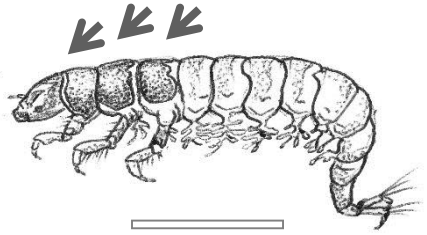


Finish

Back

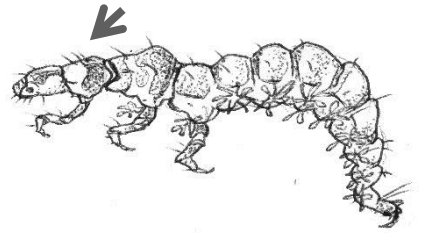
Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, without cases

All three thoracic segments covered with sclerotized gills



Hydropsyche sp.(fam. Hydropsychidae), 20 mm,nota brown
Ecnomus tenellus (fam. Ecnomidae), 8-10 mm, nota yellow

Only the first thoracic segment covered with sclerotized plate



Finish

Back

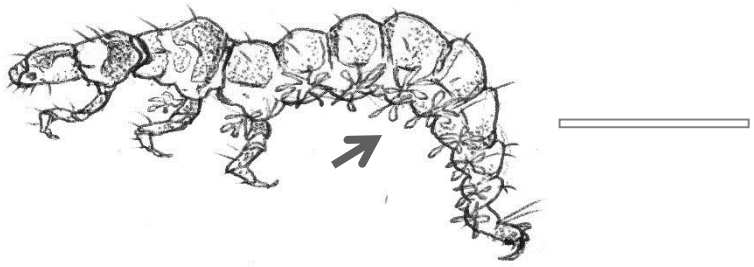
Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, without cases

With branched gills on ventral side of abdomen:

Rhyacophila sp. (fam. Rhyacophilidae)

25 mm, in streams with swift current, body often of green pale colour.

Rhyacophila tristis without gills.



Without branched gills on ventral side of abdomen

Finish

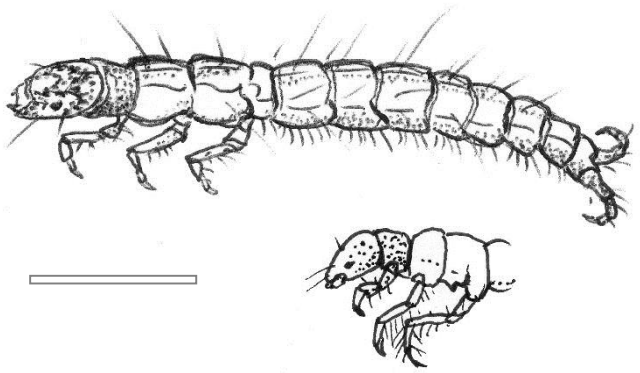
Back

Larvae of caddisflies (Trichoptera): without wing pads; with anal prolegs, without cases

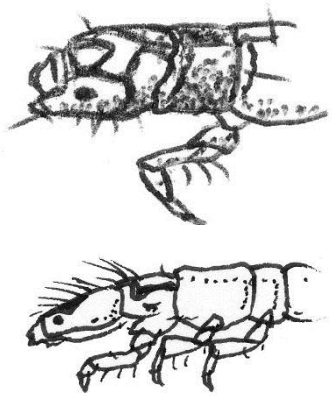
Head uniformly coloured and without pattern: Philopotamidae.

Head with colour pattern

or



Polycentropodidae, 22 mm, spotted head.



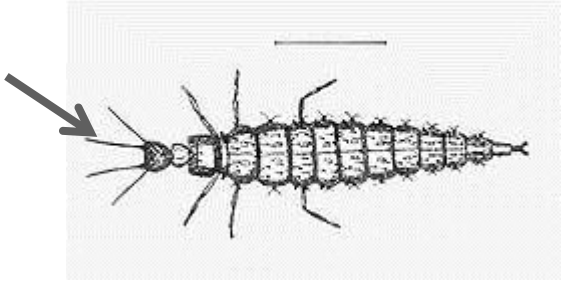
Psychomyiidae, head with pattern.

Finish

Back

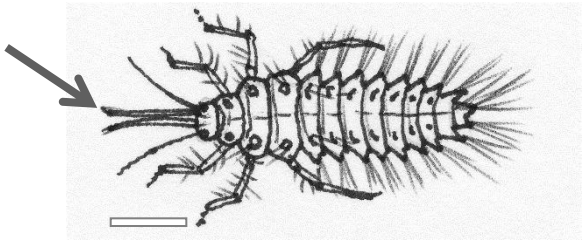
Abdomen often sclerotised or hard; sometimes with appendages: larvae of beetles (Coleoptera), Plannipenia and alderflies (Megaloptera)

Mandibles transformed into two slender rods held together: Plannipenia



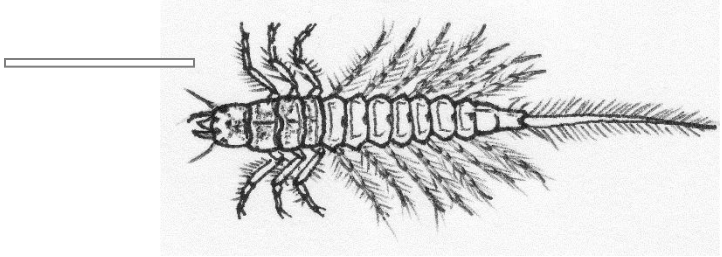
spongillaflies (Sisyridae)

or



osmylids (Osmylidae). Body covered with plenty of long hairs.

With *one* long hairy tail filament and segmented (constricted part) lateral tracheal gills: alderflies (Megaloptera). Large visible jaws, tracheal appendages segmented.



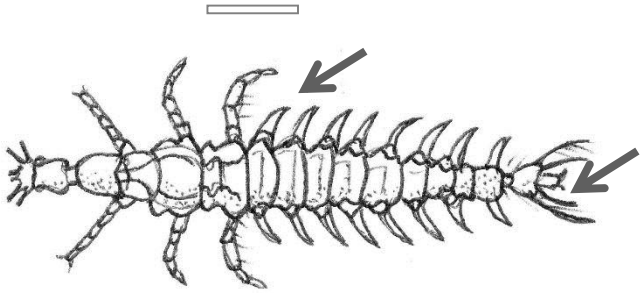
Without transformed mandibles and without plenty of long hairs: larvae of beetles (Coleoptera).

Finish

Back

Beetle larvae (Coleoptera): Without wing pads; the whole body (also the abdomen) sclerotized (harden)

With lateral abdominal tracheal gills and two pairs of hooks on the terminal abdominal segment



larvae of whirligig beetles (Gyrinidae),12 mm

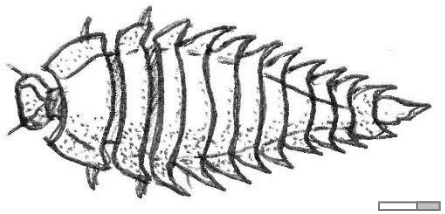
Without lateral gills and two pairs of hooks

Finish

Back

Beetle larvae (Coleoptera): Without wing pads; the whole body (also the abdomen) sclerotized (harden)

Body markedly flattened: larvae of riffle beetle (Elmidae), 3 - 16 mm (usually not larger than 8 mm)



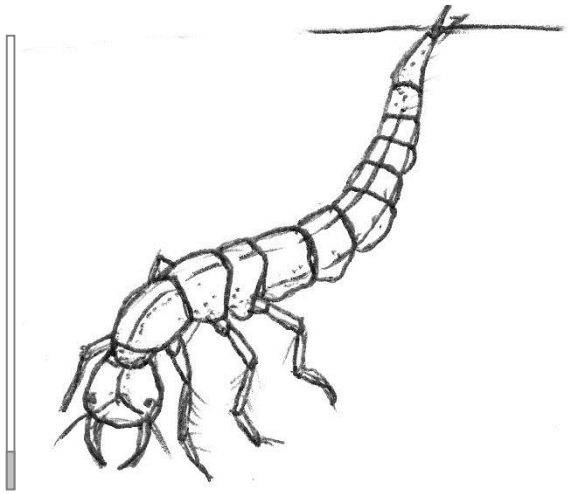
Body not flattened

Finish

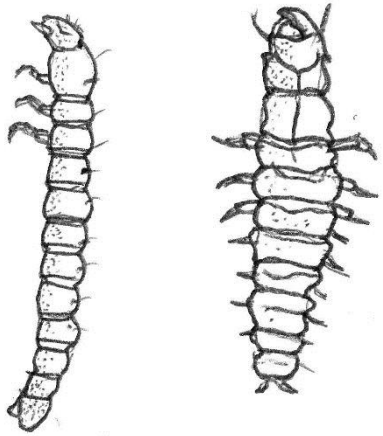
Back

Beetle larvae (Coleoptera): Without wing pads; the whole body (also the abdomen) sclerotized (harden)

Species usually larger than 20 mm and with a pair of long, large pincers: larvae of predaceous diving beetles (Dytiscidae), 5 - 60 mm, often hanging on water surface.



Smaller species without pair of long, large pincers.



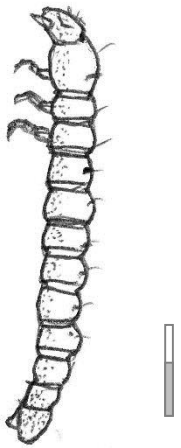
Finish

Back

Beetle larvae (Coleoptera): Without wing pads; the whole body (also the abdomen) sclerotized (harden)

Body cylindrical, with reddish colour

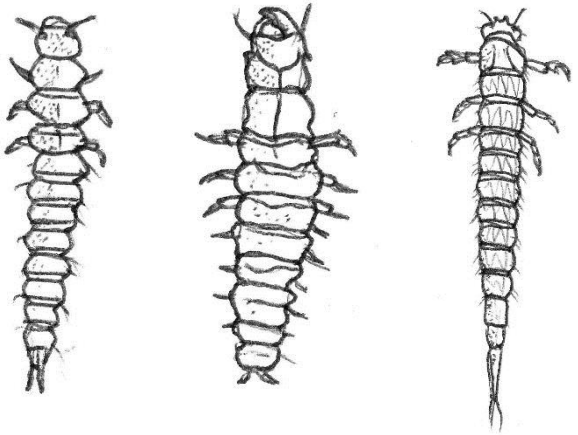
Yes



Larvae of long-toed water beetles:

Limnius sp. (Elmidae), 7.5 – 8.5 mm.

No



Other beetle larvae

Finish

Back

More than three pairs of legs; always well visible: Crustaceans and Arachnids

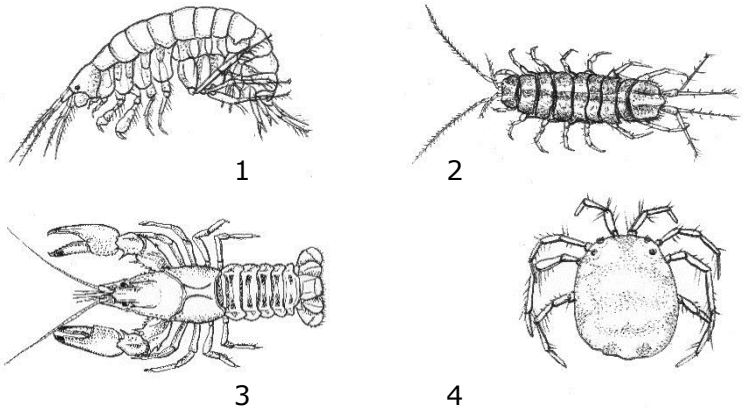
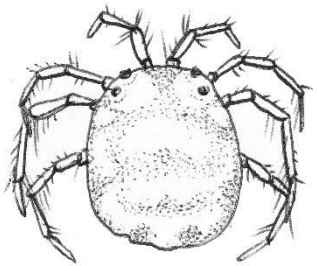


Fig. 1: freshwater shrimp (scud) , Fig. 2: waterlouse (aquatic sowbug), Fig. 3: crayfish, Fig. 4: water mite

Four pairs of legs: Arachnids (Arachnida)



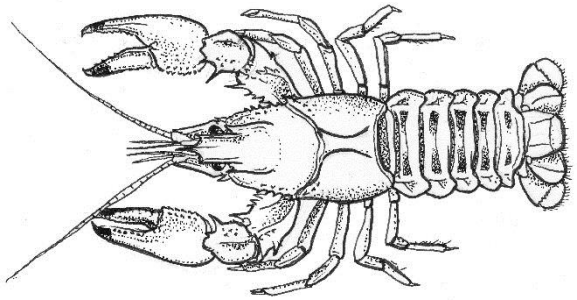
More than four pairs of legs: Crustaceans (Crustacea)

Finish

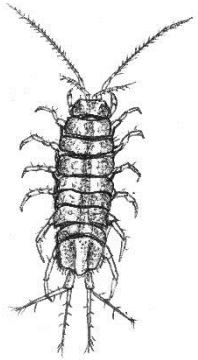
Back

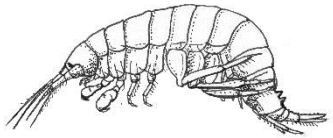
Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, with or without claws

With two big claws



Without two big claws



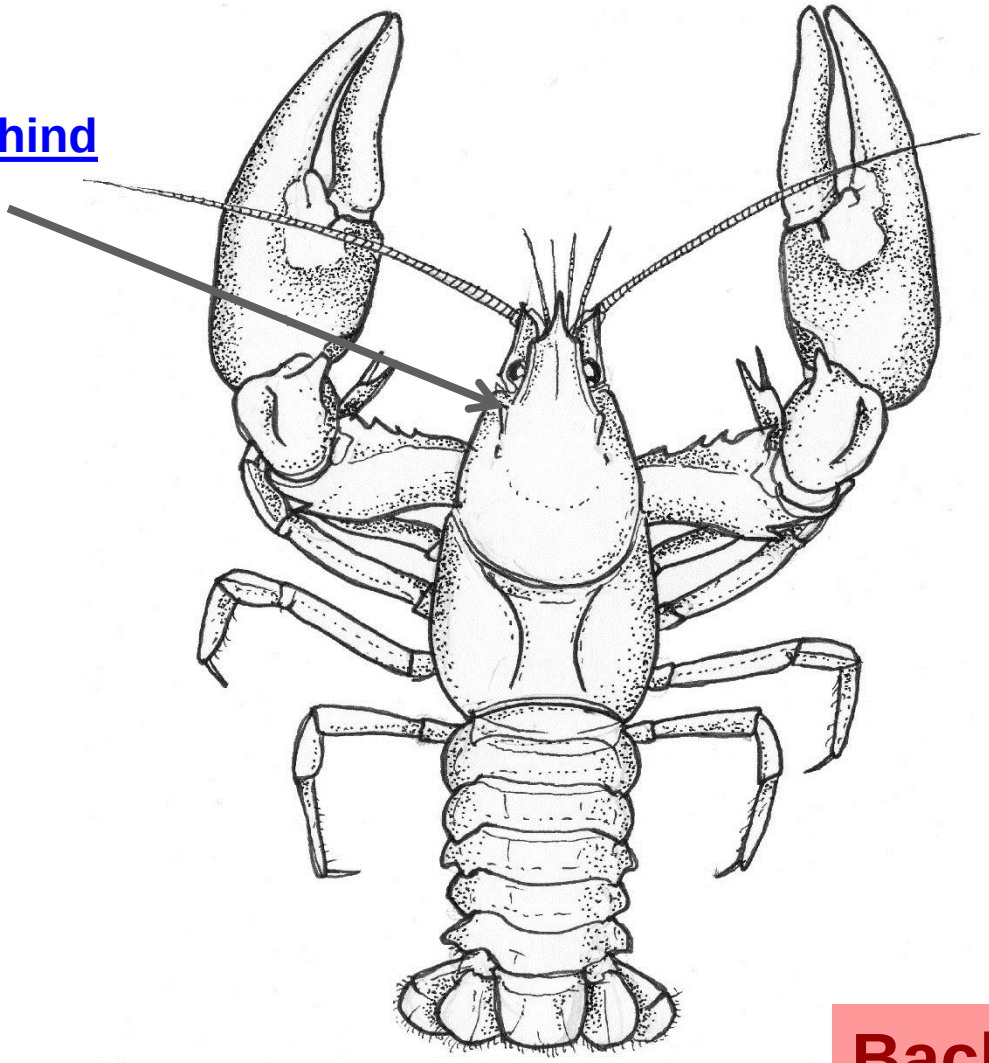


Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, with claws

Two pairs of protuberances behind the eyes (postorbital ridges)



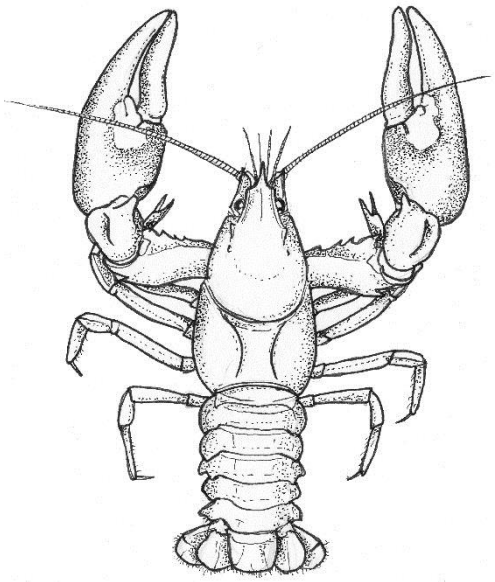
Without postorbital ridges

Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, with claws

Joint of claws with white or blue-green spot: Signal crayfish (*Pacifastacus leniusculus*), 160 mm.



Joint of claws without white or blue-green spot

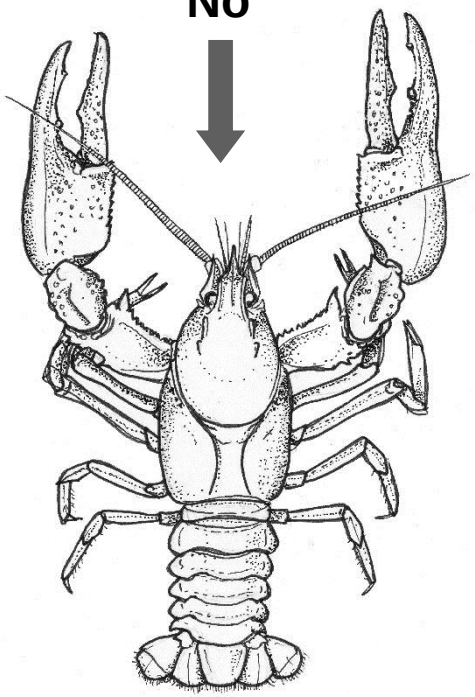
Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, with claws

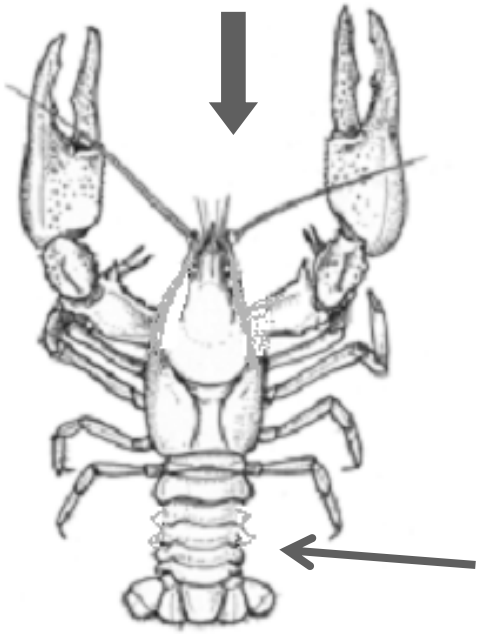
Spikes on the sides of abdominal segments

No



Noble crayfish (*Astacus astacus*), (Astacidae) 180 mm.

Yes

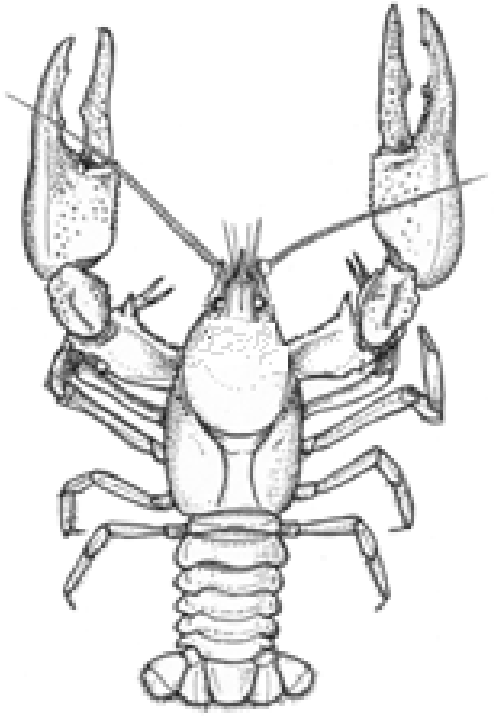


Narrow-clawed crayfish (*Astacus leptodactylus*), (Astacidae) 180 mm.

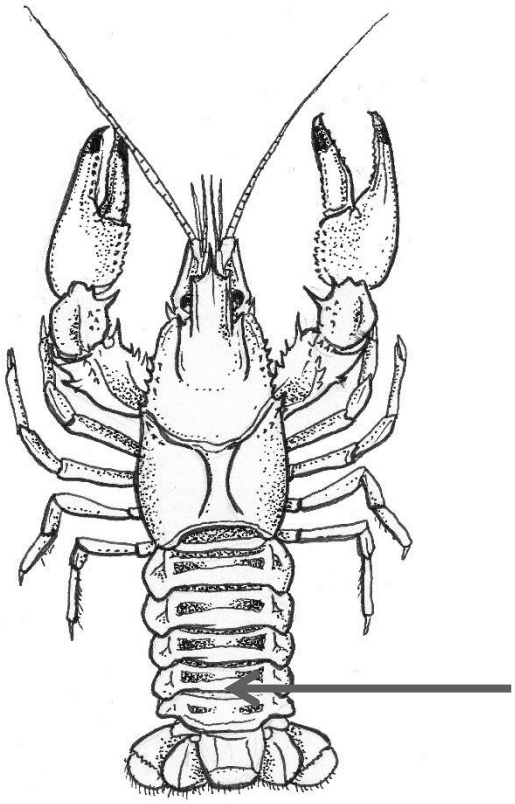
Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, with claws



Stream crayfish (*Austropotamobius torrentium*), (Astacidae) 100 mm.



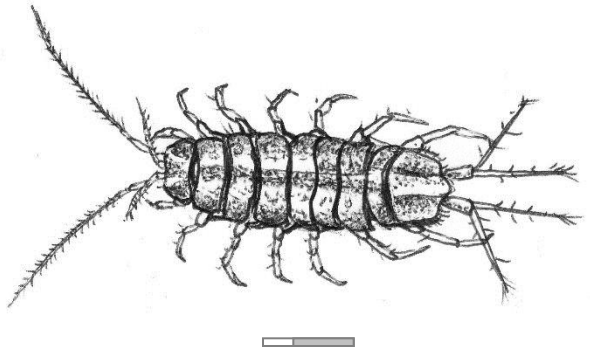
Spinycheek crayfish (*Orconectes limosus*), rusty transverse lines on the dorsal part of abdomen, 130 mm.

Finish

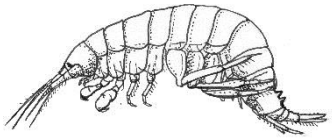
Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, without claws

Body dorsoventrally flattened: aquatic sow bug (*Asellus aquaticus*),(Asellidae) 8-12 mm.



Body not flattened

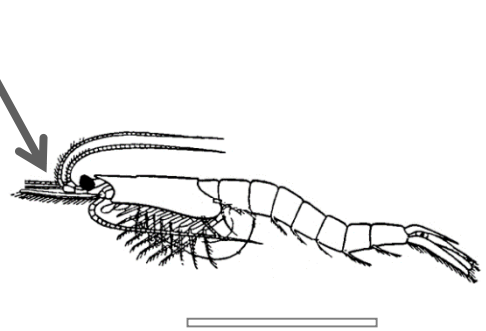


Finish

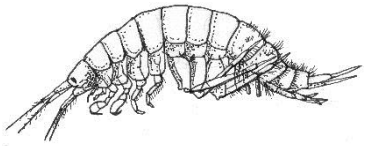
Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, without claws

Front part of the head forms rostrum:
Limnomysis benedeni, (Misidaceae), invasive species.



Front part of the head does not forms rostrum

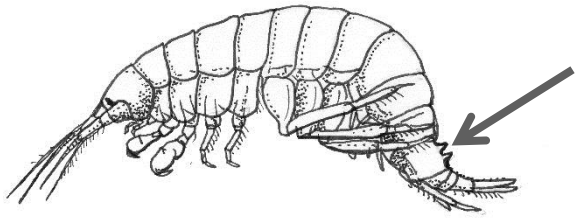


Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, without claws

Strong developed swellings with prickles on the dorsal part of the last abdominal segments (urosom): freshwater shrimp *Dikerogammarus* sp., (Gammaridae) in lowland streams.



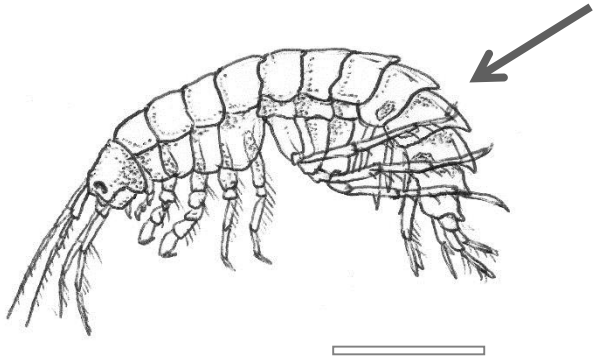
Without swellings on urosom

Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, without claws

Caudal abdominal segments with spikes:
freshwater shrimp *Gammarus roeseli* (Gammaridae).



Without spikes on abdominal segments

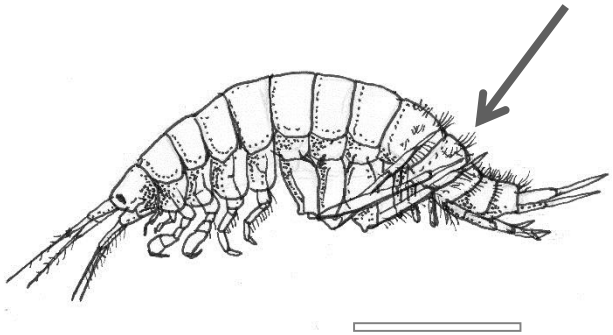
Finish

Back

Crustaceans (Crustacea); more than four pairs of legs; two pairs of antennae, without claws

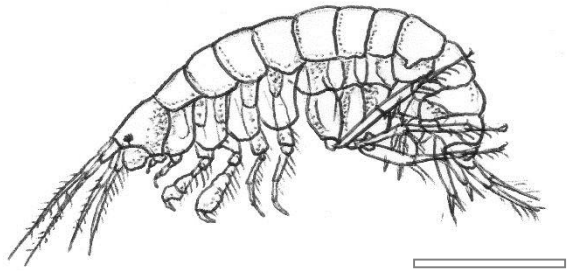
The last segments thickly haired, or uropods with curled hairs

Yes



Freshwater shrimp *Echinogammarus* sp., (Gammaridae) eyes sometimes shiny red, rare in lowlands.

No

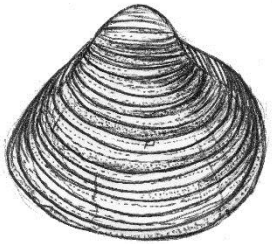


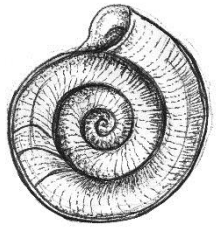
Freshwater shrimp *Gammarus* sp., (Gammaridae) 20 mm.

Finish

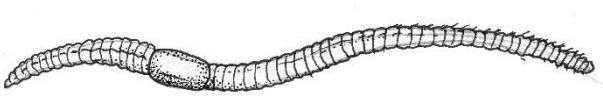
Back

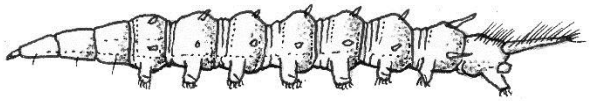
With a shell





Without a shell



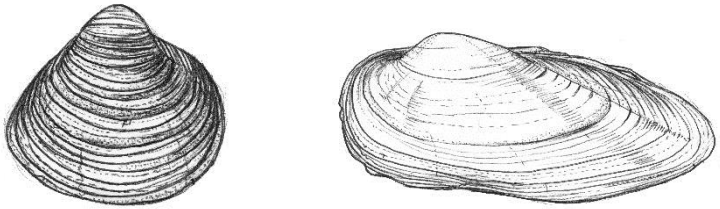


Finish

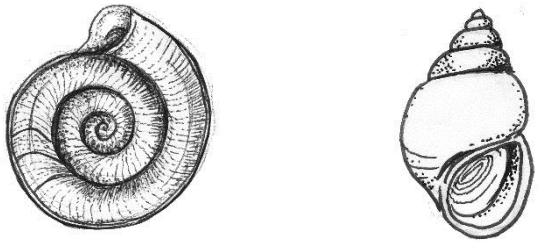
Back

Bivalves and snails

Shell consists of two pieces (valves): **bivalves (Bivalvia)**



Shell consists of one piece: **snails (Gastropoda)**

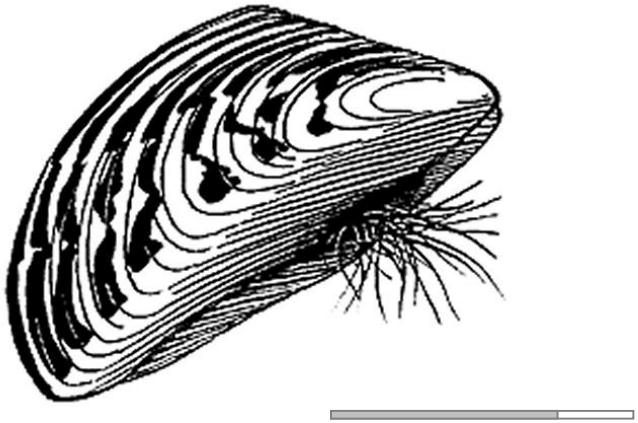


Finish

Back

Bivalves (Bivalvia): shell consist of two pieces (valves)

Three-edged shell, often found in clumps: zebra mussel *Dreissena polymorpha*, (Dreissenidae) 30-40 mm, striped zig-zag pattern.



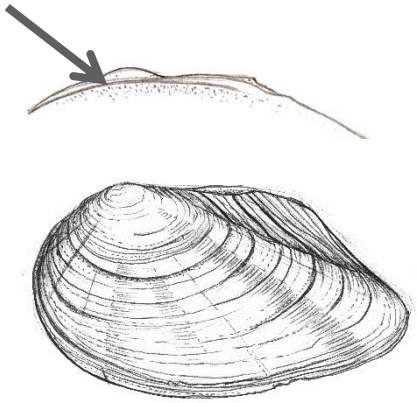
Other shape of shell

Finish

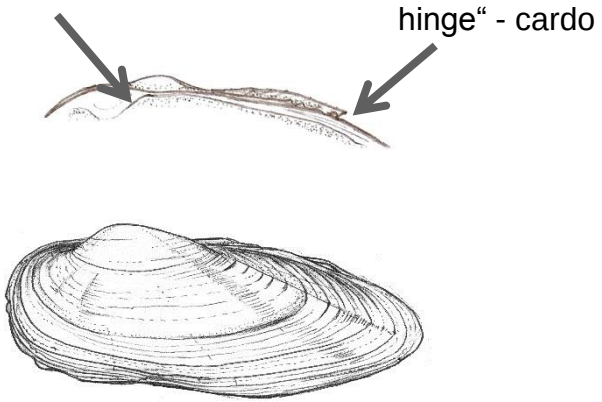
Back

Bivalves(Bivalvia): shell consist of two pieces (valves)

Shell bigger than 40 mm, shape of the shell ligulate



or



Mussel *Anodonta* sp., (Unionidae)
shell thin, without „hinge“ - cardo, 200 mm.

Mussel *Unio* sp., (Unionidae)
shell thick-walled, with „hinge“ – cardo, 70 - 100 mm.

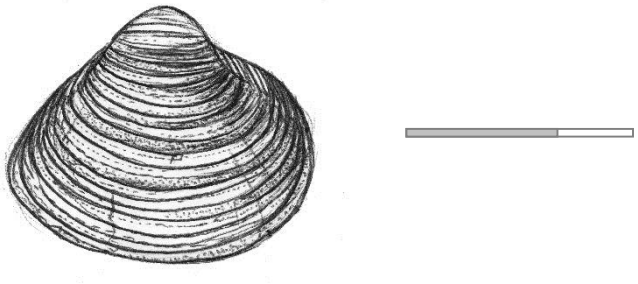
Shell more circular

Finish

Back

Bivalves(Bivalvia): shell consist of two pieces (valves)

Shell ribbed and very solid: clam *Corbicula* sp.
(Corbiculidae) 20-30 mm.



Finer surface of the shell

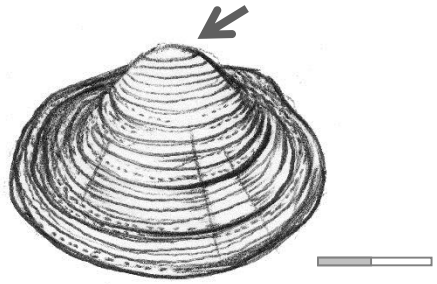
Finish

Back

Bivalves (Bivalvia): shell consist of two pieces (valves)

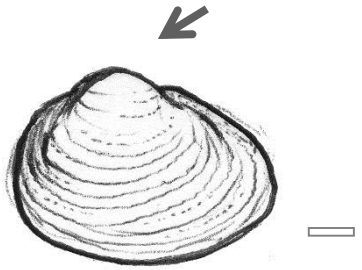
Apex of the shell lies in the middle

Yes



Clam *Sphaerium* sp., (Sphaeridae)
7-15 mm.

No



Clam *Pisidium* sp., (Sphaeridae)
smaller than 7 mm, apex not lying in the middle.

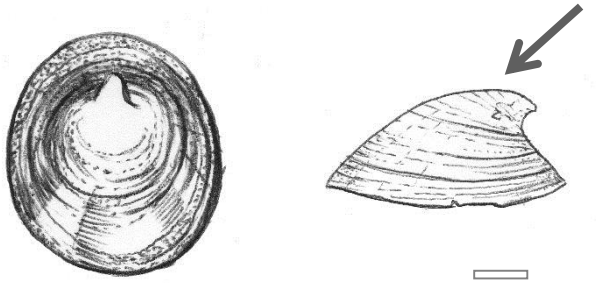
Finish

Back

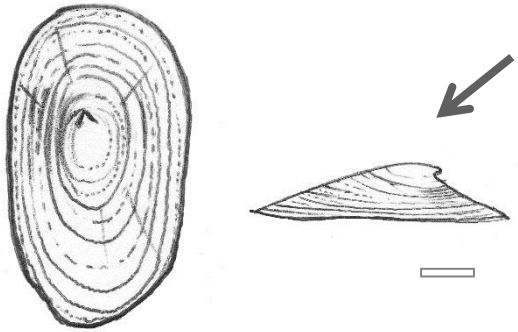
Snails and limpets (Gastropoda): Shells cap-shape

Shell cap-shape

or



River limpet (*Ancylus fluviatilis*),
(Planorbidae) height of the shell 5-7 mm.



Lake limpet (*Acroloxus lacustris*),
(Acroloxidae) shell flat, 7 mm.

Other shape of shell

Finish

Back

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

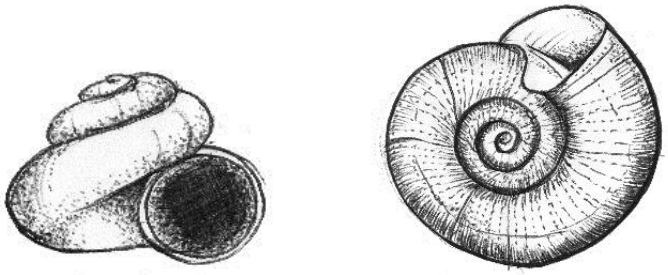
Semioval shells, with typical patern:
river nerite (*Theodoxus fluviatilis*),
(Neritidae) 10 mm.

Other shape of shell

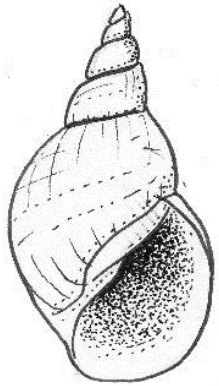
Finish **Back**

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

Plain, flat shell



Shell elevated

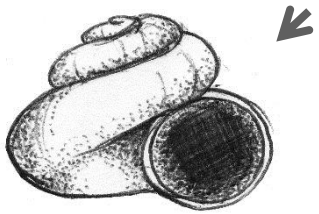


Finish

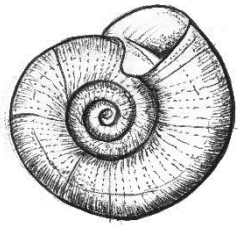
Back

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

Shell aperture round: valve snail (*Valvata* sp.), (Valvatidae) 5 mm.



Shell aperture not round

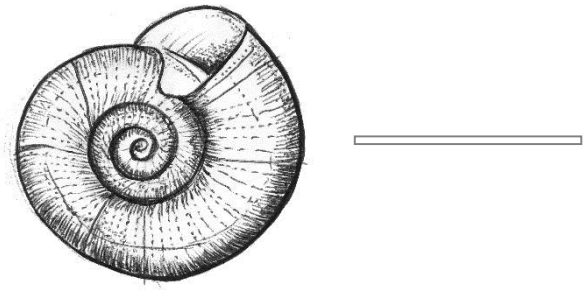


Finish

Back

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

Shell wider than 20 mm: great ramshorn (*Planorbarius corneus*), (Planorbidae)
30 mm.



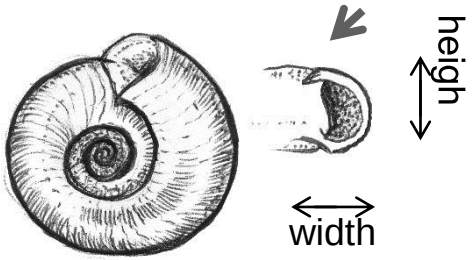
Smaller shell

Finish **Back**

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

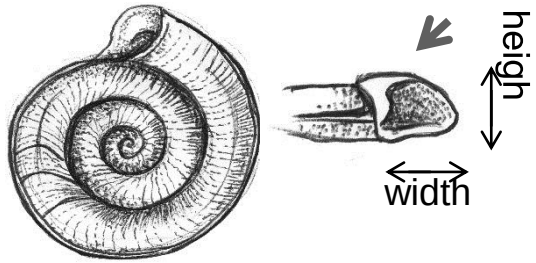
Shell aperture higher than its width

Yes



Twisted ramshorn snail (*Bathyomphalus contortus*), (Planorbidae)
5-6 mm wide, 7-8 thin whorls

No



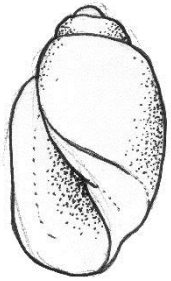
Planorbidae, Shell from 6 to 18 mm, shell aperture wider, or the same size as its height

Finish

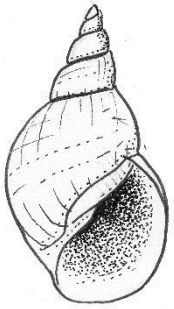
Back

Snails and limpets (Gastropoda): Shells with whorls; sinistral or dextral, shell mouth with or without operculum

Shell sinistral



Shell dextral

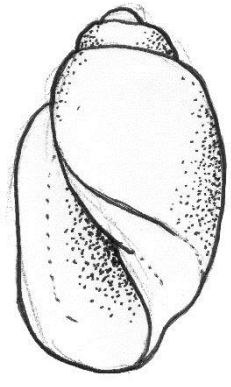


Finish

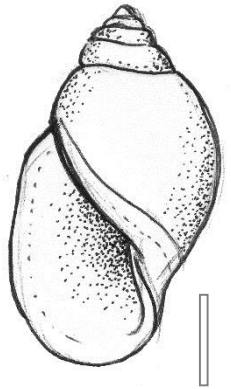
Back

Snails and limpets (Gastropoda): Shells sinistral; shell mouth without operculum

or



Bladder snail *Physa fontinalis*, (Physidae)
Round apex, 4 whorls.



Bladder snail *Physella acuta*, (Physidae)
Peak apex, 6 whorls.

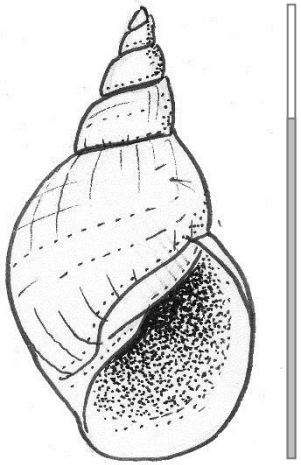
Finish

Back

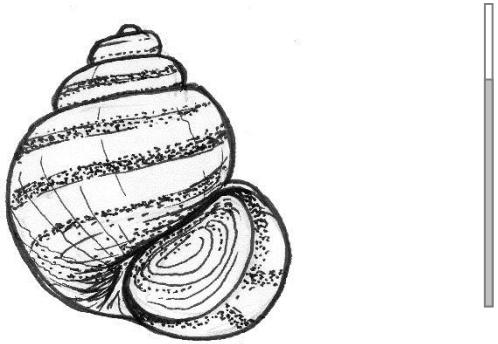
Snails and limpets (Gastropoda): Shells dextral; shell mouth with or without operculum

Shells higher than 30 mm

or



Great pond snail (*Lymnea stagnalis*),
(Lymnaeidae)
long peak shell.



River snail *Viviparus* sp.,
(Viviparidae)
stubby shell.

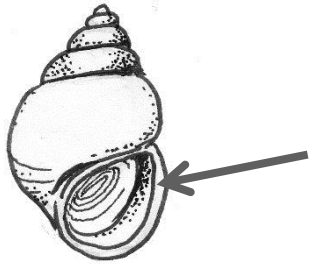
Shells not higher than 30 mm

Finish

Back

Snails and limpets (Gastropoda): Shells dextral; shell mouth with or without operculum

With operculum



Without operculum

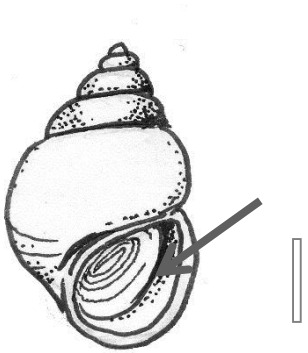
Finish

Back

Snails and limpets (Gastropoda): Shells dextral; shell mouth with operculum

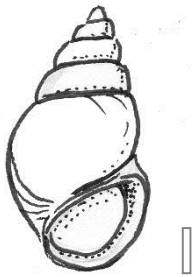
Operculum with concentric lines

Yes



Mud bithynia (*Bithynia tentaculata*), (Bithyniidae) height 8-11 mm.

No



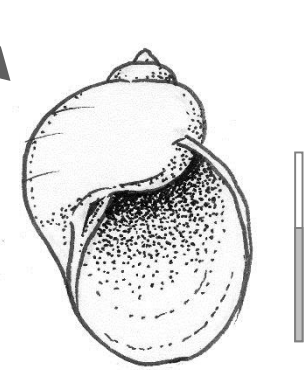
Jenkin's spire shell (*Potamopyrgus antipodarum*), (Hydrobiidae) height 4-6 mm.

Finish

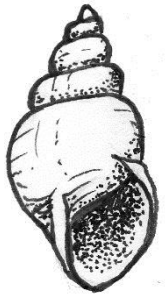
Back

Snails and limpets (Gastropoda): Shells dextral; shell mouth without operculum

The last whorl large : pond snail (*Radix* sp.)
(Lymnaeidae) 15-25 mm.



The last whorl not large

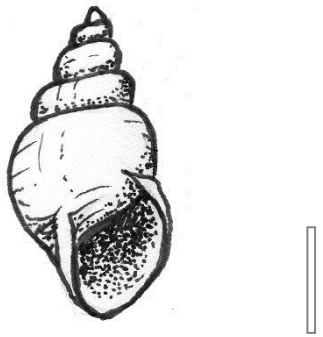


Finish

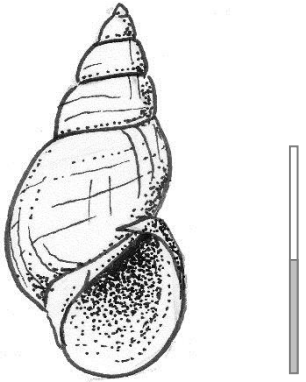
Back

Snails and limpets (Gastropoda): Shells dextral; shell mouth without operculum

Adult individuals up to 15 mm: dwarf pond snail (*Galba truncatula),* (Lymnaeidae)



Adult individuals bigger than 15 mm: pond snail (*Stagnicola* sp.), (Lymnaeidae) 15-30 mm.



Finish

Back

Animals without visible legs: larvae of true flies; hairworms, worms, leeches and flatworms

Wormlike body without appendices; some have two suckers; moving by sliding (Figs. 1-3): worms (Oligochaeta) and **leeches (Hirudinea)**

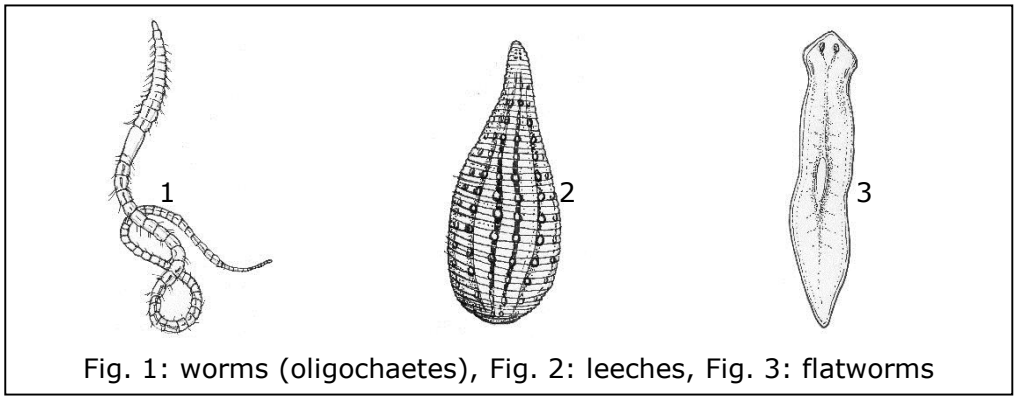


Fig. 1: worms (oligochaetes), Fig. 2: leeches, Fig. 3: flatworms

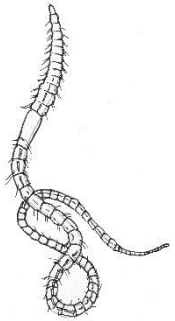
Body with appendices; without two suckers: true flies (Diptera)

Finish

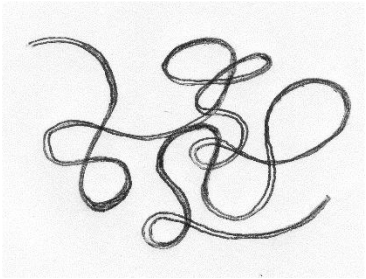
Back

Animals without visible legs: hairworms / worms / leeches and flatworms

Body segmented



Body not segmented

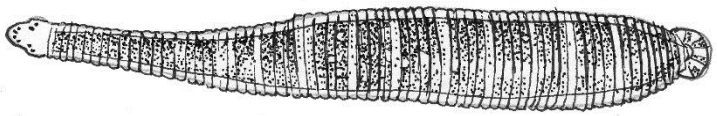


Finish

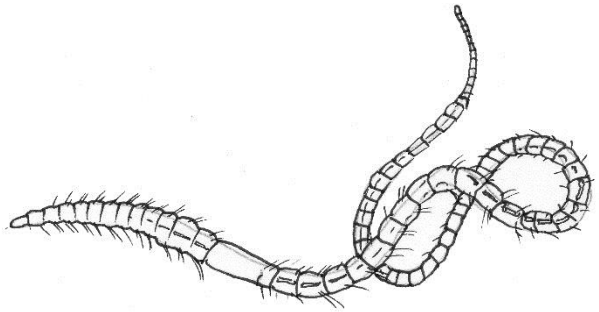
Back

Animals without visible legs: Leeches (Hirudinea) and worms (Oligochaeta)

Segmented contractive body with worm-like shape, two suckers are presented: **leeches (Hirudinida)**. Always with two suckers, one on the frontal and one on the caudal end of the body.



Body without suckers. Snaking, some are blood coloured: **worms (Oligochaeta)**.



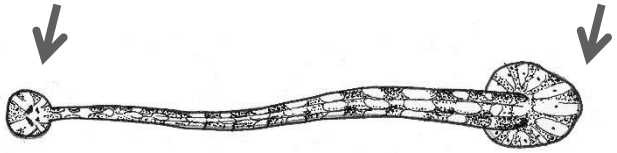
Finish

Back

Leeches (Hirudinida): Segmented contractive body with worm-like shape, two suckers are presented

With two big suckers on cranial and caudal end of the body, body length up to 50 mm:

family Piscicolidae - fish leech (*Piscicola geometra)*



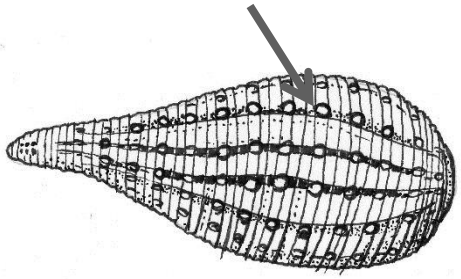
Suckers smaller, body length shorter

Finish

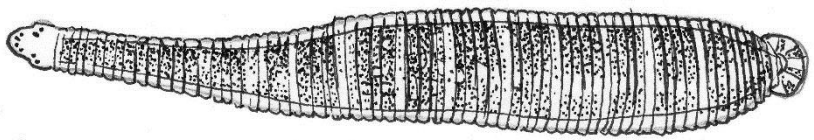
Back

Leeches (Hirudinea): Segmented contractive body with worm-like shape, two suckers are presented

Elipsoid body shape, brightly colored dorsal site with one to six longitudinal stripes or without pigmentation; on dorsal site bright papillas or spots are also presented: family Glossiphoniidae, 20-30 mm



Typical worm-like body shape, dark colored dorsal surface with black spots or black paramedial stripes or without black pigmentation : family Erpobdellidae, 60 mm.



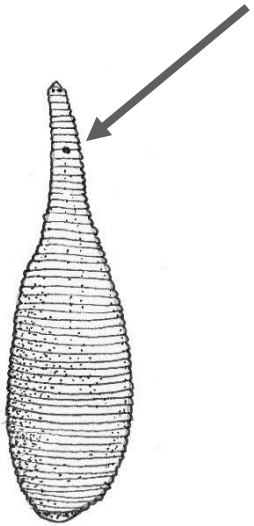
Finish

Back

Pijavice (Hirudinea): Segmented contractive body with worm-like shape, two suckers are presented

With bright cuticular plate

Yes

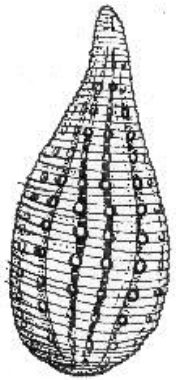


Helobdella stagnalis
5 -11 mm

No

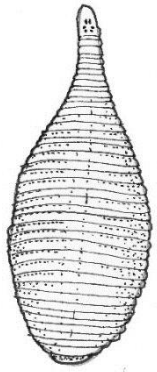
With dark pigmentation

Yes



Glossiphonia sp.
9,5 mm

No



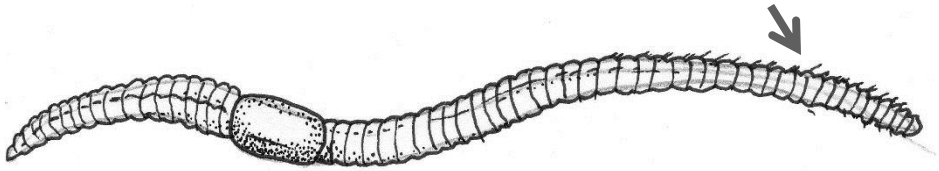
Alboglossiphonia sp
9,5 mm

Finish

Back

Worms (Oligochaeta): segmented body

Square body on intersection, thick 2-4 mm: family Lumbricidae
Eiseniella tetraedra, 30-50 mm.



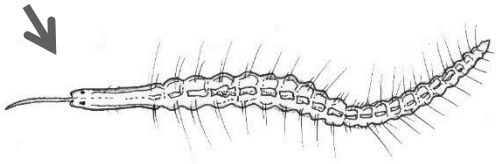
Other shape of body

Finish

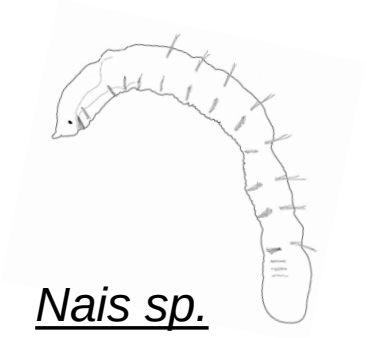
Back

Worms (Oligochaeta): segmented body

Thinner, length 6-10 mm, transparent, with tactile filament in the front and with two eye spots: family Naididae



Stylaria lacustris
18 mm



Nais sp.
5 - 10 mm

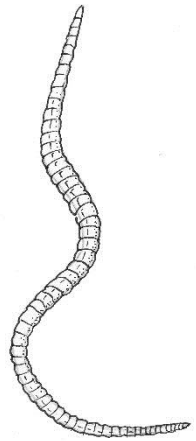
Larger, without tactile filaments on the head and without eye spot

Finish **Back**

Worms (Oligochaeta): segmented body

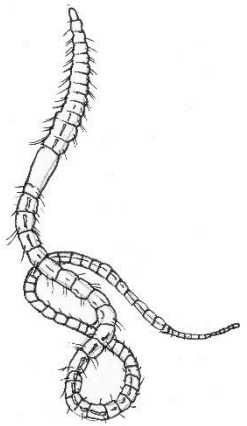
Crawling or flagellar swimming

Yes



Lumbriculidae, 100 mm.

No



Tubificinae, They can not swim, often in colonies in the mud, they straighten up when disturbed

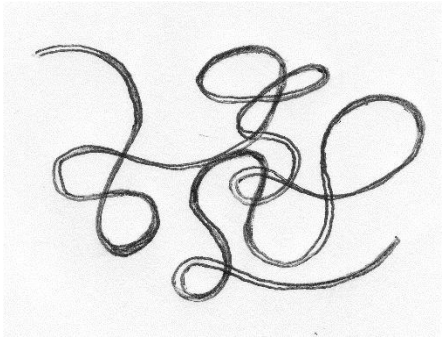
85 mm.

Finish

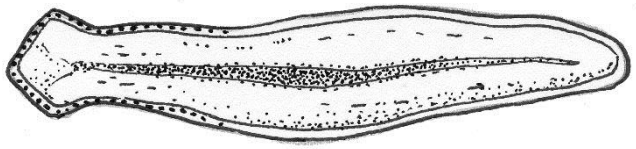
Back

Without legs; worm-like *non* segmented body: hairworms (Nematomorpha) and flatworms (Turbellaria)

Hair-like body (max. 2 mm width), round on cross-section: hairworms (Nematomorpha). Body often hard and long – up to 80 cm.



Flattened body, wider than 2 mm, crawling on the substrate: Flatworms (Turbellaria).

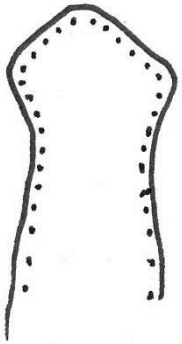


Finish

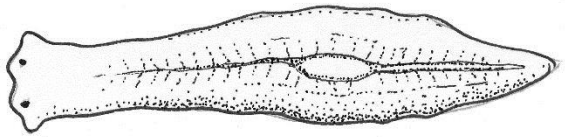
Back

Flatworms (Turbellaria) flatened body; crawling

With many small eye spots positioned in one row around the head



Without many small eye spots, eye spots lying in the pale area



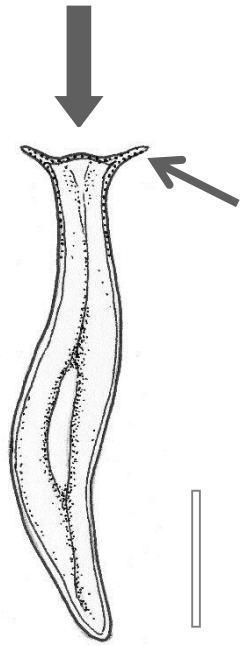
Finish

Back

Flatworms (Turbellaria) flatened body; crawling

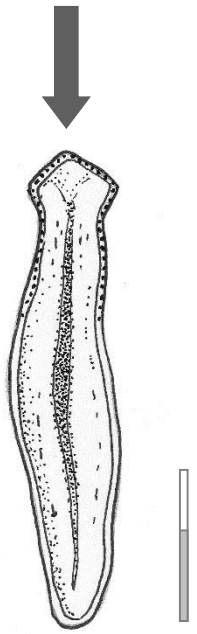
With tentacles

Yes



Flatworm *Polycelis felina* *(Planariidae)*, 18 mm.

No



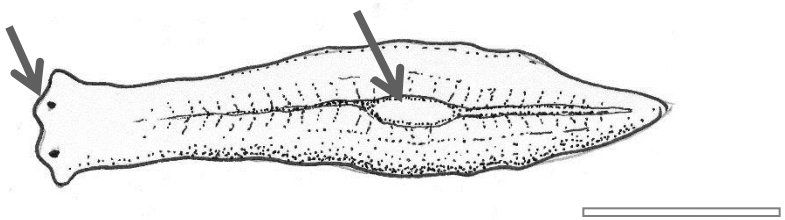
Flatworm *Polycelis* sp. *(Planariidae)*, 12 – 20 mm.

Finish

Back

Flatworms (Turbellaria) flatened body; crawling

Milk-white, with visible or transparent gut, the front edge of the head undulate: flatworm *Dendrocoelum lacteum (Dendrocoelidae)*, 26 mm.



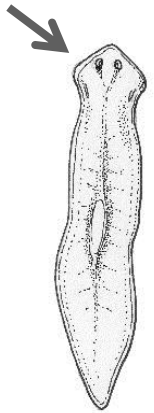
Other colour of body

Finish

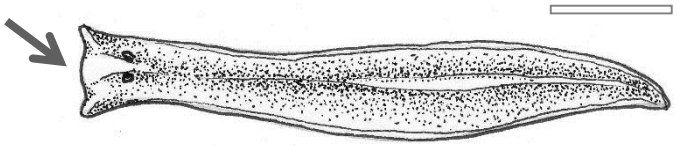
Back

Flatworms (Turbellaria) flatened body; crawling

Triangular anterior end of body (visible when moving)



Rounded anterior end of body: *Crenobia alpina (Planariidae)*, distance of the eye spots to the anterior end of the head at least three times longer than distance between eye spots. Short auricles.16 mm.



Finish

Back

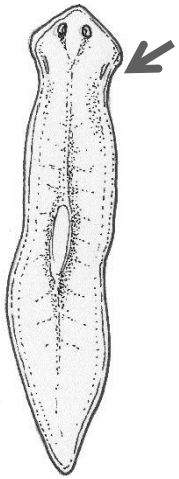
Flatworms (Turbellaria) flatened body; crawling

With auricles on the sides of the head?
Visible when moving

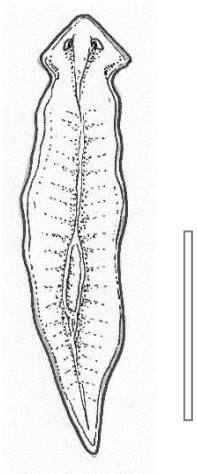
Yes

or

No



Flatworm *Dugesia tigrina* *(Dugesiidae)*. Body brown spotted, marginal part transparent.



Flatworm *Dugesia gonocephala* *(Dugesiidae).* Body not transparent, brown or black unicoloured.

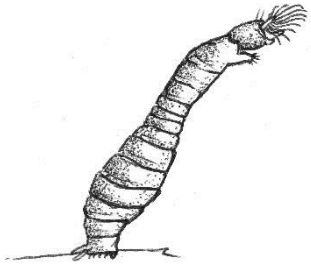
Other flatworms

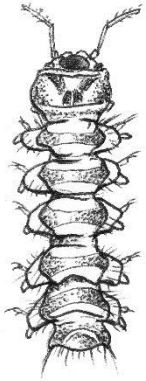
Finish

Back

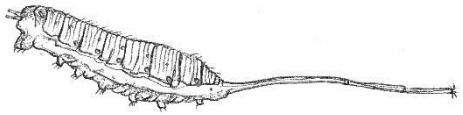
Larvae of true flies (Diptera): Without wing pads; with or without head capsule, some with prolegs (pseudopods)

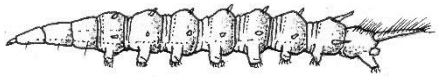
Distinct head completely separated from body, head capsule well sclerotised





Head more or less reduced, head capsule often missing, head partially or completely retracted into thorax



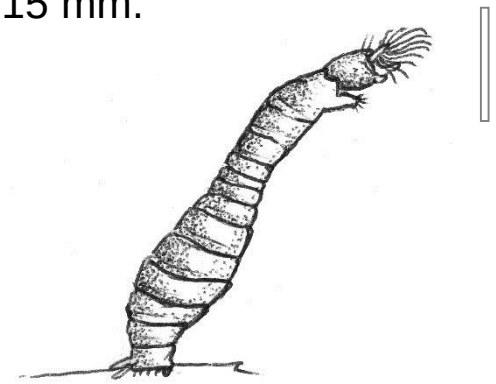


Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

The end of the abdomen swollen, larvae attached on the rocks and plants: Larvae of blackflies (Simuliidae). Head with pair of fans used for filtration, 15 mm.



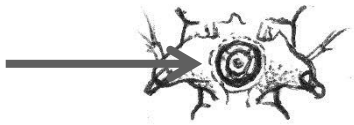
Other shape of body

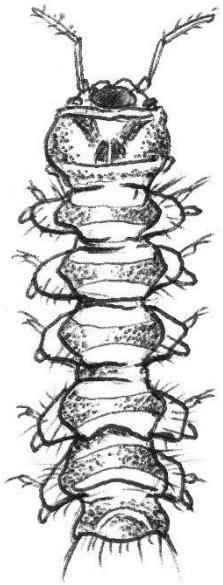
Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Ventral abdominal suckers: Net-winged midges (Blephariceridae). Only in turbulent streams with swift current, -9 mm.





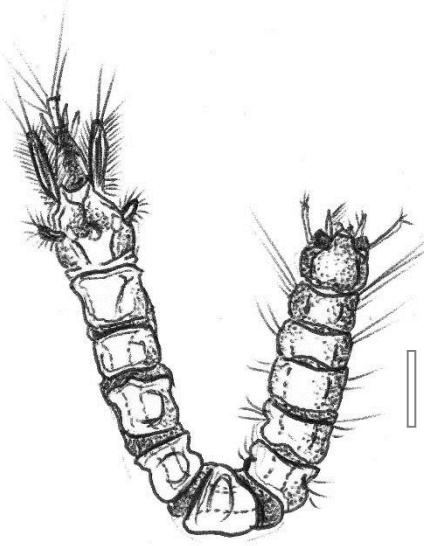
Without ventral abdominal suckers

Finish

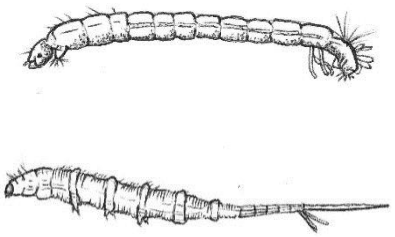
Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Found on the water surface, body U-shaped:
Larvae of dixid midges - *Dixa* sp. (Dixidae), 10 mm.



Body not U-shaped



Finish

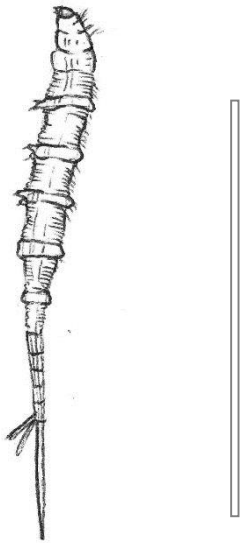
Back

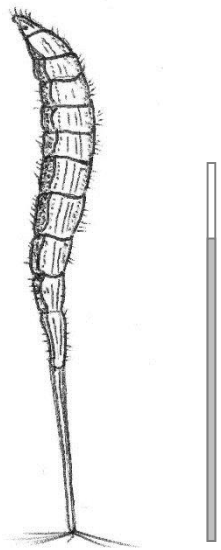
Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Body > 30 mm

or

[Body < 30 mm](#)





Larvae of fantom crane flies (Ptychopteridae), rounded soft body, pale colour, with retractable breathing tube, 70 mm.

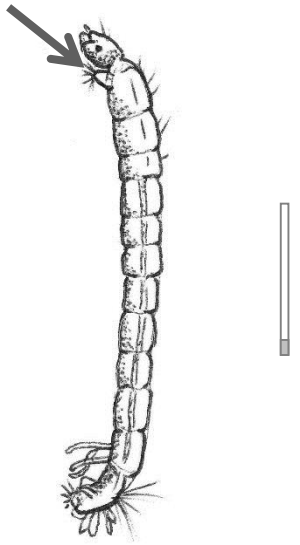
Larvae of soldier flies (Stratiomyidae), flattened and firm body, grey-green colour, with breathing tube, 40-50 mm.

Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Jerky movements when swimming, prolegs on the segment next to head: larvae of non-biting midges (Chironomidae). If the body is red coloured, than it is noted as „red midge“, 2-20 mm.



Snaking, without prolegs

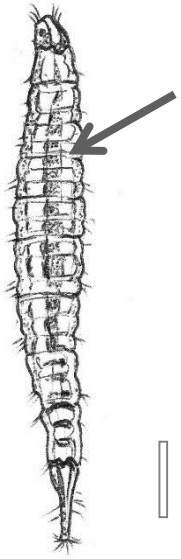
Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

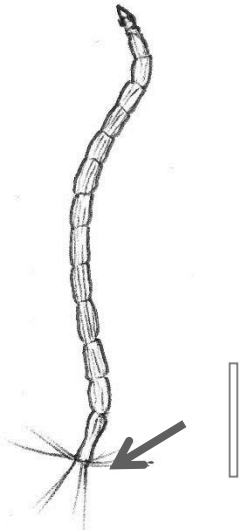
Abdomen on dorsal site with stripe of sclerised gills

Yes



Larvae of moth flies (Psychodidae), 10 mm.

No



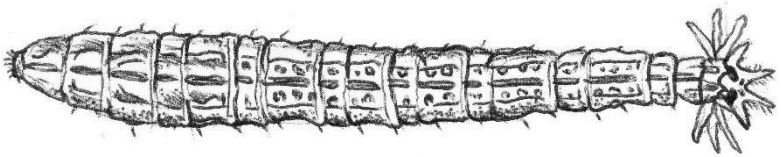
Larvae of biting midges (Ceratopogonidae). Last abodminal segment with long setae, 15 mm.

Finish

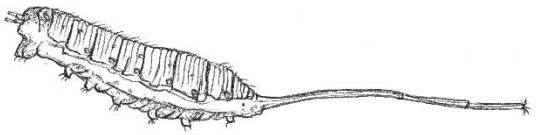
Back

Larvae of true flies (Diptera): Without wing pads; with or without head capsule, some with prolegs (pseudopods)

Head capsule clerotised, partially retracted into thorax



Head reduced, head capsule can be missing

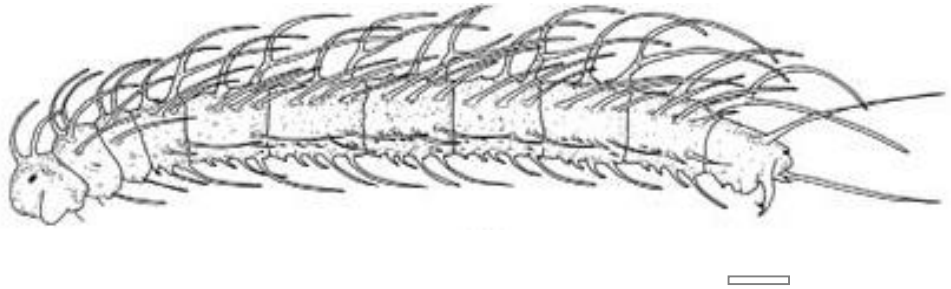


Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Larvae with long appendages on body segments: Cylindrotomidae.



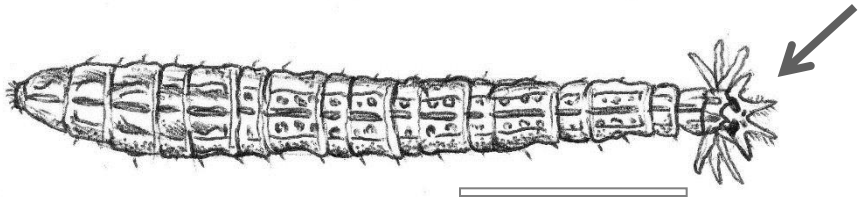
Larvae without long appendages on body segments

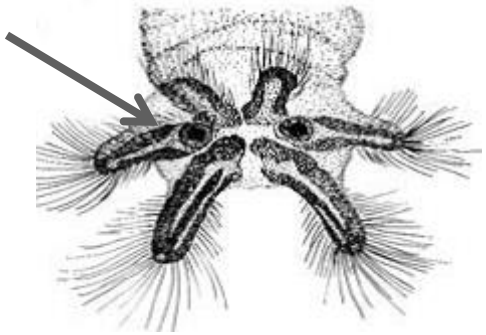
Finish

Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

With 6 lobes at the end of the abdomen, body length 30-50 mm: larvae of crane flies tipule (Tipulidae). Two spiracles (stigmata) surrounded by lobes, 30 mm.





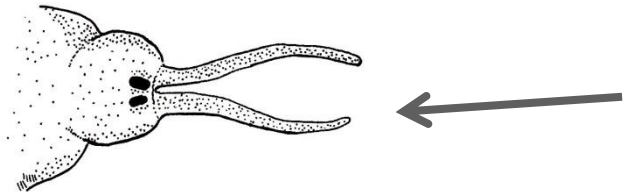
Without lobes or at most 5 lobes at the end of the abdomen.

Finish

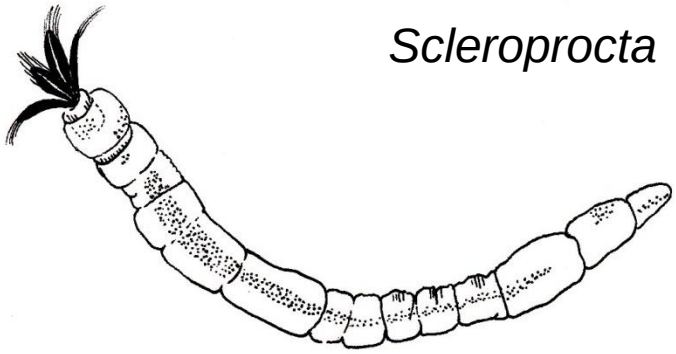
Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

With two obvious, cylindrical and hairless posterior lobes



Up to 5 lobes. If two lobes, than they are flattened with a thick tuft of hair:
Limoniidae except *Antocha vitripennis*



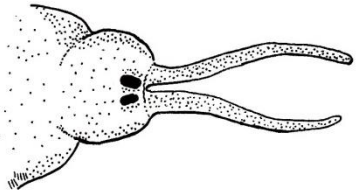
Scleroprocta

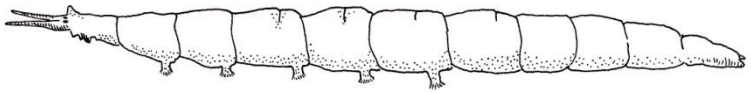
Finish

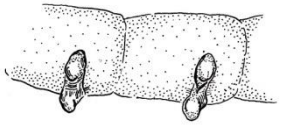
Back

Larvae of true flies (Diptera): Without wing pads; with head capsule, some with prolegs (pseudopods)

Spiracles present at the last abdominal segment: Pediciidae



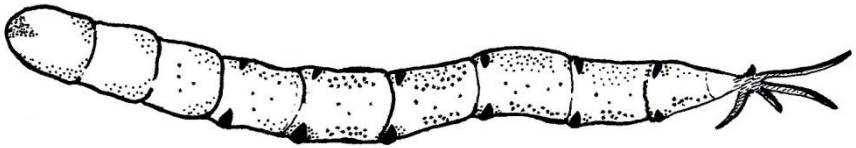




* ***Dicranota*** **sp. – with 5 paired pseudopodia**

Pedicia **sp. – with protuberances only on ventral side**

Spiracles absent: *Antocha vitripenis* (Limoniidae).



with protuberances on ventral and dorsal side

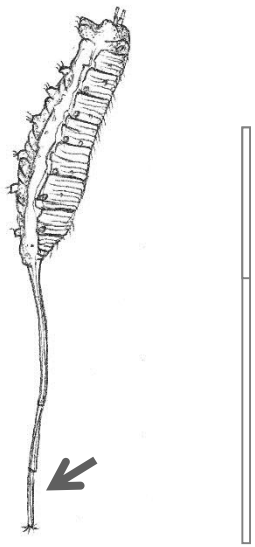
Finish

Back

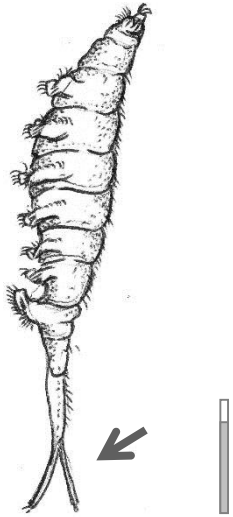
Larvae of true flies (Diptera): Without wing pads; without head capsule, some with prolegs (pseudopods)

With breathing tube. Breathing tube can be retracted (when disturbed), therefore longer time for observation without disturbing may be needed.

or



Larvae of flower flies (Syrphidae).
With long thin non-segmented berathing tube, 55 mm.



Larvae of shore flies (Ephydridae).
With short breathing tube forked at the end, 12-15 mm.

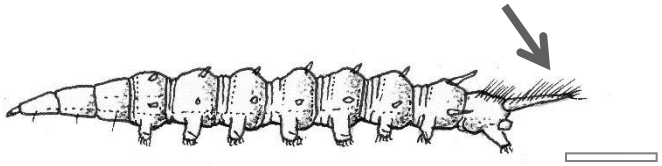
Without breathing tube.

Finish

Back

Larvae of true flies (Diptera): Without wing pads; without head capsule, some with prolegs (pseudopods)

With elongated appendices on the last abdominal segment: larvae of aquatic snipe flies (Athericidae).



Without elongated appendices

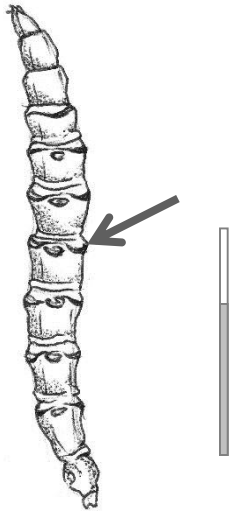
Finish

Back

Larvae of true flies (Diptera): Without wing pads; non segmented legs, without head capsule, some with prolegs (pseudopods)

Segments ringed by welts or prolegs

Yes



Larvae of horse flies (Tabanidae). Both ends of body tapering, 20-30 mm.

No

Larvae of other true flies.

Finish

Back

Benthic invertebrates and their habitats

Editors: Andrea Rúfusová, Pavel Beracko, Eva Bulánková

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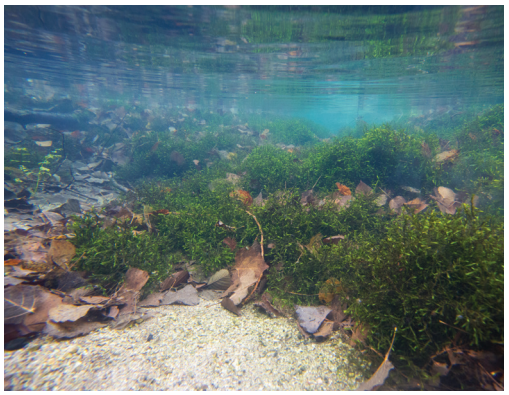
Reviewers: Prof. RNDr. Peter Bitušík, PhD., Mgr. Jan Špaček, PhD.

KEGA 015UK-4/2017

ISBN 978-80-223-4461-6



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ISBN 978-80-223-4462-3

Errata

Str. 8: Ephemeroptera: Oligoneuridae – Oligoneuriidae

Str. 9: Hemiptera: Mesovellidae - Mesoveliidae

Str. 14: vľavo, 2. odsek: *Orderix labiata – Radix labiata*

Str. 74 : Fig. 31A: Odonata (Anizoptera) – Anisoptera