Aquatic Insects of India-A fieldguide

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Ashoka Trust for Research in Ecology and Environment (ATREE)
Small Grants Programme

2007

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Acknowledgements: This field guide would not have achieved this shape without the support of ATREE through its Small Grants Programme to K.A.Subramaninan. Authors sincerely thank friends and colleagues for valuable comments and suggestions on earlier drafts of this guide. We sincerely thank the Karnataka and Kerala forest departments for their field support.

Citation: Subramanian, K.A. and Sivaramakrishnan, K.G. (2007). Aquatic Insects of India-A Field Guide. Ashoka Trust for Ecology and Environment (ATREE), Bangalore, India. 62pp.

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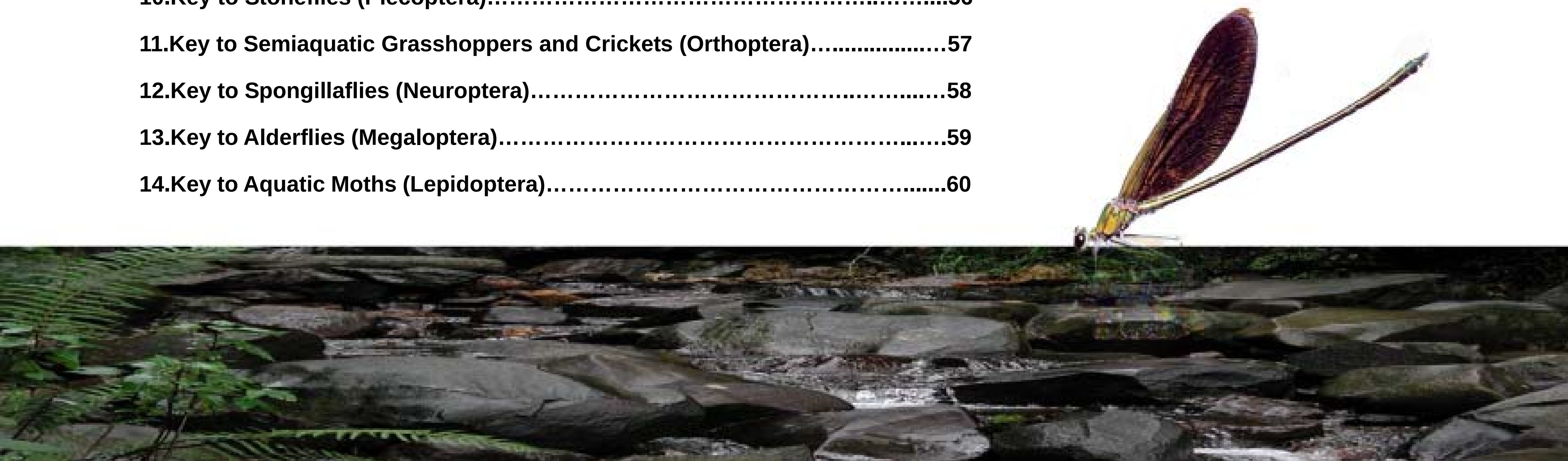

Freshwater Biodiversity

The inland freshwaters encompass a diverse array of ecosystems as varied as lakes and rivers, ponds and streams, temporary puddles, thermal springs and even pools of water that collect in the leaf axils of certain plants. This is a small fraction of world's water resource. Despite this, inland aquatic habitats show far more variety in their physical and chemical characteristics than marine habitats and contain a disproportionately high fraction of the world's biodiversity.

Inland water habitats can be classified into stagnant (*lentic)* and flowing (*lotic*)*.* They may also be classified into perennial or transient. Each of these has its own set of distinctive ecology and biological community. Lentic systems comprise lakes and ponds. Majority of large lakes are formed either by glacial or tectonic activity. Most of the glacial lakes are geologically young and were formed during Holocene, 11,500 years before present. Manmade lentic habitats such as irrigation tanks, ponds and reservoirs are historically recent and predominant landscape features in India.

Lotic system encompasses rivers and streams. A river system is essentially a linear body of water draining under the influence of gravity. Most of the river systems discharge into the sea and some into lakes. A few water courses in arid regions enter inland basins where no permanent lakes exist and disappear into the dry plains.

Large rivers such as Ganges and Brahmaputra cross over many degrees of latitude and traverse a wide range of climatic conditions. Variations in water flow and underlying geology also create a wide range of habitats, often within a short distance. Because of this change in habitats, different organisms are typically present in different parts of any given river system. Even though



The inland freshwaters encompass a diverse array of ecosystems as varied as lakes and rivers, ponds and streams, temporary puddles, thermal springs and even pools of water that collect in the leaf axils of certain plants.

rivers are physically very dynamic, large rivers rarely disappear, and there are indications that some of the large rivers are in existence for tens of millions of years. This is reflected in the fact that, all the taxonomic groups are found in running waters and some invertebrate taxa are exclusive or attain greatest diversity there.

Biodiversity at higher taxonomic levels such as Phylum, Class or Order in freshwater systems are much narrower than those in the terrestrial or marine systems. The overall number of species (species richness) is also low compared to marine and terrestrial groups. However, species richness in relation to habitat extent may be very high. For example, about 10, 000 (40%) of the 25,000 known fish species are freshwater forms. This high diversity of freshwater fishes relative to habitat extent is promoted by isolation between freshwater systems. The species richness in the freshwater systems increases towards the equator as in the case with terrestrial habitats. There are many more species in the tropical freshwater systems than in temperate regions, but in some specific groups such as freshwater crayfishes this trend appears to be reversed.

Animal species are far more diverse and numerous in inland waters than plants. Apart from fishes, invertebrates form an important group. The important groups include sponges, flatworms, mollusks, polychaete worms, oligochaete worms, crustaceans, insects and numerous parasitic species in various groups. As on land, insects are the most diverse group of organisms in inland waters. Unlike terrestrial faunas, where beetles (Order Coleoptera) are the most diverse, flies (Order Diptera) appear to be by far, the most abundant group in inland waters.

Animal species are far more diverse and numerous in inland waters than plants. As on land, insects are the most diverse group of organisms in inland waters.

Introduction to aquatic insects

Insects are the most diverse group of organisms in freshwater. Estimates on the global number of aquatic insect species derived from the fauna of North America, Australia and Europe is about 45,000, of this about 5,000 species are estimated to inhabit inland wetlands of India. Aquatic insects of inland wetlands comprise some well-known groups like mayflies (Ephemeroptera), dragonflies (Odonata) and caddiesflies (Trichoptera). Aquatic insects such as dragonflies and damselflies (Odonata) are very colourful and prominent insects of the wetlands. Different functional feeding groups of aquatic insects such as shredders, scrapers, filter feeders and predators are important links in nutrient recycling. Aquatic insects primarily process wood and leaf litter reaching the wetland from the surrounding landscape. Nutrients processed by aquatic insects are further degraded into absorbable form by fungal and bacterial action. Plants in the riparian zone absorb this nutrient soup transported through the wetlands. In addition to this significant ecosystem function, aquatic insects are also a primary source of food for fishes and amphibians.

Evolution of aquatic insects: The origin of aquatic insects has been controversial and doubts still exist as to whether or not insects are primarily or secondarily adapted to aquatic environments. The widely accepted view is that the ancestor of myriapod-insect group (millipedes, centipedes, and insects) lived in leaf litter areas along margins of pond like environment. Primitive insects of this moist environment were ancestors of aquatic insects. Their fossil record extends to Devonian in the Paleozoic era. Among extend aquatic insects, dragonflies (Odonata) and mayflies (Ephemeroptera) are the most primitive and only insects with aquatic juveniles. The understanding of aquatic insect evolution and phylogeny has been hampered by poor fossil record of freshwater animals.

Living aquatic insects represent 12 insect orders.

About 5,000 species of insects are estimated to inhabit inland wetlands of India. Dragonflies (Odonata) and mayflies (Ephemeroptera) are the most primitive insects.

Of this, larvae of species of mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), stoneflies (Plecoptera), alderflies (Megaloptera), lacewings (Neuroptera), flies (Diptera), caddiesflies (Trichoptera), moths (Lepidoptera) and wasps (Hymenoptera) are aquatic with terrestrial adults. Larval or nymphal and adult stages of aquatic beetles (Coleoptera) and bugs (Hemiptera) are fully aquatic.

Morphological and physiological adaptations: Aquatic insects have tackled the problem of living in aquatic environment by evolving various morphological and physiological modifications. These include air-tubes to obtain atmospheric oxygen, cutaneous and gill respiration, the extraction of air from plants, hemoglobin pigments, air bubbles and plastrons. Air-tubes are present in aquatic bugs (Hemiptera) and files (Diptera) restricting their activity to water surface. Cutaneous and gill respiration is widespread in the immature stages of most of the aquatic insects. This helps them to live among submerged substrates. Adult beetles and bugs often respire by the use of an air bubble. Some species use plastron (a system of microhairs or papillae) that hold an air film. Plastron respiration helps these insects to stay longer under water. Chironomid (Diptera) larvae living in eutrophic aquatic habitats survive in low oxygen levels through the use of hemoglobin pigments.

One of the major physical forces faced by aquatic insects of running waters is water current. In running waters, aquatic insect morphology are closely related to hydraulic stress and the necessity to remain in close contact with the substrate. A diverse range of body modifications are present in aquatic insects. Modifications such as flattening of body, streamlining, reduction of projecting structures, suckers, friction pads, hooks, silk and sticky secretions are widely present in different groups of insects. Morphological adaptations are closely followed by behaviour adaptations. Aquatic insects avoid

A diverse range of body modifications are present in aquatic insects to survive in running waters. Modifications such as flattening of body, streamlining, reduction of projecting structures, suckers, friction pads, hooks, silk and sticky secretions are widely present in different groups of insects.

water current by burrowing into the substrate or occupying a space in the substrate with minimum hydraulic stress such as rock crevices or under the rock.

Lifecycle adaptations: Aquatic insects have evolved diverse lifehistory strategies to suit their environment. Many temporary pool breeding species have egg stage which can remain in total dry condition (eg: *Aedes*). In many species of caddiesflies a gelatinous egg mass matrix protect the eggs and larvae from desiccation and freezing for months together. Some species have staggered hatching which prevents over crowding of newly hatched larvae.

Very few aquatic insects have adapted to a completely submerged life cycle. Most of the aquatic insects spend atleast one part of their life cycle in terrestrial habitat. A major problem in being completely submerged is respiration. Many species have developed morphological and physiological adaptations to survive in particular oxygen concentration. The distinction is being very evident in running and standing water, where the former is very well oxygenated than the latter. This is one important factor that determines the distribution of groups like mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddiesflies (Trichoptera). These groups depend upon dissolved oxygen and achieve their maximum diversity in running water. Among holometabolous aquatic insects, aquatic pupa is found in caddiesflies (Trichoptera), flies (Diptera) and aquatic moths (Lepidoptera). Aquatic beetles, alderflies (Megaloptera) and lacewings (Neuroptera) have semi aquatic or terrestrial pupa.

During the course of life, aquatic insects encounter diverse physical environmental conditions, the most pronounced being temperature. The temperature varies daily and seasonally. This variation in temperature affects emergence pattern of aquatic insects. In tropics because of relatively constant temperature, many pool breeding species show continuous emergence throughout the year. However, in the Western Ghats, most of the stream breeding species emerge during pre and post monsoon months. Some species in tropics follow an emergence pattern coinciding with phases of moon.

The presence of diapausing egg and pupa are important life history evolutions that help insects to survive unfavourable conditions. Aquatic insects complete single or multiple generations during a year. Some tropical species have life cycle greater than a year. Life cycle completion time for a species varies with altitude and latitude.

Feeding strategies: Essentially all aquatic insects are omnivorous, atleast in their early instars. Species which use similar morpho-behavioural mechanisms for food acquisition have evolved similar mouth parts. This has facilitated classification of aquatic insects to functional feeding groups, which is equivalent of guild. The "functional group" approach reflects both convergent and parallel evolution leading to functionally similar organisms. Mouth parts, legs and other morphological structures or constructed devices (silk nets) together with associated feeding behaviour may change with larval development. Widely recognized functional groups are shredders, collectors, scrappers, predators and piercers. The shredders feed on woody debris and leaf litter, and collectors filter feed or gather suspended organic matter from water column. Scrappers graze algae and other plants growing on substrate. Predators feed on other aquatic invertebrates and small vertebrates. Piercers obtain liquid food from plants or other animals.

Aquatic insects and their habitats: Aquatic insects are adapted to either running waters (streams and rivers) or standing waters (ponds and lakes). These habitats can also be viewed as erosional (streams and rivers) or depositional (ponds and lakes). Both stream/ river currents and lake shoreline waves create erosional habitats while lake basins, river flood plain pools and stream/river backwaters provide depositional conditions. Species adapted to erosional habitats frequently colonize lake shorelines. Similarly many species of depositional habitats are common in flood plain pools and backwaters.

The habitats for the aquatic insects can be visualized within the framework of various spatial -temporal scales. At a spatial scale, it ranges in size from particles of few millimeters to the entire drainage basin, which extends to squares of kilometers. Temporally, the changes in the habitats can be visualized from days to thousands of years. The permanence of the physical structures of the habitats varies with the spatial scale. This ranges from few days for individual grain and microhabitat to thousands of years for the drainage network. Insect communities of the wetlands respond to this spatial-temporal variation as well.

Within a given habitat, aquatic insects maintain their location by clinging, swimming, skating or burrowing into the habitat. Distribution of aquatic insects within a habitat is determined by intricate interplay between substrate, flow, turbulence and food availability. The habit (mode of locomotion, attachment or concealment) of a given species determines the frequency of movement within the habitat

Substrate, an important physical component of habitat is very complex. The water current and the nature of the available parental material determine the physical nature of the substrate. The organic detritus adds complexity to the substrata and can strongly influence the organism's response to the substrate. It has been established across continents and biomes that the faunal composition changes with the substrate. Sand is a relatively poor habitat with low

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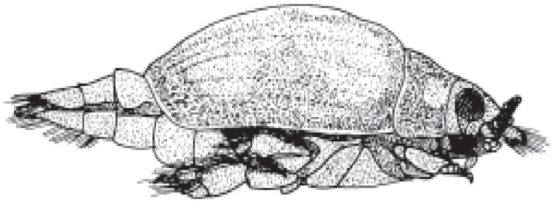
abundance and diversity. Relatively, the diversity is high in silty-sand and biomass may be high and diversity low in muddy substrata. The presence of sand and silt reduces and changes fauna. Atleast in stony substrata it is known that the space available for colonization determines species abundance. In general, diversity and abundance increase with substrate stability and the presence of organic detritus.

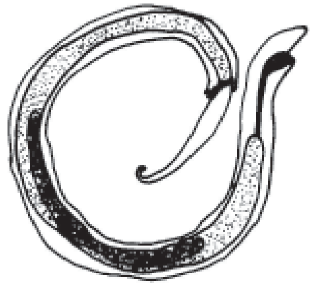
Aquatic insects in biomonitoring: Biological monitoring or biomonitoring is the systematic use of living organism or their responses to determine the health of aquatic ecosystem. Fish, algae, protozoans, and other groups of organisms is being used in water quality assessment but macroinvertebrates which largely consist of insects are more frequently used. They are suitable and sensitve indicators of water quality and ecosystem health because: (1) they are ubiquitous and, consequently affected by perturbations in many different aquatic habitats; (2) the large number of species respond to a range of environmental stress; (3) their sedentary nature relative to other aquatic organisms permits effective determination of spatial extend of perturbation; and (4) long life cycles allow to examine temporal changes in abundance and age structure.

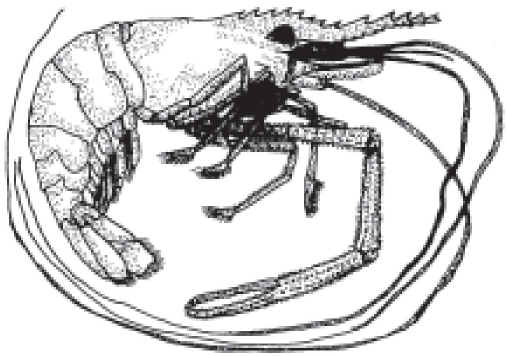
Traditional physico-chemical analysis of water quality provides a snap shot of water quality at the time of sample collection. In contrast, biomonitoring adds a temporal component to the sample and provides a history of the perturbation if any. However, physico-chemial measurements and biomonitoring are not mutually exclusive and an ideal water quality monitoring programme should involve both approaches.

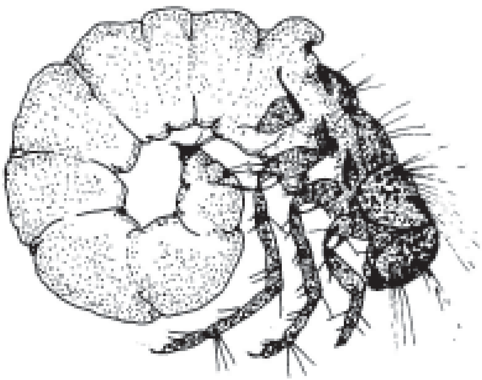
Macroinvertebrates which largely consist of insects are frequently used for biomonitoring. They are suitable and sensitive indicators of water quality and ecosystem health. Biomonitoring adds a temporal component to the sample and provides a history of the perturbation if any.

Key to Aquatic Macroinvertebrates



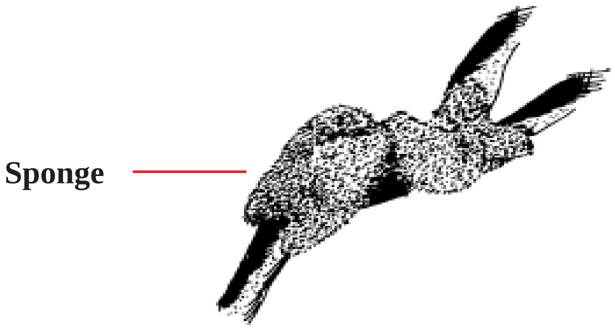






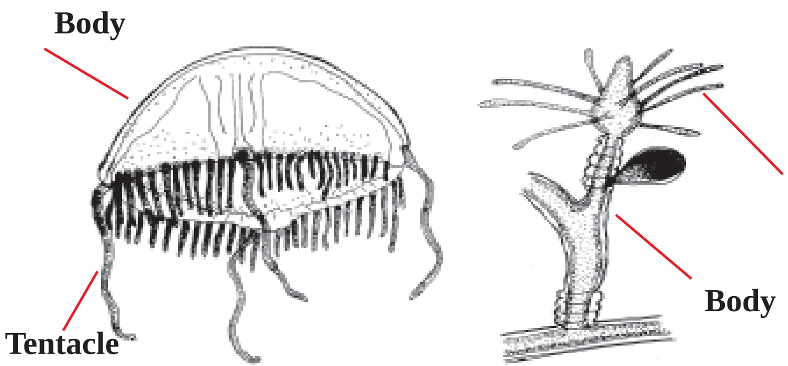
Key to Aquatic Macroinvertebrates

1. Encrusting forms with an irregular, asymmetric shape, lacking discrete organs or tentacles; spongy to touch…………**Freshwater Sponges(Phylum: Porifera)**



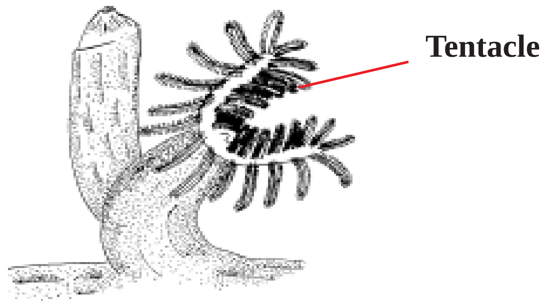
Without the above characters; bilaterally symmetrical with organ-systems……………...**2**

2. Either free-floating and transparent, like an umbrella shaped disc (< 30 mm diameters); or sessile and rather small (generally < 5 mm, but individuals may be solitary or colonial) with a short stem and several tentacles arising from it; rare…………**Coelentrates (Phylum: Cnidaria)**



Without the above characters……………………….........................**3**

3. Sessile, colonial forms made up of numerous small individuals each bearing several retractile tentacles on a horse-shoe shaped structure around the mouth; the rest of the body is enclosed in a gelatinous structure; the colony may be encrusting, compact, or branching, and twig-like………………......**Moss Animals (Phylum: Polyzoa (Ectoprocta))**

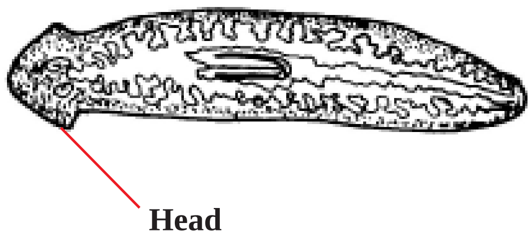


Form not as above; free-living and not colonial…………….........……**4**

4. Body segmented, or with joint legs, or bearing a shell, or any combination of these features………………………...……**8**

Body unsegmented, lacking jointed legs or a shell………..……………**5**

5. Small (< 30 mm) elongate flattened body pressed to the substratum; moves with a gliding motion; often with a pair of anterior eyespots………**Flatworms or Planarians (Phylum: Platyhelminthes)**



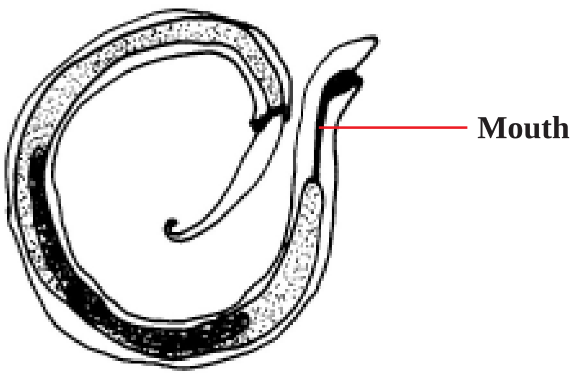
Without the above characters……………………......................……………..**6**

6. Body thin, flattened and 'bootlace-like'; with a long, eversible proboscis (inconspicuous when retracted) and three pairs of eyes………….............**Ribbon or proboscis worm (Phylum: Nemertea)**

Body is long and thin it is approximately circular in cross-section………………...………**7**

7. Body long (may be >20 cm long) and threadlike; anterior and posterior ends blunt (not tapering); usually dark brown…...**Horsehair worms (Phylum: Nematomorpha)**

Worm-like cylindrical body tapering at both ends and lacking external segmentation; move in a 'whip-like' fashion; usually < 1 cm long…………….......................................…**Nematodes (Phylum: Nematoda)**

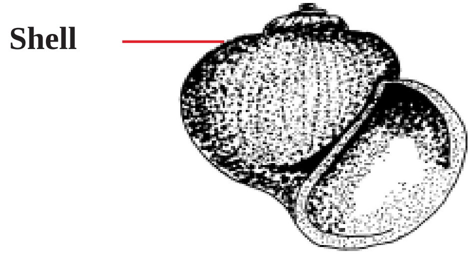


8. Body enclosed by an unsegmented calcareous shell which may be coiled, spherical or bi-valved; body is soft and unsegmented with a ventral muscular foot….**Snails, Clams and Mussels (Phylum Mollusca)**…….**9**

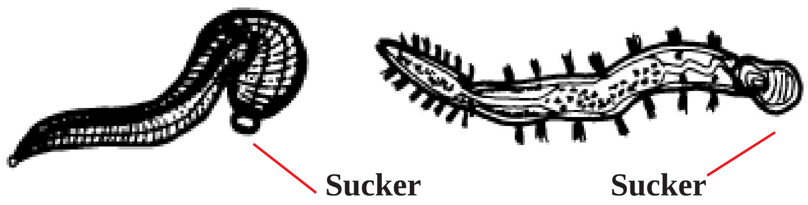
Body segmented and not enclosed in a calcareous shell………………..**10**

9. Body completely enclosed by a bi-valved shell………**Clams and Mussels (Bivalves) (Class: Bivalvia).**

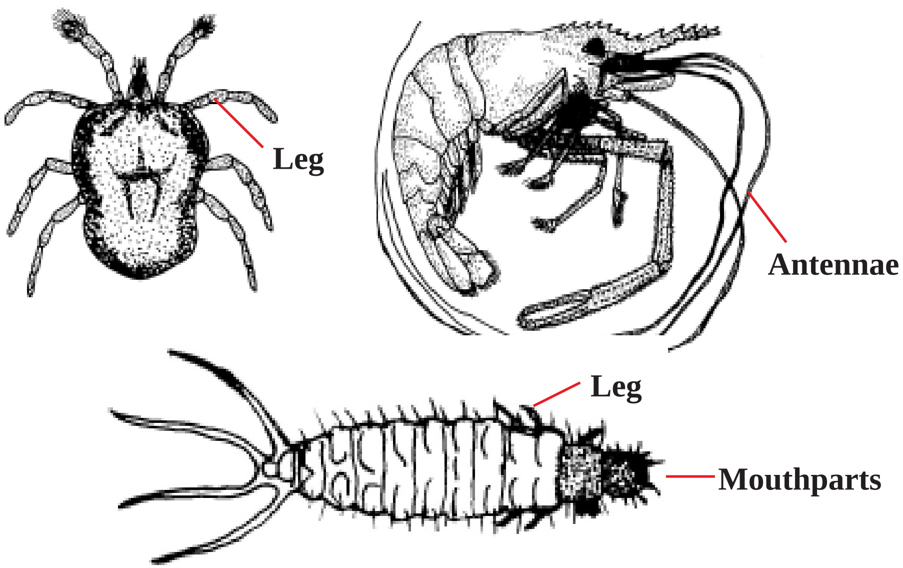
Shell not bi-valved, body may not be entirely enclosed by the shell …………...................................**Snails and Limpets (Class: Gastropoda)**



10. Body more or less elongated or worm-like with obvious segmentation and generally > 30 similar segments; may have anterior and posterior suckers; if suckers are lacking then the sements bear paired, fleshy, lateral outgrowths or bundles of fine bristles (chaetae)……….**True Worms and Leeches (Phylum: Annelida)**

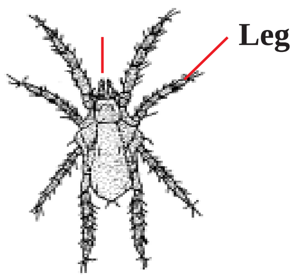


Generally with jointed legs and a segmented body (which is often hardened) and usually divided into two or more discrete regions (e.g. head, thorax and abdomen); if legs are lacking then there are < 15 body segments and the head bears paried mandibles…………**Crustaceans, Arachinds and Insects (Phylum Arthropoda).**



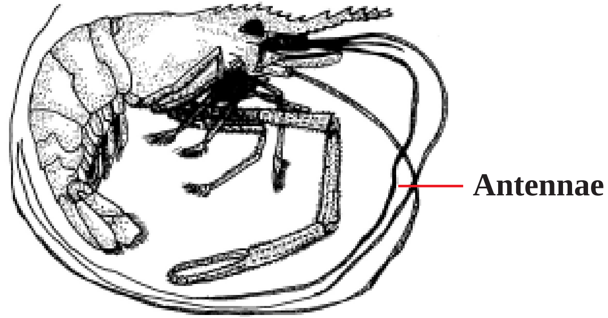
Key to Aquatic Arthropods

1. Four pairs of joined legs; antennae absent; body either globose or divided into two with indistinct segmentation (some minute forms [2 mm long] with globose bodies may have six legs only)………………**Water Mites and Spiders; (Class: Arachnida)**

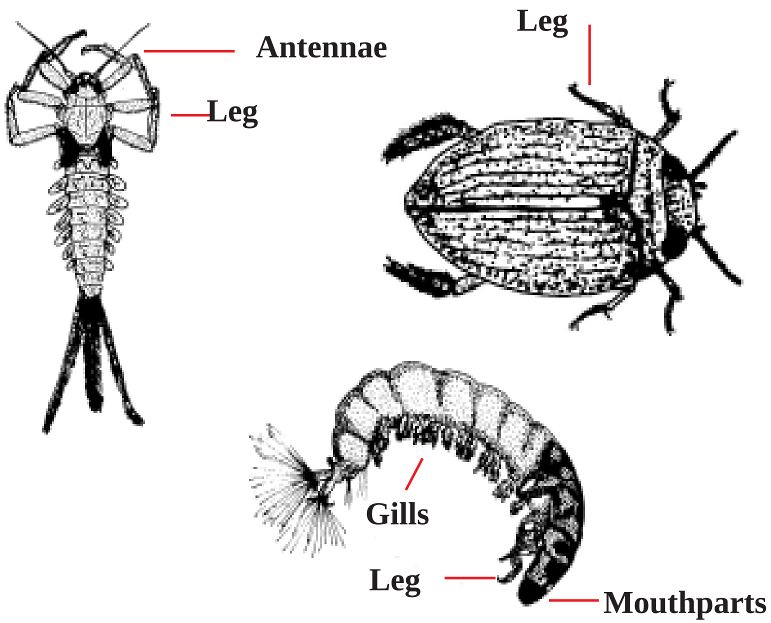


2. Body not as above; antennae present or inconspicuous......…………….**3**

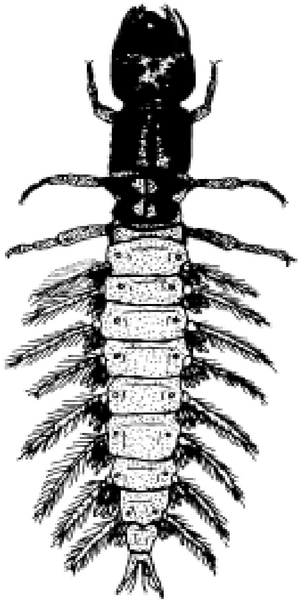
3. More than three pairs of jointed legs; two pairs of antennae……………....................**Crustaceans (Subphylum: Crustacea)**

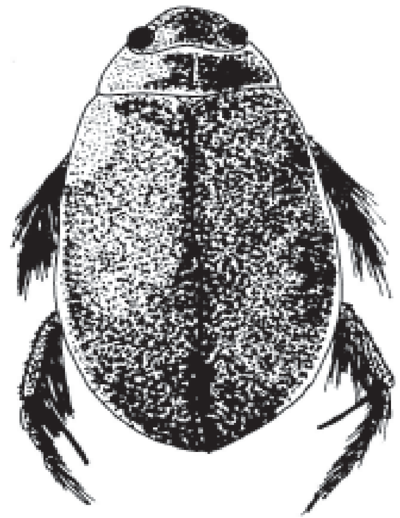


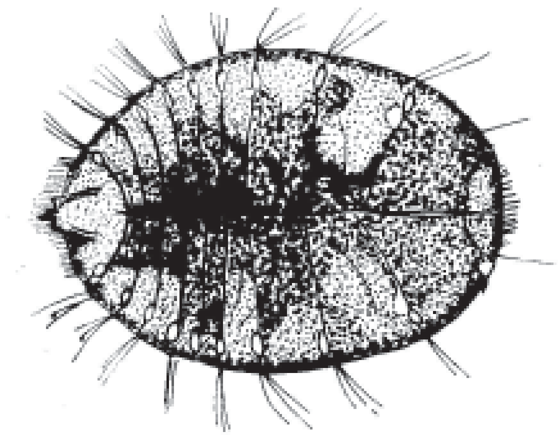
Either whith three pairs of jointed legs or legless; one pair of antennae…………..**Insects (Class: Insecta)**



Key to Aquatic Insect Orders







Key to Aquatic Insect Orders

1. Thorax bears three pairs of segmented legs; head fully formed.……....**2**

Thorax lacks segmented legs (but unsegmented prolegs may be present); head may be fully formed but is often inconspicuous and incompletely formed or retracted into the thorax……… **Larval Flies (Order: Diptera)**
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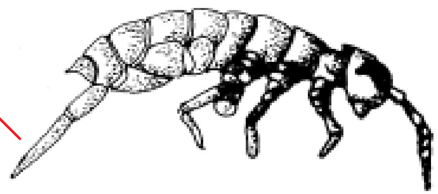
2. Minute insects (generally < 5 mm long), with a midventral forked appendage on the abdomen ……........**Springtails (Order:Collembola)**



Body generally considerably longer than 5 mm; ventral abdominal appendages absent but ventral gills may be present………......................**3**

3. Hind legs long with expanded femora and modified for jumping ……….
....................................**Crickets and Grasshoppers (Order: Orthopetra)**

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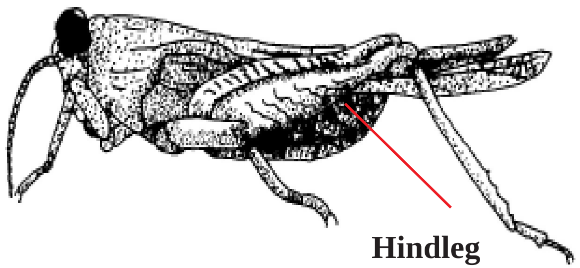
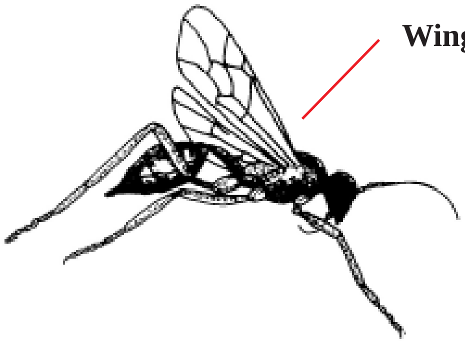


Hind legs not modified for jumping; femora not expanded….........……**4**

4. Wings or wing pads present…..……..**5**

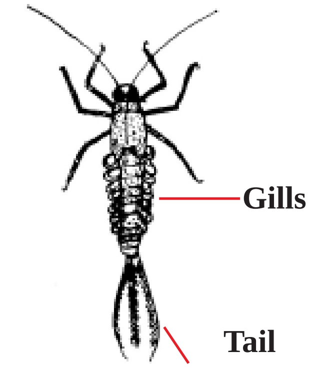
External wings or wing pads completely absent……..........................**12**

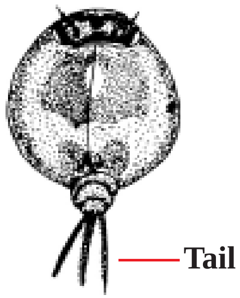
5. Two pairs of short membranous wings with few veins…………**Wasps (Order: Hymenoptera)**



Wings or wing pads present but, if wings are present, the first pair are leathery or hardened and overlie the second pair…………………….........**6**

6. Abdomen ends in three long 'tails'………………**Mayflies (Order: Ephemeroptera)**
Page-21





Abdomen ends in one, two or no such 'tails'…………………..............**7**

7. Mouth in the form of an elongate beak, or tube or cone-like structure……..................................……..**Aquatic Bugs (Order: Hemiptera)**

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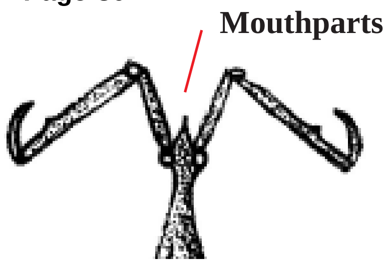

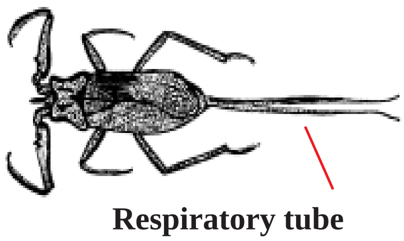

Mouth not as above………………...**8**

8. Labium (lower 'lip') is modified into a large mask like structure which covers the other mouthparts when viewed from below….Damselflies and Dragonflies (Order: Odonata)……..**9**

Labium not modified into a large mask-like structure………..............**10**

9. Abdomen ending in leaf-like gills…………..**Damselflies (Suborder: Zygoptera)**

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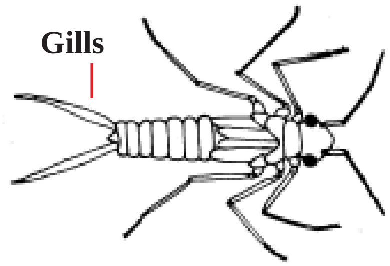
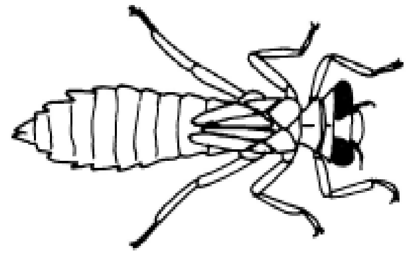


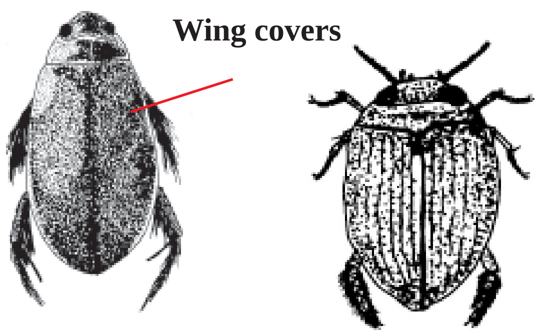
Abdomen without caudal lamellae………………………**Dragonflies (Suborder: Anisoptera)**

Page-26



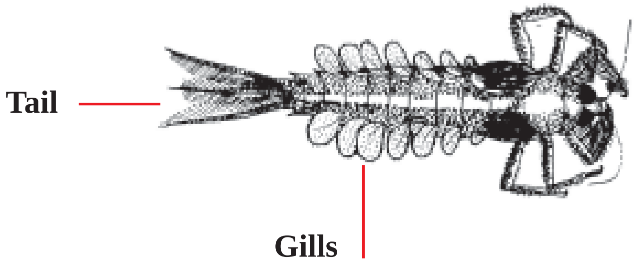
10. Forewings modified into hard protective coverings, concealing most of the dorsal surface…………….....................**Beetles (Order: Coleoptera)**

Page-48

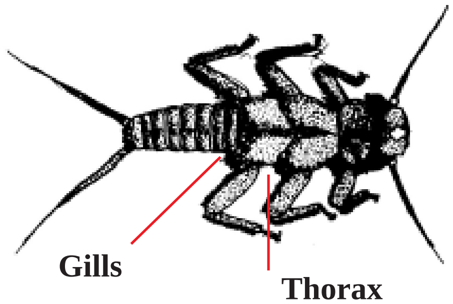


Forewings not thus modified; abdomen ends in a pair of segmented terminal filaments or 'tails'…………………..**11**

11. Most abdominal segments possess lateral gills………………**Mayflies (Order: Ephemeroptera) Page-21**



Lateral abdominal gills are absent but thoracic gills in the form of tracheal tufts present…………….......................**Stoneflies (Order: Plecoptera) Page-56**

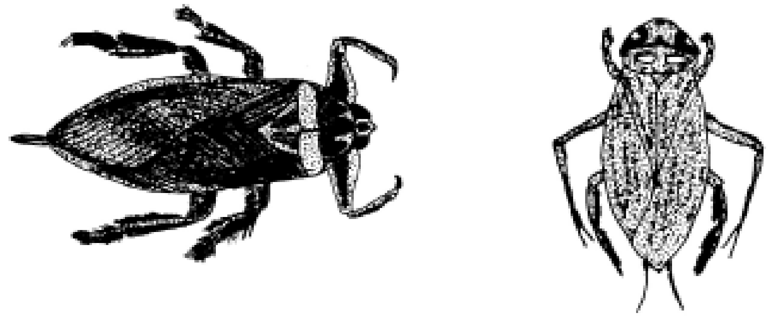


12. Mouth parts adapted for sucking……………………..........................…**13**

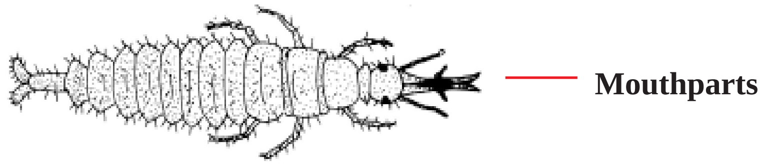
Mouth parts adapted for chewing with mandibles …………...................**14**

13. Mouth parts in the form of a tube, a beak or cone-like structure ……………..**Aquatic Bugs (Order: Hemiptera)**

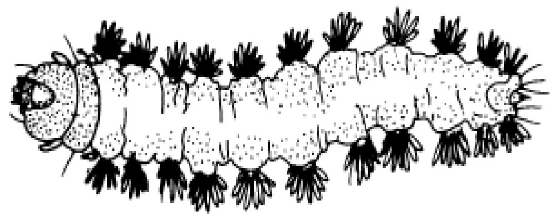
Page-30



Mouthparts are a pair of long, needle-like stylets; associated with freshwater sponges…………**Spongilla Flies (Order: Neuroptera; Family: Sisyridae)**
Page-58

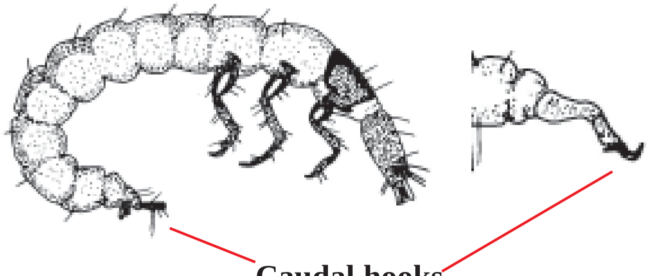


14. Abdomen on the underside of segments 3-6bears pairs of short, fleshy prolegs, each with a ring of tiny hooks………………**Aquatic Moths (Order: Lepidoptera; Family: Pyralidae).**
Page-60



Abdomen lacks ventral prolegs (but may have lateral projections, or prolegs at the end of the abdomen)……………..................……….….**15**

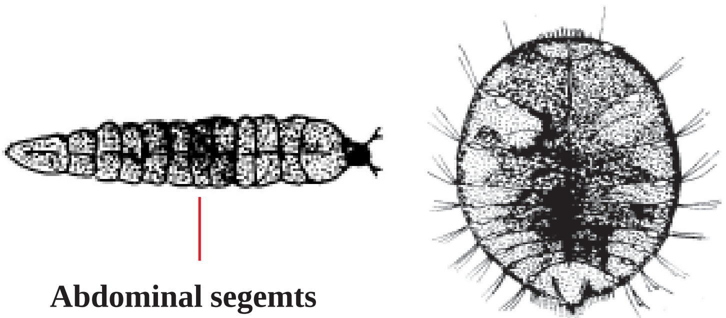
15. Abdomen ends in a pair of short or long, fleshy prolegs (sometimes fused together) that end in a single hook……………**Caddiesflies (Order: Trichoptera) Page-36**



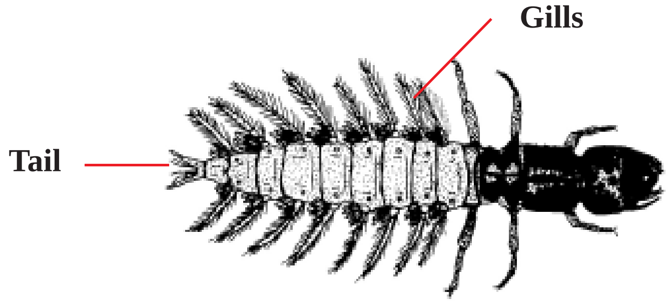
Abdomen ends variously, but never in a pair of fleshy prolegs each ending in a single hook…………..…**16**

16. Abdomen is fleshy with well-developed lateral filaments………………..**17**

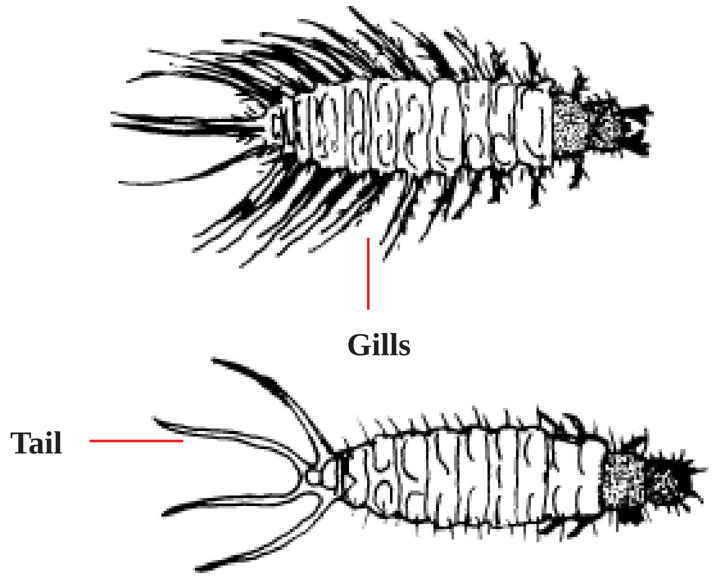
Abdomen hardened and lacks well developed lateral filaments……………...............................……**Larval Beetles (Order: Coleoptera) Page-48**



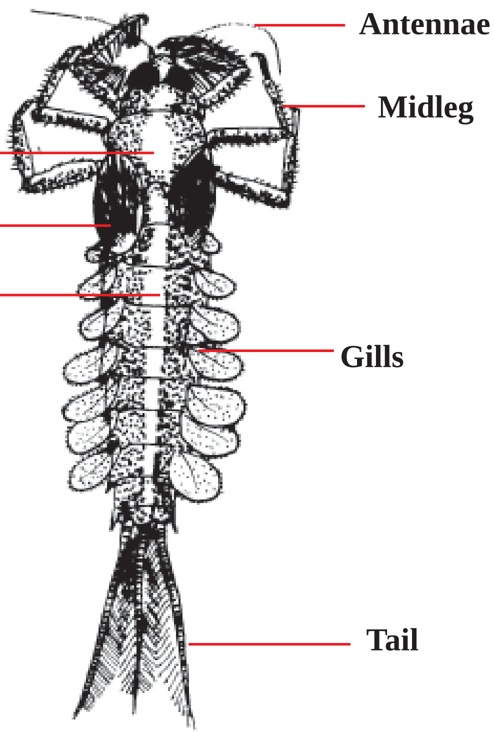
17. Abdomen ends in a pair of prolegs, each with a pair of hooks… **.Alderflies (Order: Megaloptera) Page-59**



Abdomen ends variously but never in a pair of prolegs each having a pair of hooks (although there may be two pairs of prolegs which each have hooks)…………….........**Larval Beetles (Order: Coleoptera)Page-48**

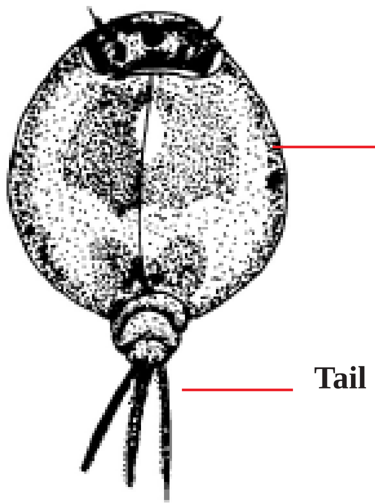


Key to Mayfly (Ephemeroptera)



Body parts of Mayfly Larvae

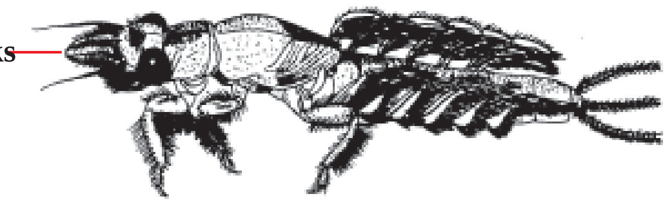
1.Body beetle like (smooth and hemispherical); a thoracic shield covers all of the gills (six pairs) and the abdomen ……………........……..**Prosopistomatidae**



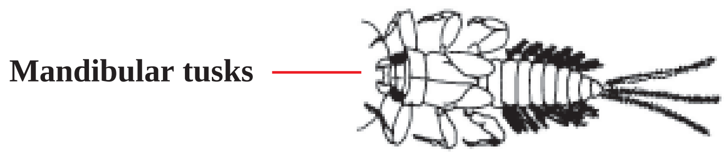
Body form not as above; abdominal gills partially or completely exposed; mandibles with tusk-like projections…………...….**2**

Mandibles without tusks like projections: gill form otherwise……......………….**3**

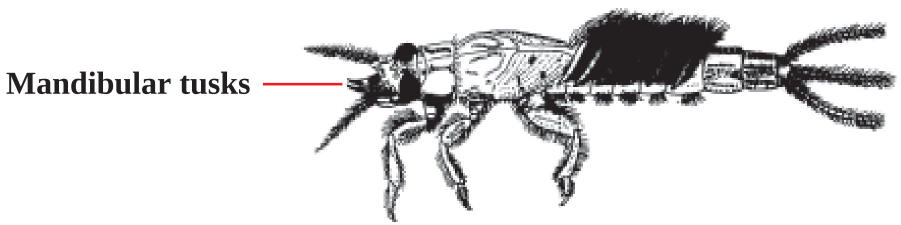
2a. Mandibular tusks long and sickle-shaped, with long setae; maxillary palp more than   twice as long as the apical part of the maxilla ....…..**Polymitarcyidae**



2b. Mandibular tusks otherwise, bearing short bristles; maxillary palp as long or slightly longer than the apical part of the maxilla ……………........**Potamanthidae**



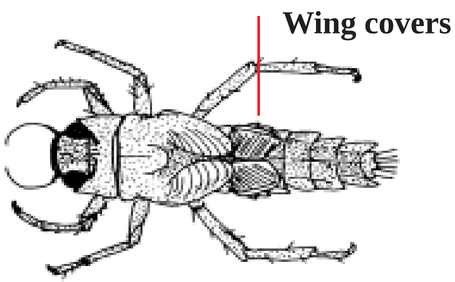
2c. Tusks curved outwards, inner edges convex……………............**Ephemeridae**



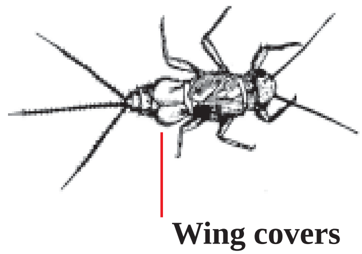
3.Second abdominal segment with large and plate-like (=operculate) gills, touching or overlapping along the dorsal midline and covering all or some of the gills arising posteriorly, gills III-VI with fringed margins…......……………….**4**

Second abdominal gills not as above…………………….................................……**5**

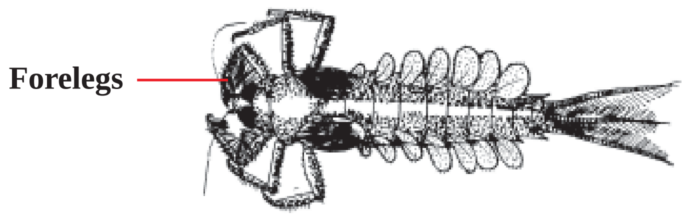
4a. Terminal gill filament densely clothed with setae on both margins, cerci (= lateral filaments) with setae on the inner margins only; mature larvae has small hindwing pads beneath the forewing pads on the metathorax ………………...….………**Neoephemeridae**



4b. Gills on abdominal segment II not fused but overlapping along the midline and covering all of the succeeding (III-VI) gills; cerci and terminal filament with short and sparse setae on the inner and outer margins; hindwing pads absent ………………..…**Caenidae**

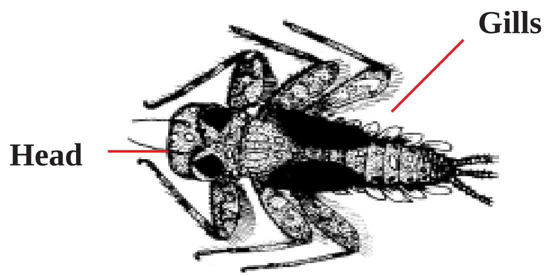


5.Inner margins of femora and tibiae of forelegs with conspicuous rows of long setae …………...…….**Isonychidae**



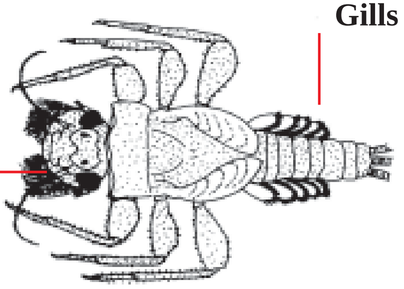
Inner margins of femora and tibiae of forelegs without rows of long setae ……**6**

6.Head is flat and plate-like with dorsal eyes; body dorsoventrally compressed (flattened); gills plate-like and never doubled but may have a dorsal tuft of tracheae (= gill tufts) at the base of the lamellae……………….**Heptageniidae**



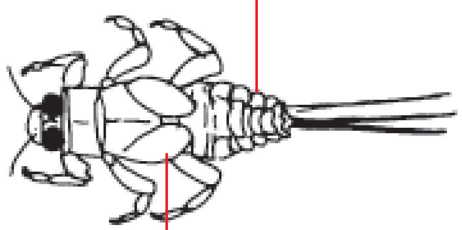
Head not plate-like; gill form various shapes but if plate-like then never with a dorsal tracheal tuft at the base of he lamellae………..........………………..**7**

7.Labium fused into a single semicircular structure, palps with long setae; gills on abdominal segments II-V or II-VII, gill II may overlay and partially conceal the rest of the series; a terminal filament is present; …………….**Tricorythidae**



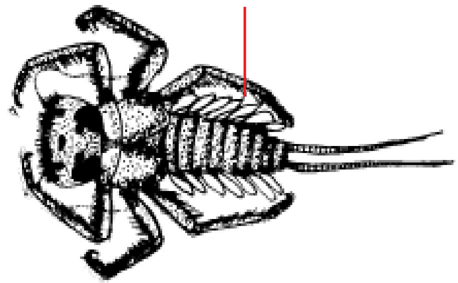
Mouthparts and gills not as above; terminal filament reduced or lacking……..**8**

8. Gills lamellate on abdominal segments III-VII or IV-VII or more rarely, II-V, II-VI or I-V (gill on segment I rudimentary if present); gills usually consisting of a dorsal lamellae and a ventral pair of tufts or lamellules; first lamellate gill may conceal some or all of the posterior gills; forewing pads fused to the thoracic notum for more than half their length……………...............……**Ephemerellidae**

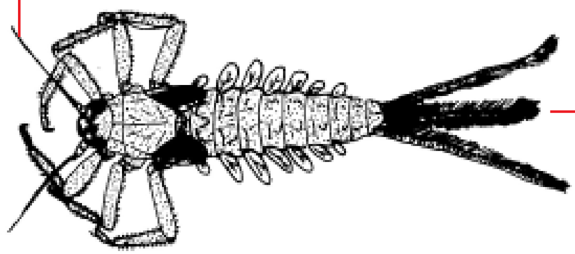


Gills lamellate or plate-like, rarely doubled, all members of the series rather similar in general form; terminal filament sometimes reduced or lacking …….**9**

9a. Gills are similar, long, slender and bifurcate (forked) in form or the first pair is rudimentary (thread-like) and others plate-like (usually with apical prolongations or fringes) and doubled; terminal filament is well-developed and similar to cerci (= lateral filaments)………………......…………**Leptophlebiidae**



9b. Antennae long and twice the width of the head; median terminal filament often much reduced and always shorter than the cerci (lateral filaments); hind corners of the last few abdominal segments are not drawn out into spines;……………………...…..**Baetidae**

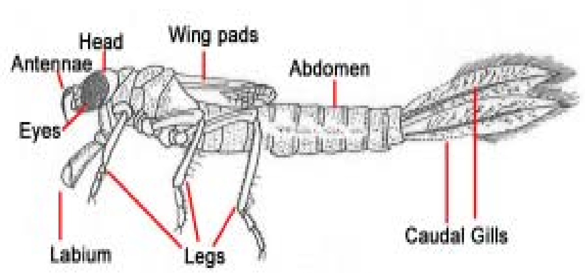


Space for Field Notes on Mayflies (Ephemeroptera)

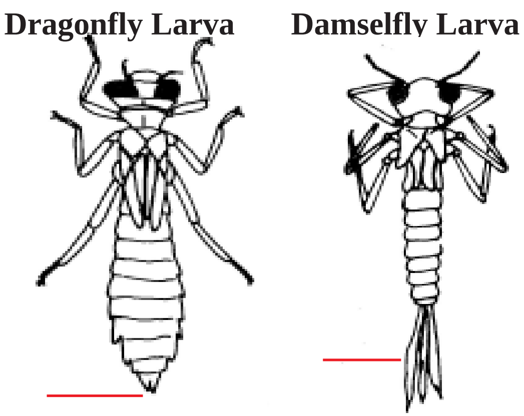
Key to Dragonflies and Damselflies (Odonata)

1.Abdomen short and stout, caudal gills absent and terminating in five short spine-like processes………..**Dragonflies (Anisoptera)-I**

2.Abdomen long and slender and terminating in three (rarely two) leaf or sac like caudal gills……………..**Damselflies(Zygoptera)-II**



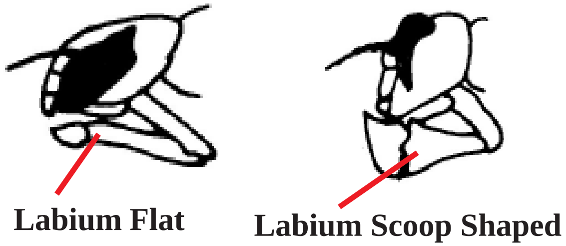
Body Parts of Damselfly Larva



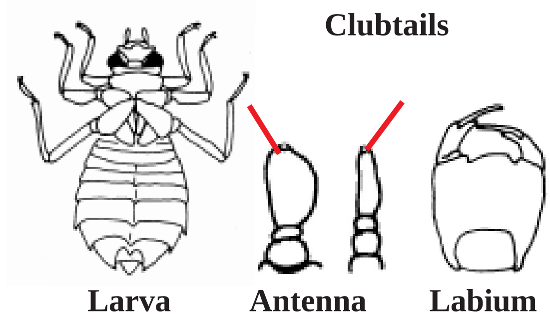
<u>**I. Dragonflies (Anisoptera)**</u>

Prementum and palpal lobes of labium flat……………..................................**1**

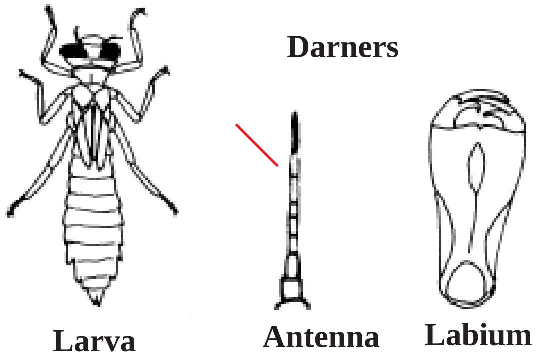
Prementum and palpal lobes of labium scoop or spoon shaped...**2**



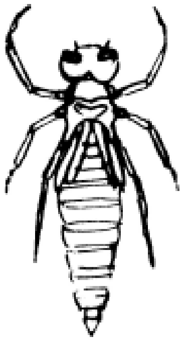
1a. Antennae four-segmented, 3rd segment enlarged and fourth vestigial…..……...**Clubtails (Gomphidae)**



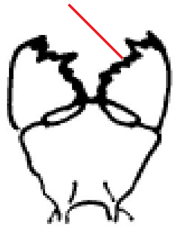
1b. Antennae six or seven segmented and filamentous…...**Darners (Aeshnidae)**



2a. Body elongate and covered with bristles or tufts of setae, labium with large irregular teeth…..................................**Mountain Hawks (Cordulegasterdiae)**

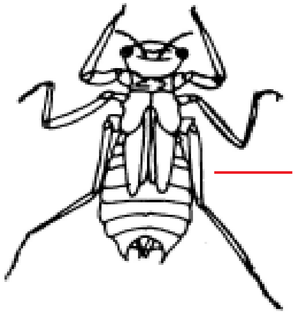


Mountain Hawks

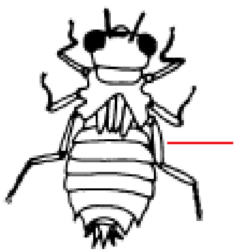


2b. Hind femur does not extend beyond abdominal segment VIII, labium with small teeth…..**Torrent Hawks and Skimmers (Corduliidae and Libellulidae)**

Torrent Hawks



Skimmers



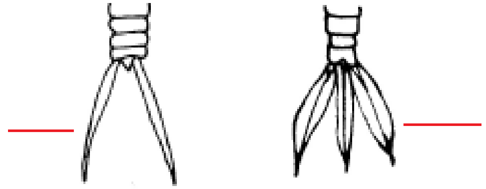
Labium

II. Damselflies (Zygoptera)

Two forceps like caudal gills………...**1**

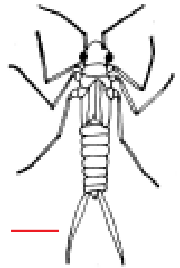
Three leaf, blade or sac like caudal gills..…...**2**

Caudal Gills of Damselfly Larva

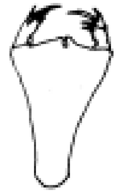


1a. Two forceps like caudal gills, which are triangular in cross section………..**Stream Jewels (Chlorocyphidae)**

Stream Jewels

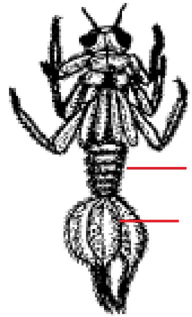


Labium

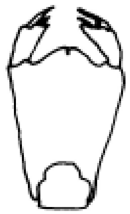


2a. Filamentous gills on the underside of abdominal segments II-VIII, caudal gills are sac like……………...............................**Torrent Darts (Euphaeidae)**

Torrent Darts



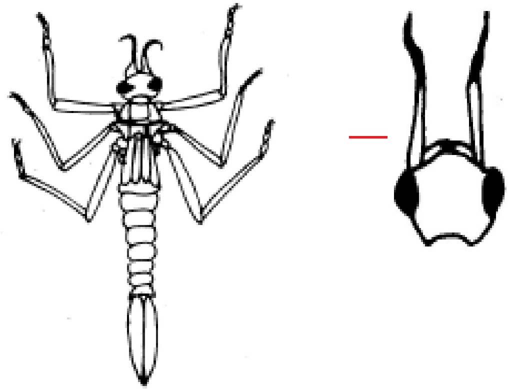
Labium



Without filamentous gills on abdominal segments II-VIII……….......................**3**

3a. First antennal segment longer than the combined length of other segments; body slender and long, caudal gills blade like with a distinct dorsal ridge………..**Glories(Calopterygidae)**

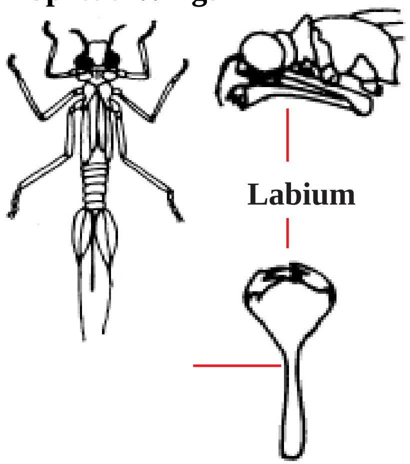
Glories **Antenna**



First antennal segment similar to other segments………….........................…..**4**

4a. Labium distinctly spoon shaped and strongly tapered posteriorly with large sharp teeth...**Spread Wings (Lestidae)**

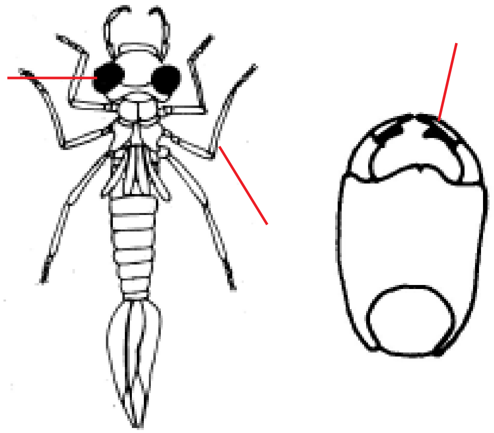
Spread Wings



Labium quadrate or more or less triangular in shape, but not spoon shaped; with movable hooks or spines at the tip……...…**5**

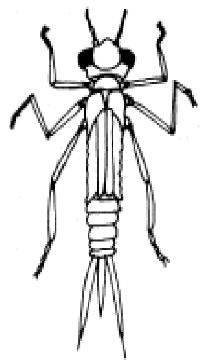
5a. Pale and lanky larvae with large bulbous eyes, labium with single spine and one movable hook..**Reedtails (Platystictidae)**

Reedtails **Labium**



5b. Gills clearly divided into a thickened dark proximal part and a thin, paler distal part.......…...…**Bambootails (Protoneuridae)**

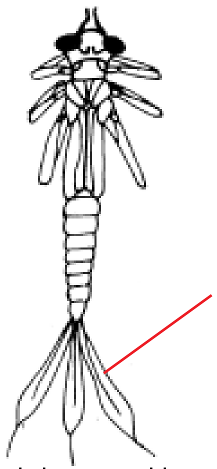
Bambootails



Gills not divided into proximal and distal parts…...…**6**

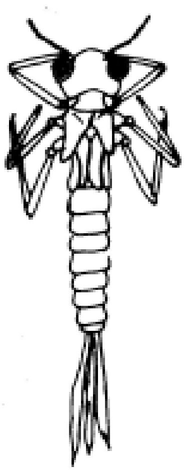
6a. Caudal gills long, about same length as the abdomen, apices pointed or tapering, third segment of antenna longer than the second ....**Bush Darts** (**Platycnemididae)**

Bush Darts

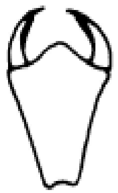


6b. Caudal gills shorter than the abdomen, with rounded apices third segment of antenna shorter than second........................**Marsh Darts (Coenagrionidae)**

Marsh Darts

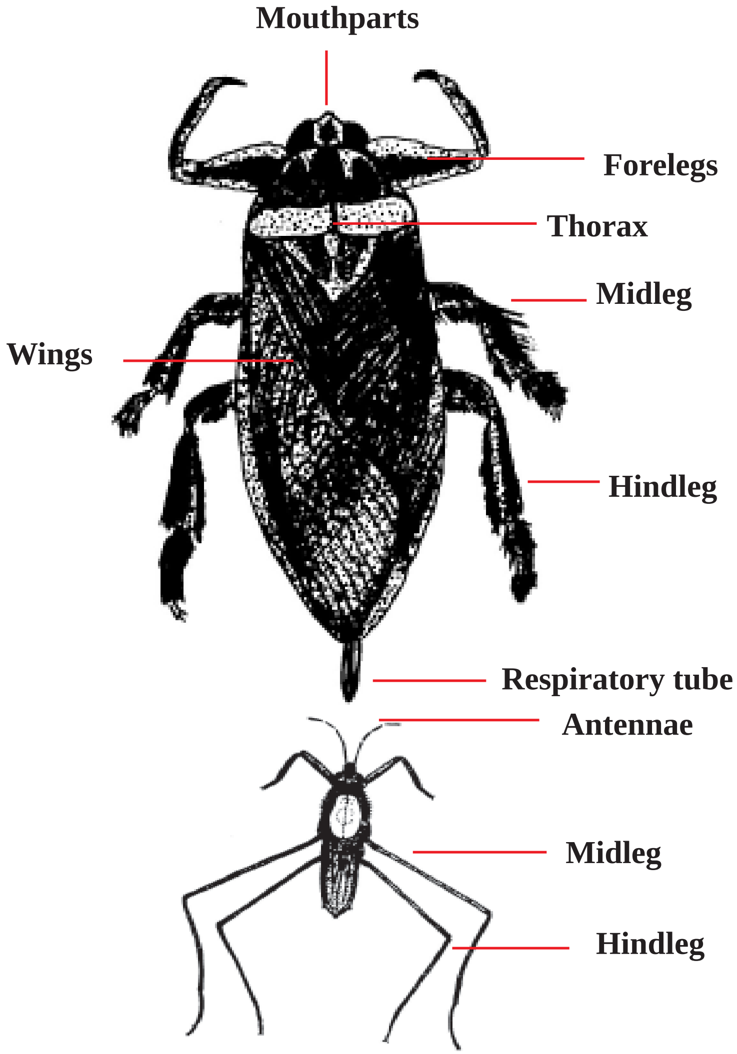


Head and Antenna



Labium

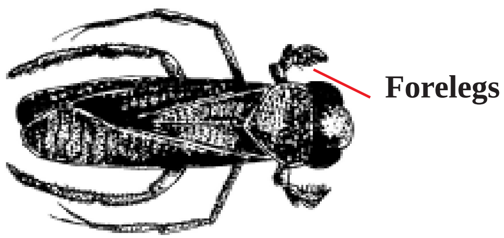
Key to Adult Aquatic Bugs (Hemiptera)



1.Antennae not visible from above; shorter than the head and inserted beneath the eyes …………………..**Suborder Nepomorpha**………….............................**2**

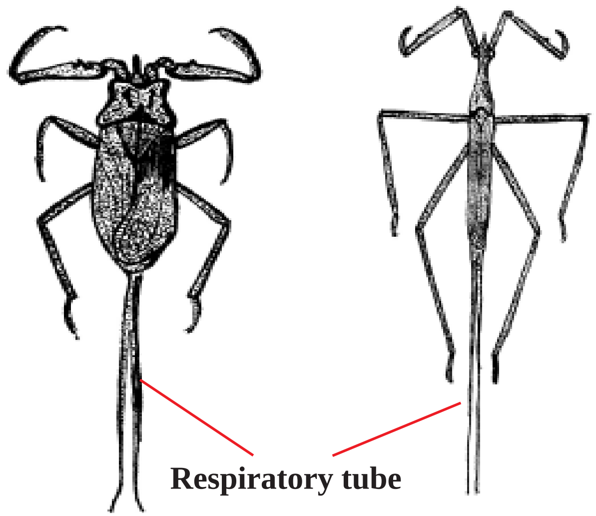
Antennae visible from above; longer than the head and inserted in front of the eyes …………..………….**10**

2.Mouthparts blunt and triangular or beak-like; the tarsus of forelegs modified into a scoop-like structure …………...…….**Corixidae**



Mouthparts elongate and cylindrical or cone-shaped, divided into segments and adapted for piercing; tarsi of fore legs not as above (often raptorial)……..**3**

3.A slender respiratory tube made up of two grooved filaments present at the apex of abdomen...……………..**Nepidae**



Respiratory tube either absent or very short……………......................................….**4**

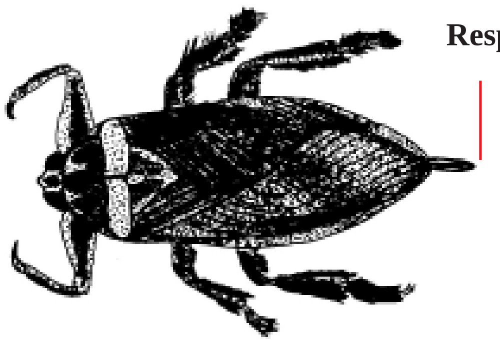
4.Swimming hairs present on the fringes of mid and hind legs; aquatic……….**5**

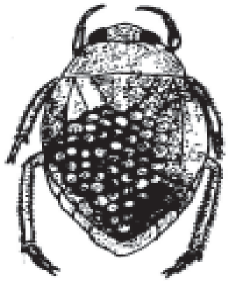
Swimming hairs absent on the fringes of mid and hind legs; riparian………..**10**

5.Forelegs raptorial with broadened femora; body dorsoventrally flattened and oval insects..…………………….**6**

Fore legs and femora not flattened; Elongate or hemispherical and distinctly ovid insects ………………………...…….**8**

6.A pair of short, strap-like appendages at the tip of the abdomen; eyes protrude from margin of the head; mid- and hind legs somewhat flattened; anterior margin of the pronotum is not concave ……………….**Belostomatidae**

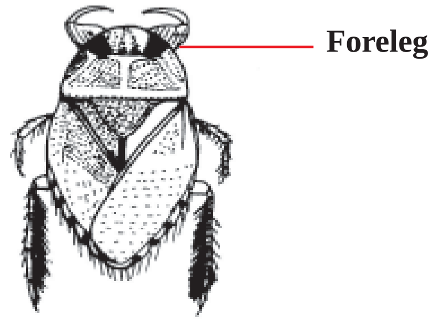




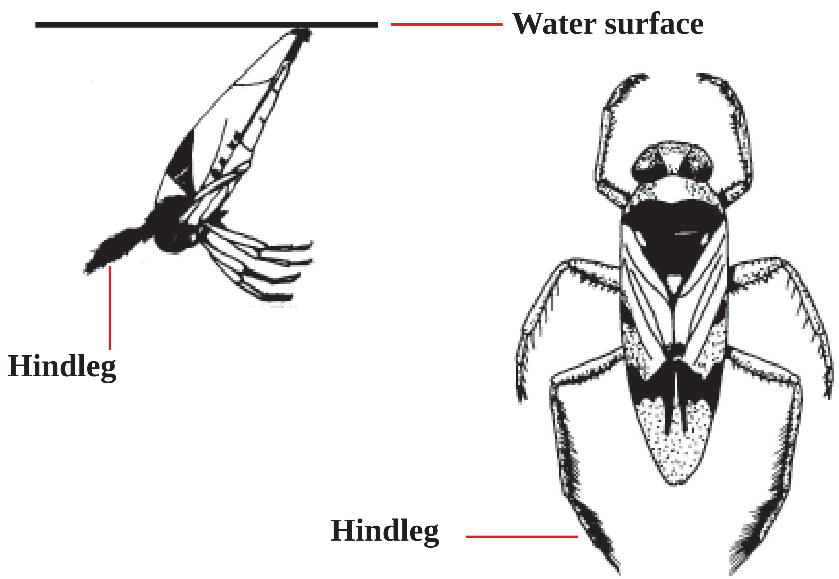
Strap like appendages absent at the tip of the abdomen; eyes do not protrude; mid- and hindlegs cylindrical; anterior margin of pronotum concave; ………………..**Naucoridae**…….**7**

7a. The tip of rostrum extends back to the base of the hindlegs; forefemora slightly broad …………..................…………**Naucoridae (Aphelocheirinae)**

7b. Rostrum short and stout with the tip extending back to the base of the forelegs; fore femora very broad………………..**Naucoridae (Cheirochelinae)**

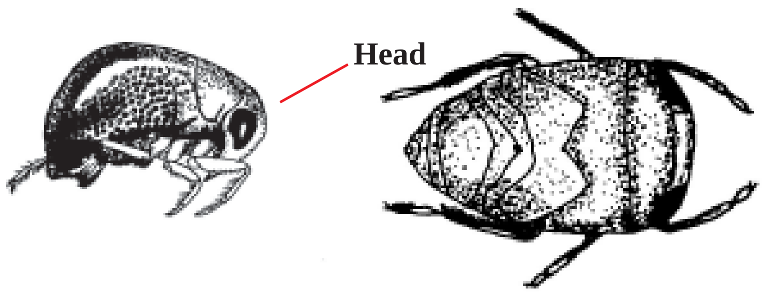


8. Hind legs long and oar-like and fringed with hairs; body elongate ………………………...…………**Notonectidae**



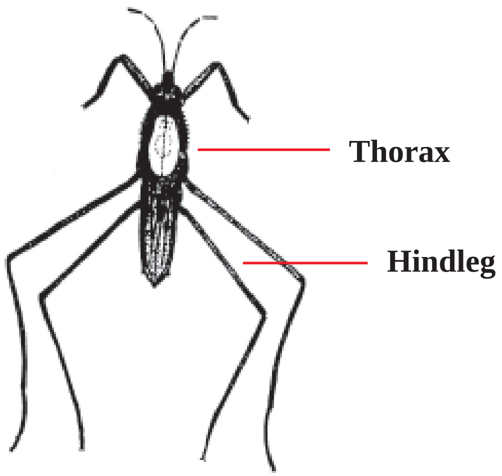
Mid- and hind legs of similar length; body hemispherical and ovoid (the head and thorax are fused) ……………..………………..9

9. Antennae with three segments; Body very small, laterally compressed with convex round face……..…..**Pleidae**

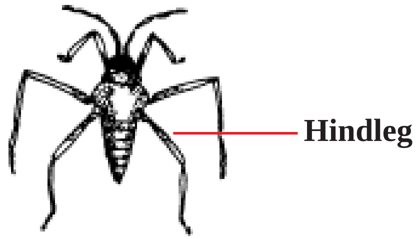


10. Body elongate or very slender; mid- and hind legs unusually long; …………..**suborder Gerromorpha**……..**11**

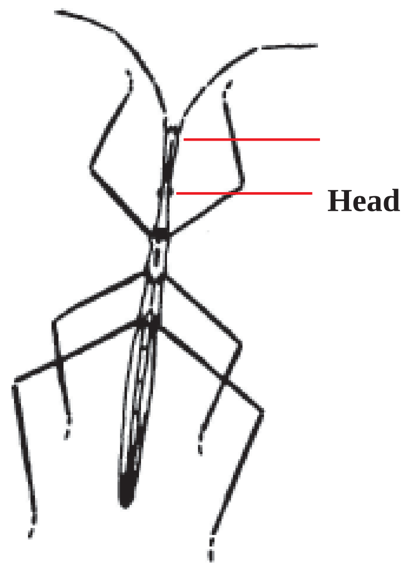
11a. Mesothorax longer than the other thoracic segments; Femora of hind legs longer than the abdomen………...……**Gerridae**



11b. Thoracic segments of approximately equal length; Femora of hind legs not longer than the abdomen ………...…..**Veliidae**

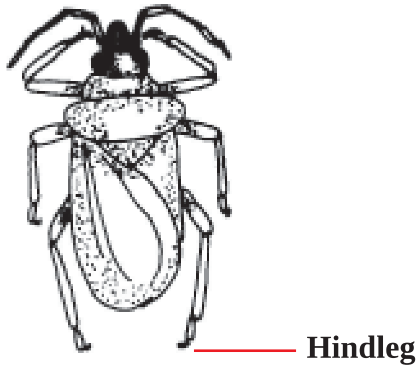


11c. Body delicate and stick like; head is as long as the thorax with eyes set halfway..……….**Hydrometridae**

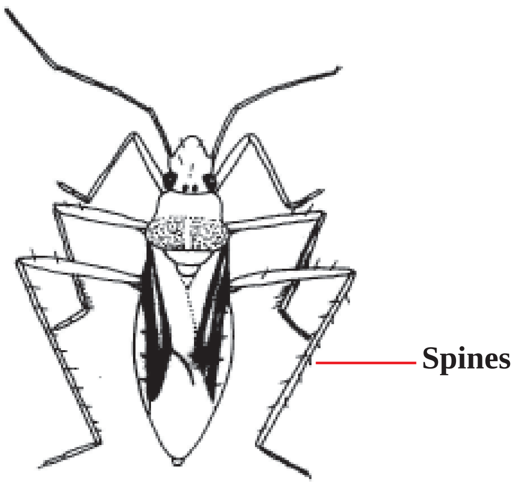


Without the above combination of characters………………….................……**12**

12a. Tarsi with two segments; hind legs without spines; ventral surface of the head grooved with a pair of prominent vertical plates covering the base of the rostrum…...…………..**Hebridae**

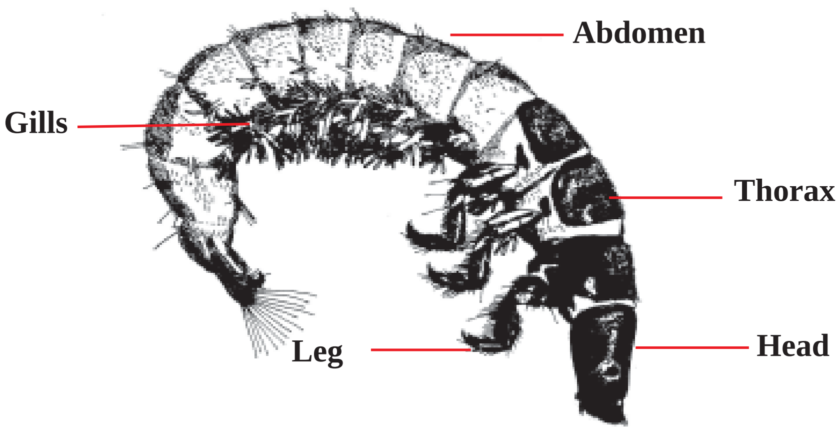


12b. Tarsi with three segments; hind legs armed with spines; ventral surface of head not as above;; ……..…………………**Mesoveliidae**

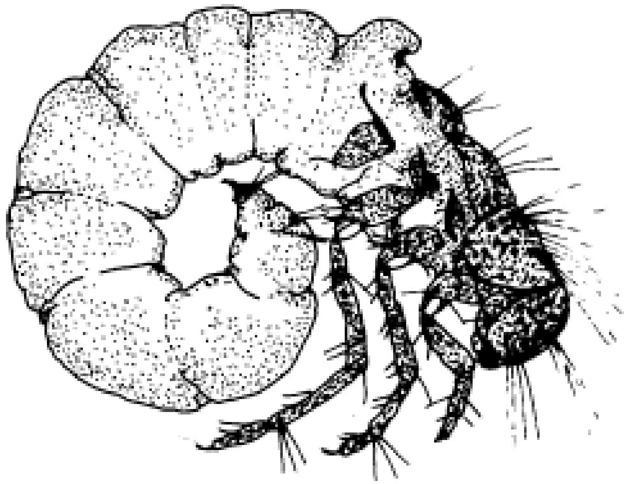


Space for Field Notes on Aquatic Bugs (Hemiptera)

Key to Larval Caddiesflies (Trichoptera)



1.Larval case is made up of sand grains resembling a snail shell; body strongly curved; anal claw comb-like ……………………….......................**Helicopsyche**



Larval case not spiral or larvae free-living; anal claw generally hook-like.……**2**

2.Dorsal surface of all three thoracic segments covered with sclerotized plates ……………...……….**9**

Dorsal surface of thorax membranous or fleshy and never entirely sclerotized ……………...…………**3**

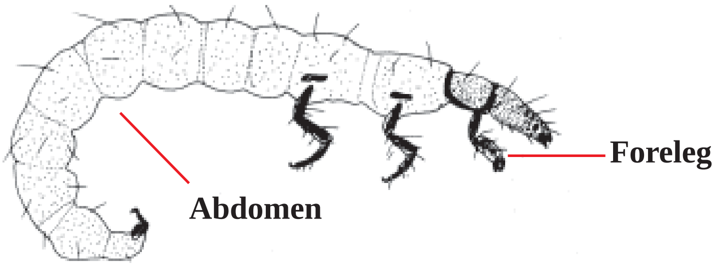
3.Second thoracic segment partly or largely covered by sclerotized plates (although these may be lightly pigmented); larvae construct portable cases of various materials………...…………**10**

Second thoracic segment without sclerotized plates but a few small sclerites and setae may be present; larvae without a portable case, but may construct a shelter or live within a net………..………………**4**

4.Dorsal surface of abdominal segment IX with sclerotized plate; tracheal gills may be present on the sides of the abdomen………………...............……………**5**

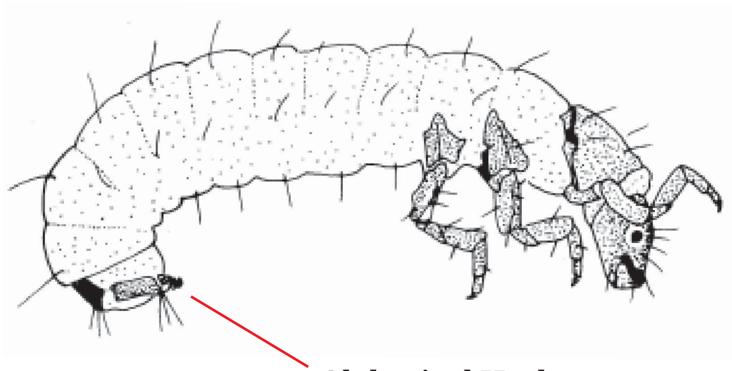
Dorsal surface of abdominal segment IX without sclerotized plate; tracheal gills absent on the sides of the abdomen…………...…..**7**

5.Forelegs with modified tibia and tarsus (chelate, or pincer-like with an attenuated tarsus); abdomen without gills ……..........……………**Hydrobiosidae**

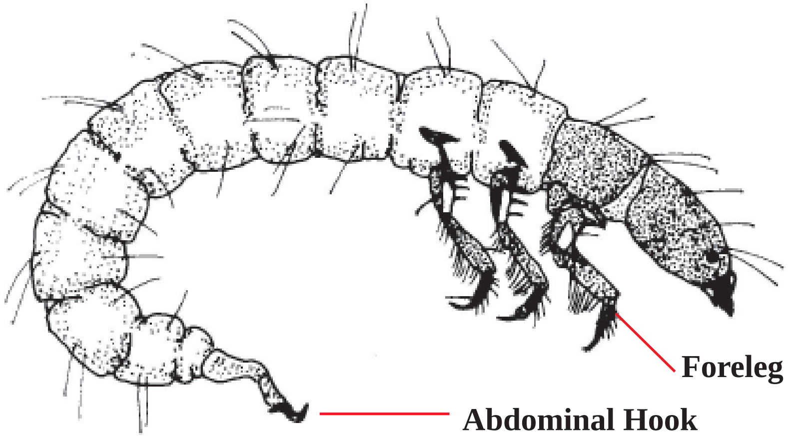


Forelegs not modified; limbs similar to each other in general form……………....**6**

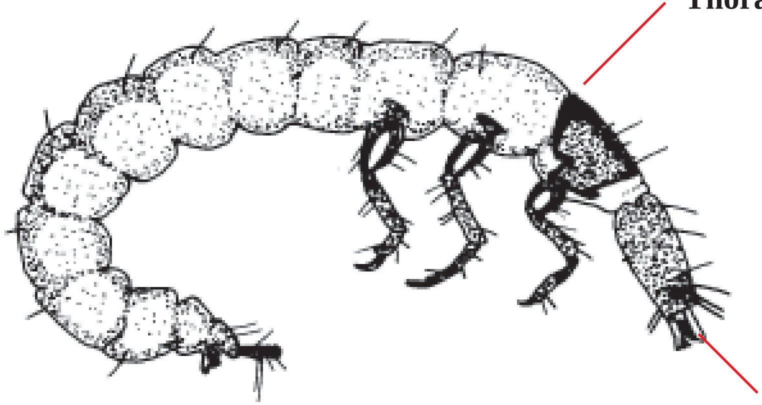
6a. Larvae live in a tortoise-like case made of small stones; anal prolegs short and broadly joined to abdominal segment IX; anal claws small with at least one dorsal accessory hook; forelegs not noticeably stouter than the other limbs; ………...……………**Glossosomatidae**



6b. Larvae free-living; anal prolegs free and rather long, with well-developed claws which may have accessory hooks on the inner margin; forelegs rather robust and raptorial; abdomen and thorax may bear lateral gills …………..….**Rhyacophilidae**

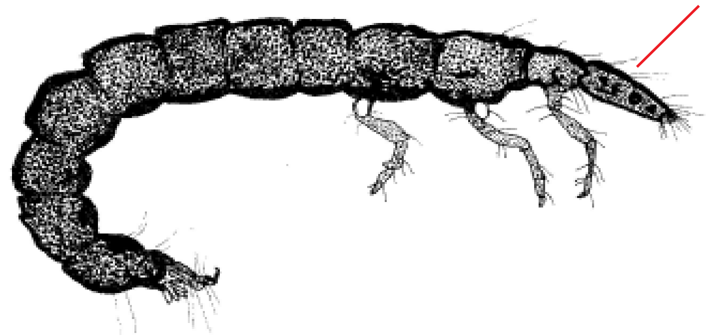


7.Larvae spine sac-like nets of fine silk; Labrum T-shaped and membranous, anterior margin densely fringed with fine setae; sclerotized parts usually yellow or orange and the posterior margin of the prothorax is rimmed with black ………...………**Philopotamidae**



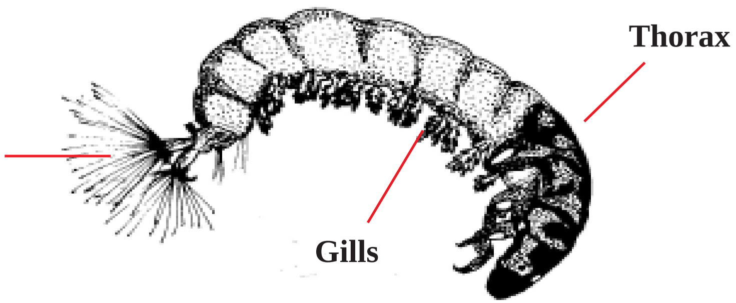
Labrum sclerotized, not T-shaped………………........................………………..**8**

8.Head at least twice as long as wide; larvae large and usually dark in colour; larvae spins an irregular net among stones and debris on the stream bed………...…**Stenopsychidae**

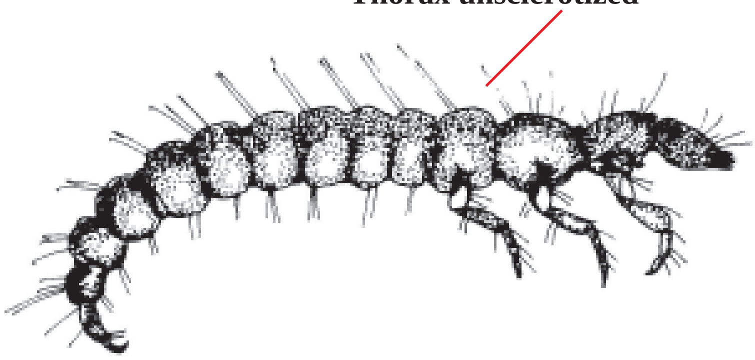


Head never twice as long as wide; larva usually small and pale; larvae spin fine-meshed nets or live in fixed tubes……...……**9**

9a. Larvae lives within a silken net and fixed retreat; abdomen with conspicuous ventral and lateral gill tufts; anal prolegs with a distal brush of long setae; posterior margins of thoracic shield lobed ……………...……**Hydropsychidae**

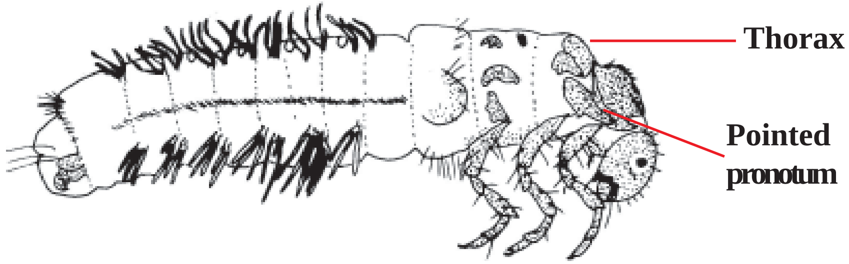


9b. Larvae spin nets or build tubes on hard surfaces; abdomen more- or less cylindrical and lacks gill tufts and lateral fringe of setae; last thoracic segment unsclerotized; labium short and not extend beyond the maxillary palps; margins of the labrum without dense fringe of setae; fore-trochantin relatively long; ………..….**Polycentropodidae**



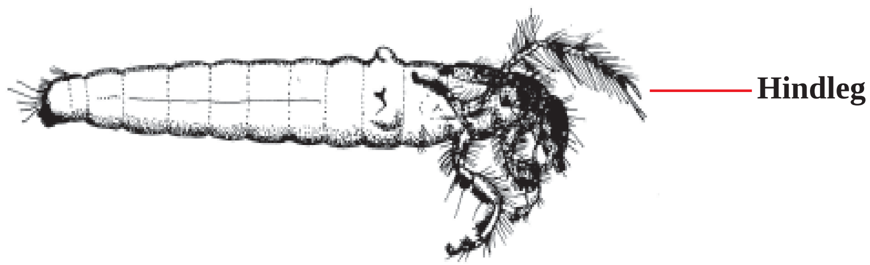
Ventral or lateral gills absent; anal prolegs lack a distal brush; posterior margins of thoracic nota straight…...…………**10**

10. Larval case of rock fragments with lateral ballast stones. Pronotum is thickened and the anterior margins are pointed and directed forward; mesonotum with four sclerites in addition to lateral projections that point forward; head can be retracted beneath the pronotum; ……………………..……………………**Goeridae**



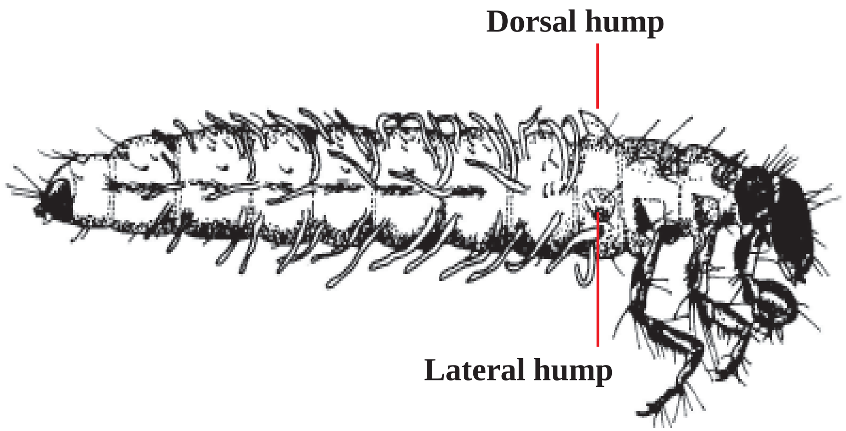
Pronotum and mesonotum not as above; head not retractable……………….**11**

11. Antennae prominent; sclerotized plates on the mesonotum usually lightly-pigmented and sometimes have a pair of dark curved lines on the posterior half; hind legs longer than other limbs with the femur and tibia (and, in some cases the tarsi) subdivided into two 'pseudosegments'................**Leptoceridae**



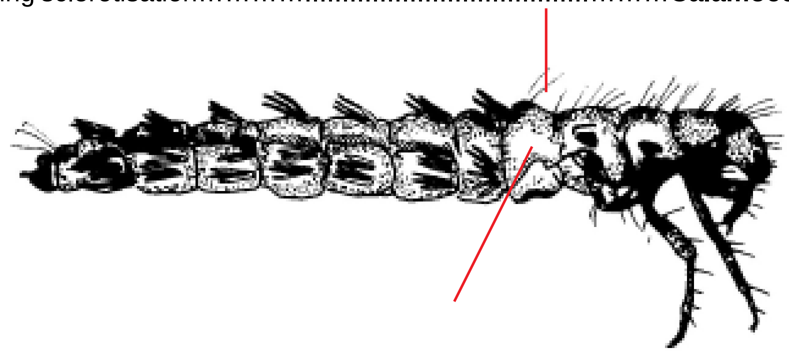
Abdominal segment I with membranous dorsum and lacks a shield-like sclerite, but setae or a dorsal hump or a small sclerite may be present; no sclerites on the meso- and metasterna and underside of abdominal segment I ……...….**12**

12. Larvae makes cases of plant material; large larvae with conspicuous head capsule; a membranous, finger-like projection (the prosternal horn) is present on the underside of the prothorax (prosternal horn); abdominal segment I with dorsal and lateral humps ………………….................................…..**Phryganeidae**



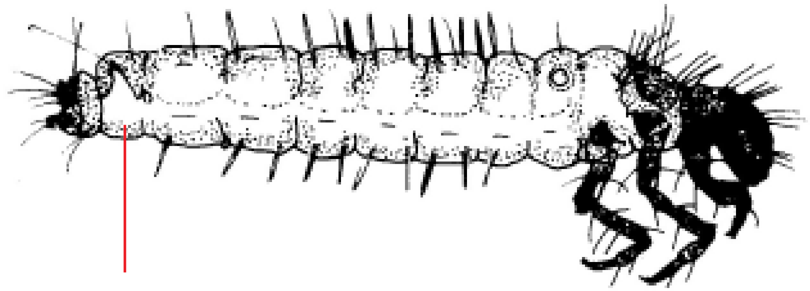
Thorax not as above…………..…….**13**

13. Larvae makes cases decaying leaves and twigs; abdominal segment I with dorsal and lateral humps; anterior corners of pronotum project forward; Labrum with a transverse row of 15-20 stout setae; mesonotum with a pair of anteriolateral sclerites and a larger central plate; metanotum almost entirely lacking sclerotisation…………...............................….……..**Calamoceratidae**



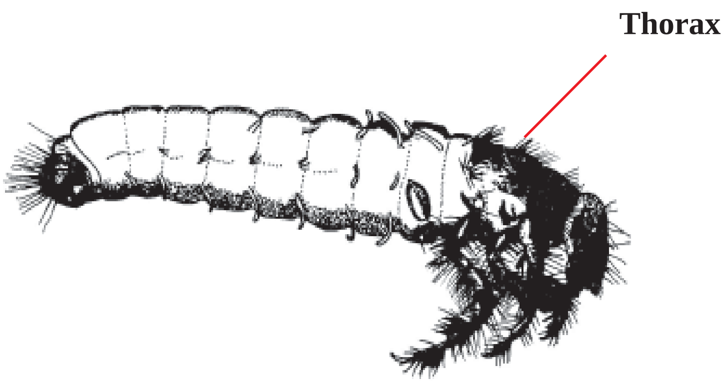
Labrum not like above; without the above combination of characters……....**14**

14a. Larval case square in cross-section and made of panels cut leaves; antennae situated close to the anterior margin of the eye; abdomen with out dorsal hump on segment I; prosternal horn present; abdominal segment VIII with a fleshy lateral lobe on either side……………………..**Lepidostomatidae**



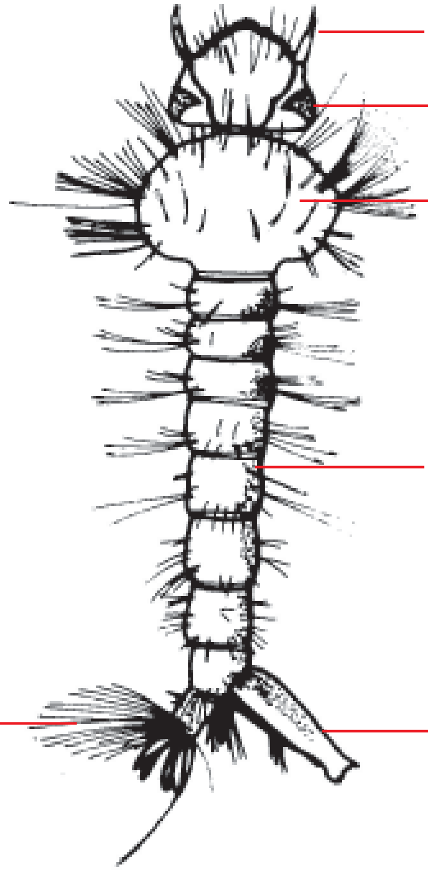
Lateral fleshy lobe

14b. Larval cases of rock fragments or detritus, often resembles pipe; anterior margin of the metanotum with a pair of sclerites; mandibles almost always toothed; gills consist of single or multiple filaments …………….**Limnephilidae**



Space for Field Notes on Caddiesflies (Trichoptera)

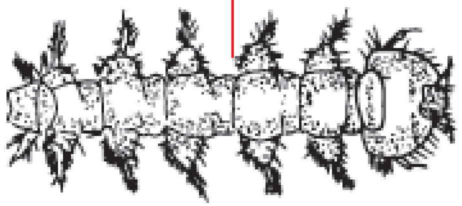
Key to Larval Flies (Diptera)



1.Larvae with a sclerotized head capsule; mandibles move laterally ……..**Suborder: Nematocera**…….**2**

Larvae without capsule or it is partially formed; mandibles move vertically and they are hook-like; prolegs sometimes (but not always) absent and body may be pale and maggot-like ……………..**Suborder: Brachycera**……................….**6**

2. Body segments appears to be deeply constricted with seven segments; conspicuous ventral sucker present on first six 'segments'…..**Blephariceridae**



Abdomen without ventral suckers; prolegs present or absent...........................**3**

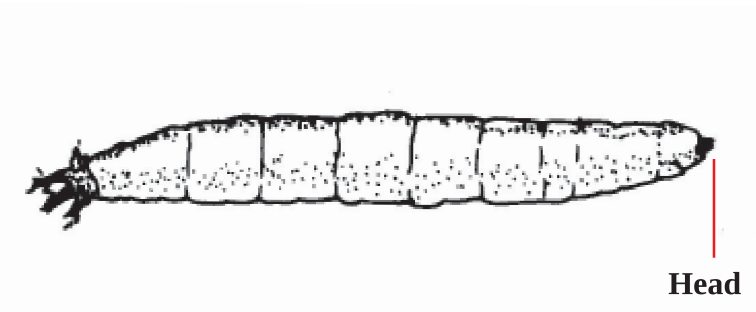
3. Prolegs absent..**4**

Prolegs present...**5**

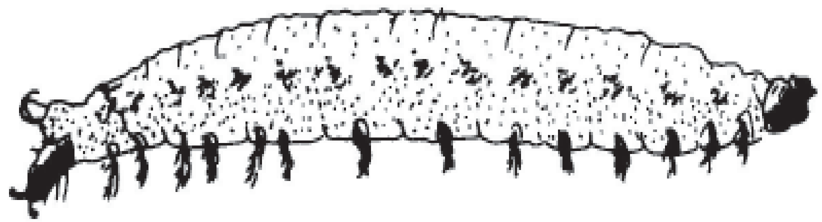
4a. Body segments secondarily segmented; head capsule strengthened only by sclerotized rods...**Ceratopogonidae**

Head capsule well sclerotized or, if strengthened only with sclerotized rods, then body segments not secondarily segmented

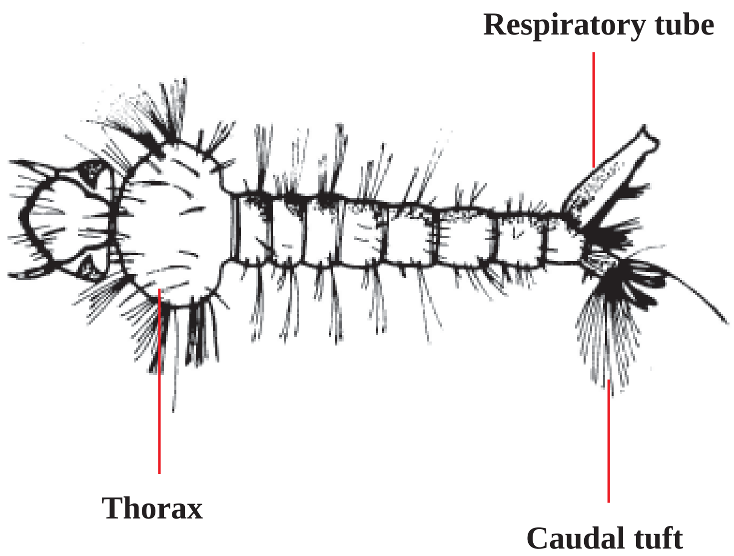
4b. Head capsule with incomplete posterior margins and retracted into body cavity...**Tipulidae**



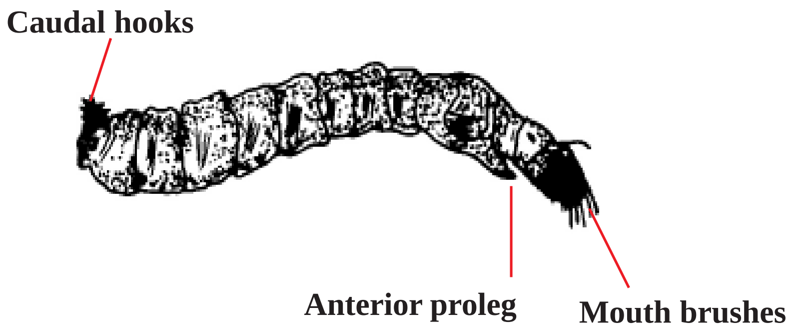
4c. Ventral suckers may be present; thoracic and abdominal segments divided up by one or more annuli; dorsal sclerites may be present.. .... **Psychodidae**



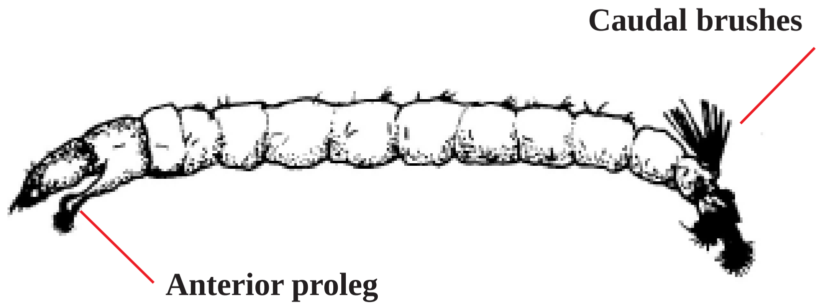
4d. Thorax disc like and wider than abdomen. Thoracic and abodminal segments with tufts of setae. Prominent mouth brushes present..........................**Culicidae**



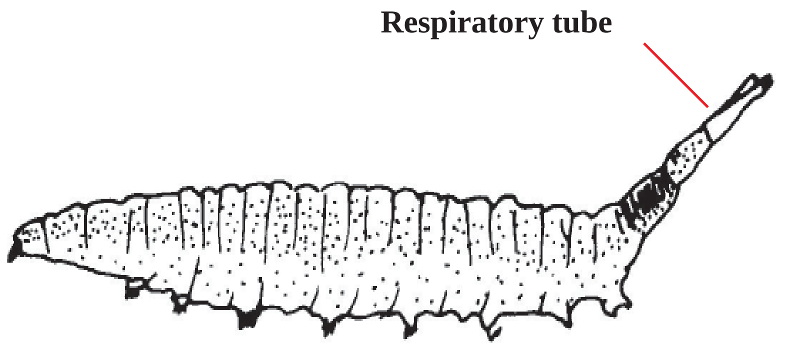
5a.A single proleg on the prothorax, and no posterior proleg(s); body club-shaped, posterior end swollen with a ring of tiny hooks at the tip….**Simuliidae**



5b. Posterior and anterior prolegs paired (although the anterior pair may be fused partially); widespread and abundant……………..............…**Chironomidae**

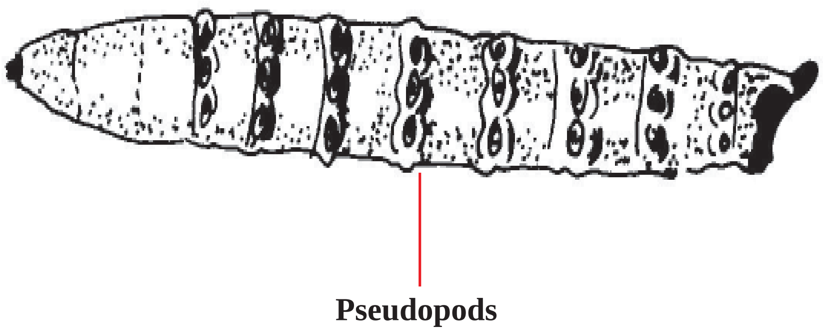


6.Body ends in a short respiratory tube that is divided at the apex..**Ephydridae**



Respiratory tube lacking………...………….**7**

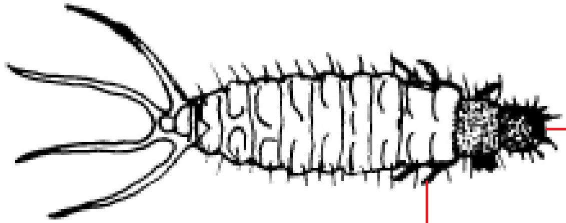
7. Abdomen without distinct prolegs but with a girdle of at least six pseudopods around each segment…..……**Tabanidae**



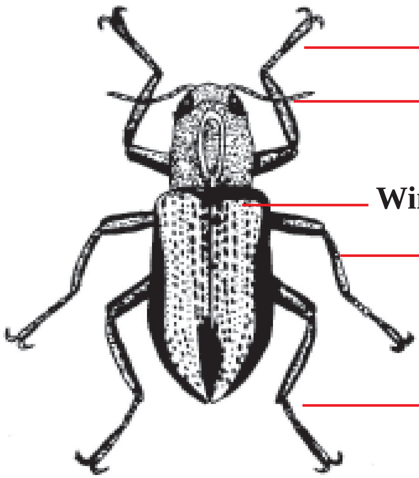
Space for Field Notes on Flies (Diptera)

Key to Aquatic Beetles (Coleoptera): Larvae and Adult

Larvae



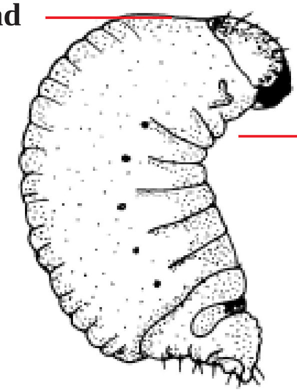
Adult



1.Membranous wings covered by hardened wing covers (elytra) which overlay the abdomen ………...…….. **Coleoptera- Adult 10**

Wings and elytra absent……………........................……**Coleoptera- Larvae.…..2**

2.Associated with aquatic macrophytes; legs absent or minute; thorax and abdomen short………………………..….. **Curculionidae**

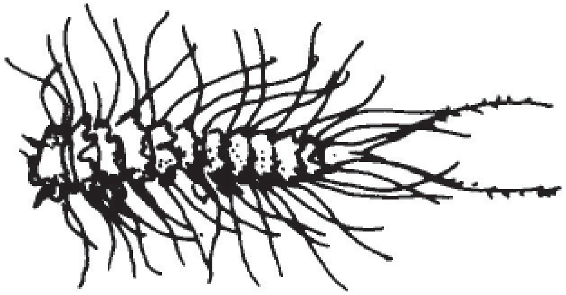


Not confined to aquatic macrophytes; Legs present and well defined.......…..**3**

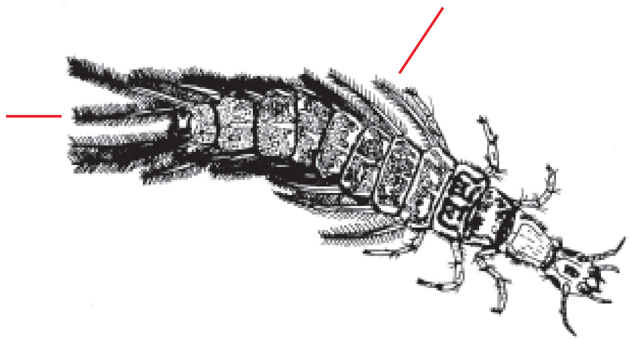
3. Legs with a single tarsal claw…..….………….**4**

Legs with two tarsal claws………...…………….**5**

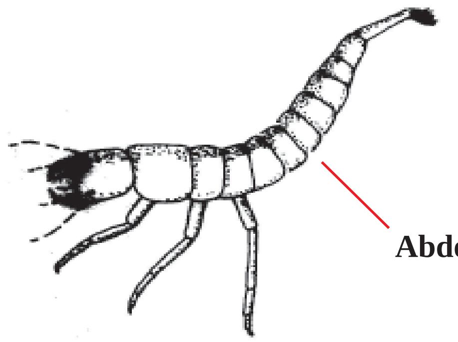
4. Body elongate and tapered posteriorly; legs with five segments (excluding claw) ……………………………………………………………………….**Haliplidae**



5a. Lateral gills present on abdominal segments I-IX; two pairs of stout hooks at the tip abdominal segment X ……………………………………….**Gyrinidae**

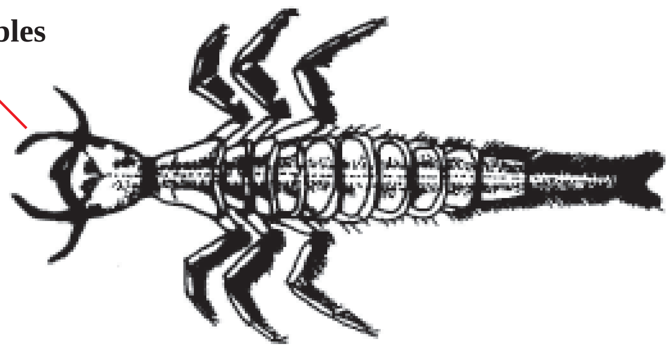


5b. Lateral gills are absent; abdomen eight segmented without terminal hooks; Abdominal segment VIII with a pair of large terminal spiracles; Cerci on the tip of the abdomen are slender and usually much longer than abdominal segment-I………………………………………………………………..**Dytiscidae** (in part)



Cerci either short and stout or absent……………………………………………….**6**

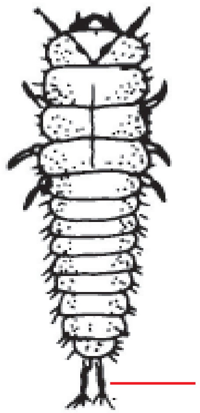
6a. Legs short and slender, and may be adapted for swimming; mandibles sickle shaped…………………………………………………………..**Dytiscidae** (in part)



6b. Legs short and stout and adapted for digging; mandibles not sickle-shaped………...……………….**Noteridae**

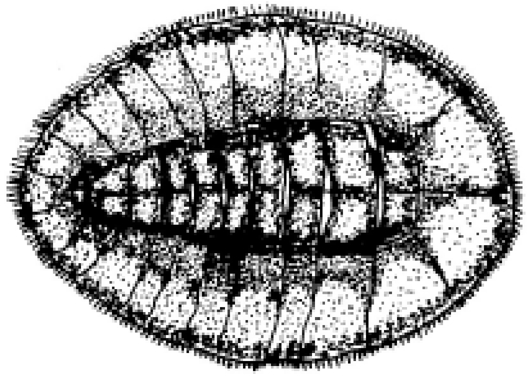
Without the above combination of characteristics ………….........................……**7**

7. Abdominal segment X with a minute pair of recurved venteral hooks; segment IX has a pair of two segmented articulated cerci……….**Hydraenidae**

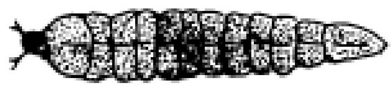


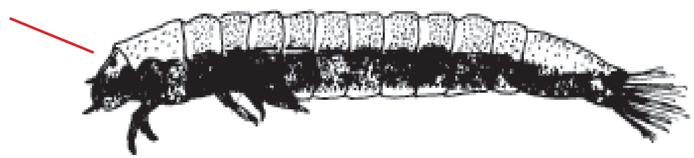
8.Head and legs visible when viewed from above; body cylindrical …………..**9**

Head and legs not visible when viewed from above; body greatly flattened like a disc…………..………**Psephenidae**

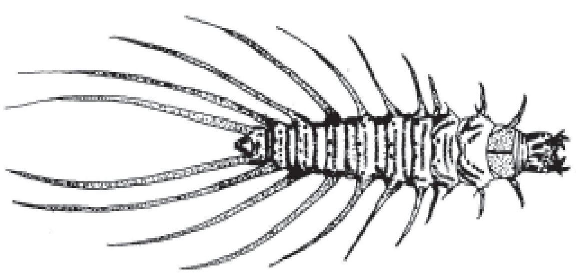


9a.Head capsule with groups of five lateral ocelli; abdominal tip distinctly pointed, bifid or notched with – often with– lateral ridges or longitudinal crests ………………..…………….**Elmidae**

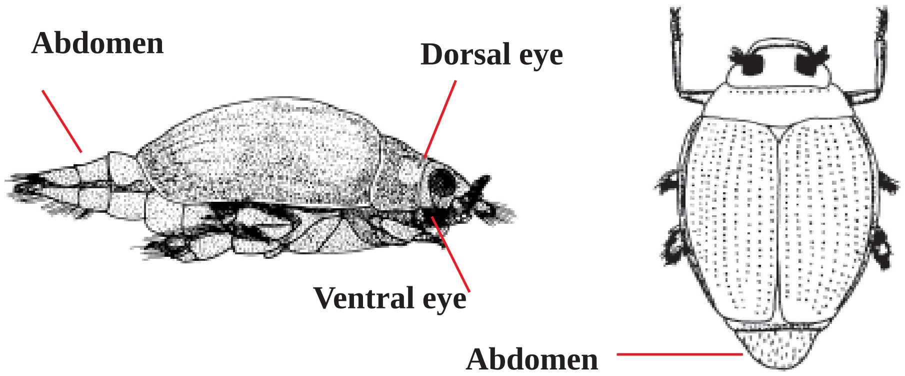




9b. Head capsule with groups of six ocelli (five lateral and one ventral) or without ocelli; abdominal tip rounded; antennae arise behind the insertion point of the mandibles………...…….**Hydrophilidae**

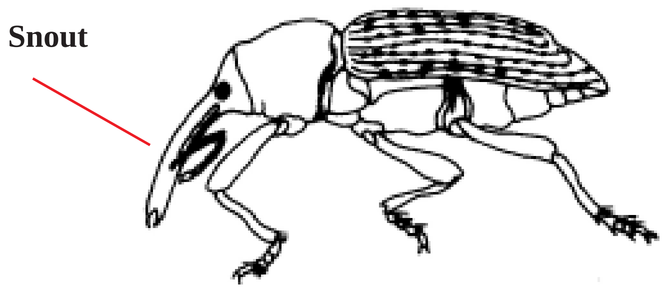


10. Eyes divided into dorsal and ventral portions; forelegs long and raptorial, mid- and hindlegs short and paddle- like; antennae stout and club-shaped; lives on water surface …………………….....................................….**Gyrinidae**



Eyes undivided; form of legs and antennae various but not as above; aquatic or semiaquatic but never on water surface…….................……………………..**11**

11.Head with elephant's trunk like anterior prolongation or snout..**Curculionidae**

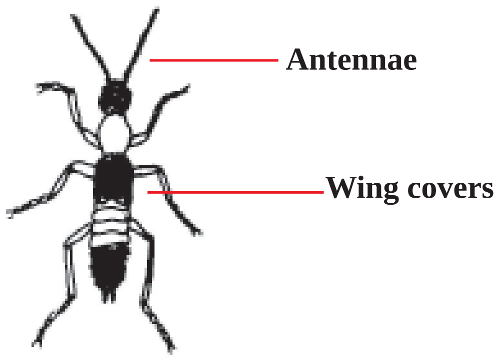


Head not produced into a snout………...…….**12**

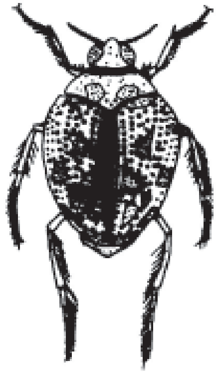
12.Elytra short and partially covers the dorsal surface of the abdomen…….**13**

Elytra covering entire dorsal surface of the abdomen……...............................….**14**

13. Semi aquatic; metallic or iridescent beetles; antennae with more than eight segments…..……….**Staphylinidae**

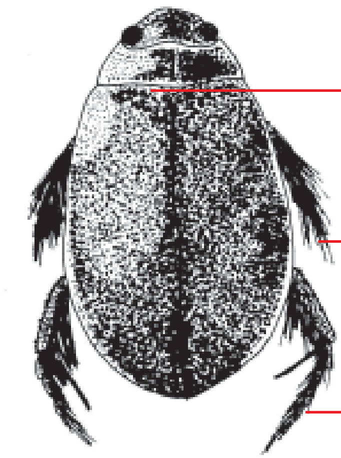


14. Abdominal segments I-III covered by plate like expansion of hind coxae ……………………………………………………………………………………… **Haliplidae**

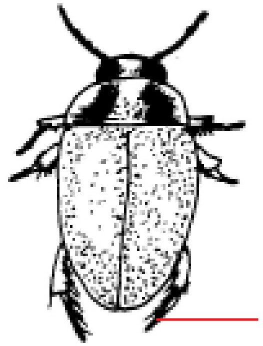


Hind coxae not expanded into plates but extend posteriorly to divide the first abdominal sternite……………………………………………………………………………**15**

15a. Eyes do not protrude; body convex shaped in cross section; hind tarsus with a single claw, if two claws are present, the mesoscutellum (a triangular plate lying mid-dorsally on the mesothorax between the elytra) is large and exposed ……………………………………………………………………………**Dytiscidae**



15b. Hind tarsus with two claws; mesoscutellum concealed; dorsal surface more strongly convex than the ventral surface…………………………**Noteridae**

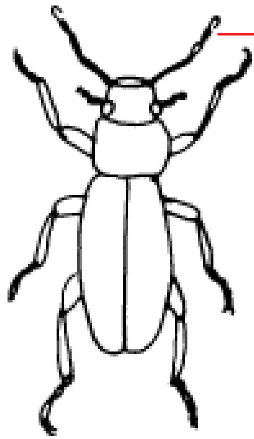


Not with above combination of characters……………………………………**16**

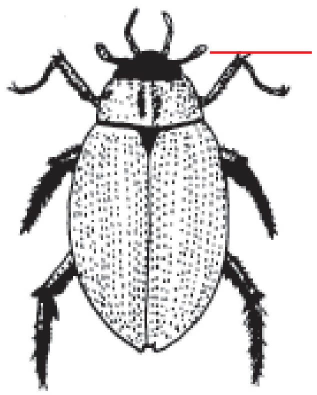
16. Tips of antennae an abrupt globular or elongate club……………………**17**

Tips of antennae do not form a club……………………………………………**18**

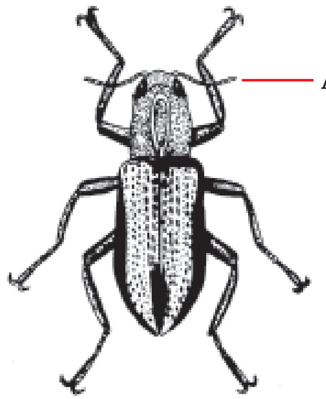
17a. Antennal club made up of five segments; abdomen with six or seven segments visible on the underside……………………………………**Hydraenidae**



17b. Antennal club made up of three segments with five segments before the 'club'; abdomen with five segments visible on the underside; fore tarsi with five segments. Pronotum broadens posteriorly; eyes prominent or not……..…..**Hydrophilidae**

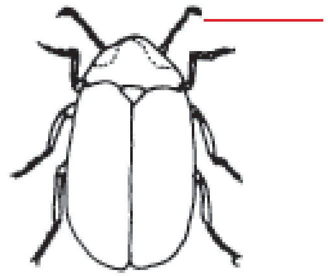


18. Abdomen with six or seven segments visible on the underside; antennae filiform and concealed within the prothroax and never longer than the combined length of head and prothorax; body heavily sclerotized……..**Elmidae**

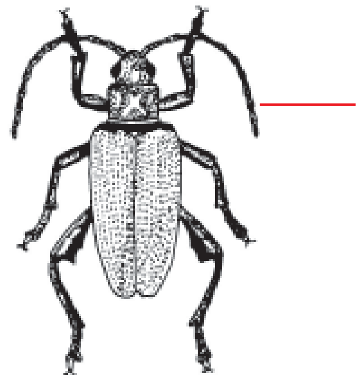


Antennae longer than the combined length of head and prothorax…..............**19**

19a. Antennae somewhat comb-like; broadly oval and somewhat flattened weakly-sclerotized beetles with less than 10 mm body length; antennae inserted between the eyes……...…..**Psephenidae**



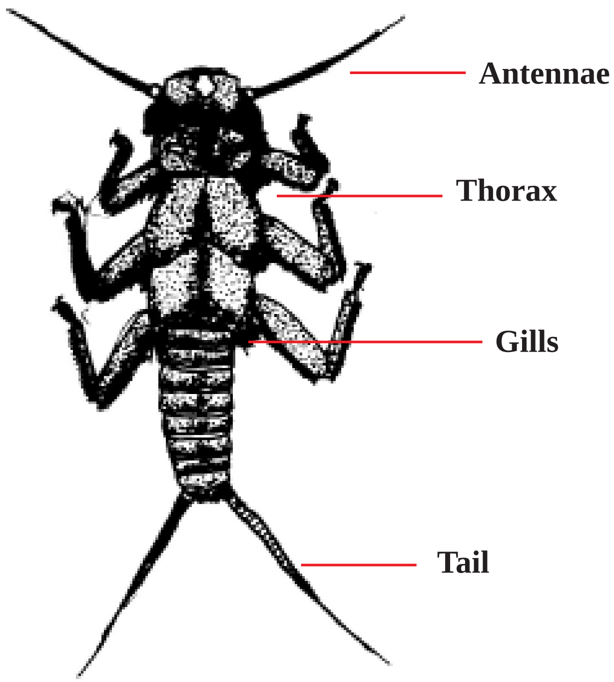
19b. Antennae slender and longer; mandibles inconspicuous, directed venterally; brightly coloured, metallic or iridescent beetles; semiaquatic and associated with aquatic plants…………......................................…..**Chrysomelidae**



Space for Field Notes on Aquatic Beetles (Coleoptera)

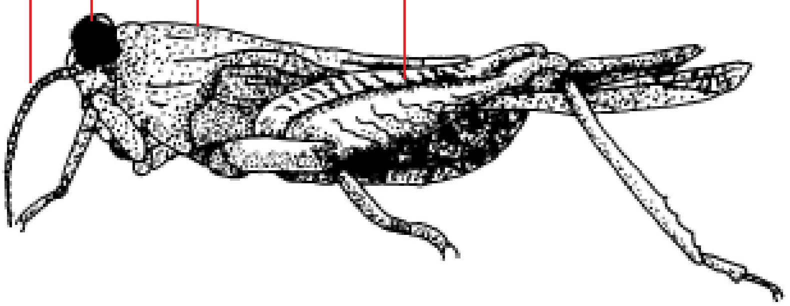
Key to Larval Stoneflies (Plecoptera)

1. Larvae generally brown with yellow markings; branched thoracic gills are present; abdomen terminates in two tails..............................**Perlidae**

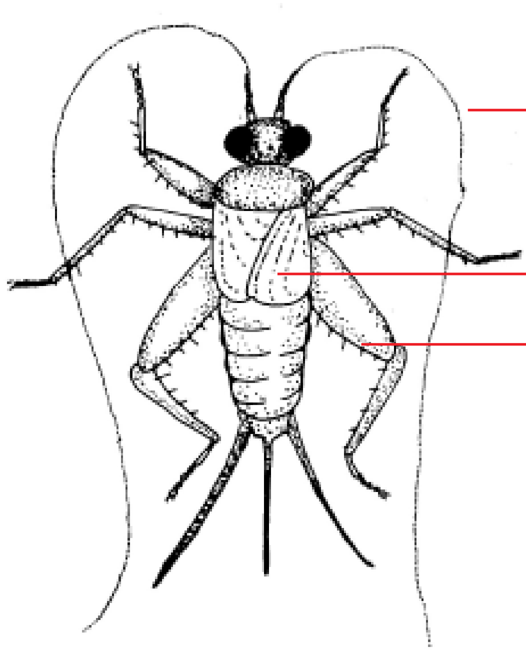


Key to Semi-aquatic Grasshoppers and Crickets (Orthoptera)

1. Hind femora enlarged and adapted for jumping; body laterally compressed; throax drawn into a long spine over the abdomen; eyes dorsally placed..**Tetrigidae**

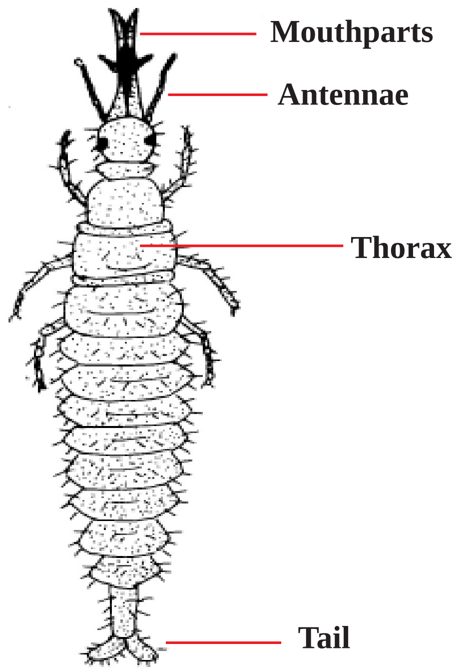


2. Body dorso ventrally compressed; antena longer than the body and thread like; wings absent or reduced...................**Gryllidae (Nemobinae)**



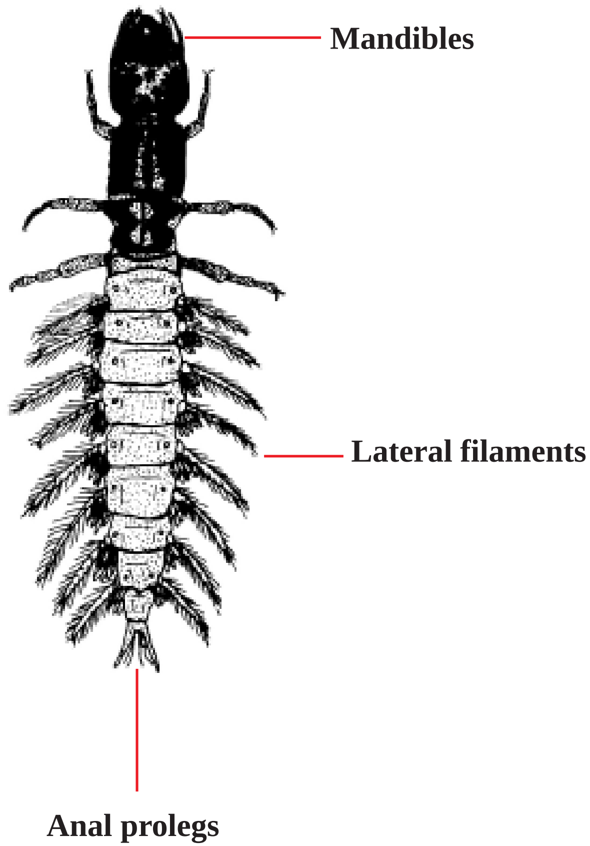
Key to Spongillaflies (Neuroptera)

1. Body covered with small bristles; antenna long; mouth parts needle like; wings pads and tails like structures are absent..................**Sisyridae**



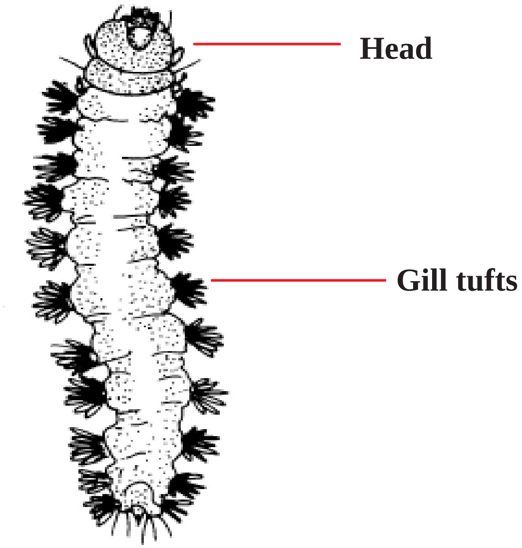
Key to Alderflies (Megaloptera)

1. Abdomen with eight pairs of lateral filament and hooked anal prolegs; mandibles large and conspicous..**Coridalidae**



Key to Aquatic Moths (Lepidoptera)

1. Abdomen with gill tufts and pseudo legs; associated with aquatic plants..**Pyralidae**



Space for Field Notes on other Aquatic Insects (Odonata, Plecoptera, Orthoptera etc.)