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DIVISION OF STRUCTURES AND ENGINEERING SERVICES
TRANSPORTATION LABORATORY
WATER QUALITY MANUAL

A Simplified Taxonomic Key To The Families Of California Aquatic Insects

FINAL REPORT

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16. ABSTRACT

This manual was compiled to facilitate the identification by transportation environmental personnel of the orders and families of selected aquatic insects found in California. The keys are simplistic with illustrations for use by personnel not trained in biology and unfamiliar with entomological terminology and techniques.

Field and laboratory procedures for processing of collected insect materials are discussed. Taxonomic keys to the orders and families of aquatic insects are presented. The keys will allow the identification of fairly well developed immature aquatic insects. There is a short synopsis of general information for each order. Additionally there is a discussion of some ecological information for the families covered by this manual.

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OFFICE OF TRANSPORTATION LABORATORY

August 1976

FHWA No. 2-D-4
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Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have reviewed and now submit for your information this final research project report titled:

A SIMPLIFIED TAXONOMIC KEY TO THE FAMILIES
OF CALIFORNIA AQUATIC INSECTS

Study made by .....Envirochemical Branch

Under the Supervision of.....Earl C. Shirley, P.E.

Principal Investigator .....Richard B. Howell, P.E.

Co-Investigators.....Gary R. Winters and George R. Leidy

Report Prepared by.....Gary R. Winters and George R. Leidy

Very truly yours,

George A. Hill

George A. Hill
Chief, Office of Transportation Laboratory

Attachment

ACKNOWLEDGEMENTS

This manual is a compilation of many existing figures and illustrations. The authors would like to thank B.D. Burks (1953) for use of his Ephemeropteran illustrations, M. Wright and A. Peterson (1944) for their Odonata figures, P.W. Claasson (1931) for the use of his Plecopteran drawings and R.L. Usinger (1956) for the use of his fine Hemipteran figures.

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The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

During the course of environmental investigations, aquatic organisms may be studied to assess potential impacts from proposed projects and to evaluate the recovery of an ecosystem following construction. In order to effectively develop this information, it maybe necessary to collect and identify the aquatic macroinvertebrates found during field investigations.

Macroinvertebrates are defined as animals that are large enough to be seen with the unaided eye, are retained by a U.S Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings) and live at least part of their life cycles within or upon available substrates in a body of water or water transport system (EPA,1973). The major taxonomic groups included in freshwater are insects, annelids, molluscs, flatworms, roundworms, and crustaceans.

Normally Caltrans studies the insect portion of the macroinvertebrate populations. The macroinvertebrate community, with its substantial insect segment, is very sensitive to environmental stress. Monitoring of this community is an effective method for detecting environmental change. An analysis of macroinvertebrate communities can yield water quality information not always available through physical and chemical measurements.

Macroinvertebrates are relatively large, have limited mobility and usually have a long life span. As a result, these organisms as aquatic communities are indicators of environmental conditions encountered during their development. This community can give investigators an indication of unfavorable or limiting conditions that have occurred prior to sampling.

When an organism is collected the investigator will wonder, "what is it?", usually meaning "what is its name?". The science of naming and classifying of all biological organisms is called Taxonomy. A different name is given to every known or discovered organism and the name acts as a reference point which must be known to find information about a particular organism. Currently there are over 1½ million different animals described and each must be given a different name to ensure its uniqueness in the literature. Add to these names the large number of plants in the world which also must be given names and it is easy to understand the necessity for long names and the problems they can cause the newly interested worker.

The necessity of a different scientific name for each organism becomes apparent when using everyday common names for animals. For example, on the Pacific Coast one species of salmon is known as king, silver, spring, dog, blackmouth, tyee, chinook and quinnat salmon. Scientific names get around the difficulty of multiple

common names. The scientific name of the king salmon is Oncorhynchus tshawytscha and this name will definitely identify this fish as a particular species of salmon. In addition, the scientific name is a classification system which is intended to show relationships as well as for identification.

While many of the larger and more common animals and plants have rather stable common names, at least for a particua geographic area, many of the smaller and less familiar organsims do not. As a result, many of the insects and other smaller animals and plants are referred to by their generic designation. For example, a small fly may not have a common name but is known as Chironomus, the name of its genus.

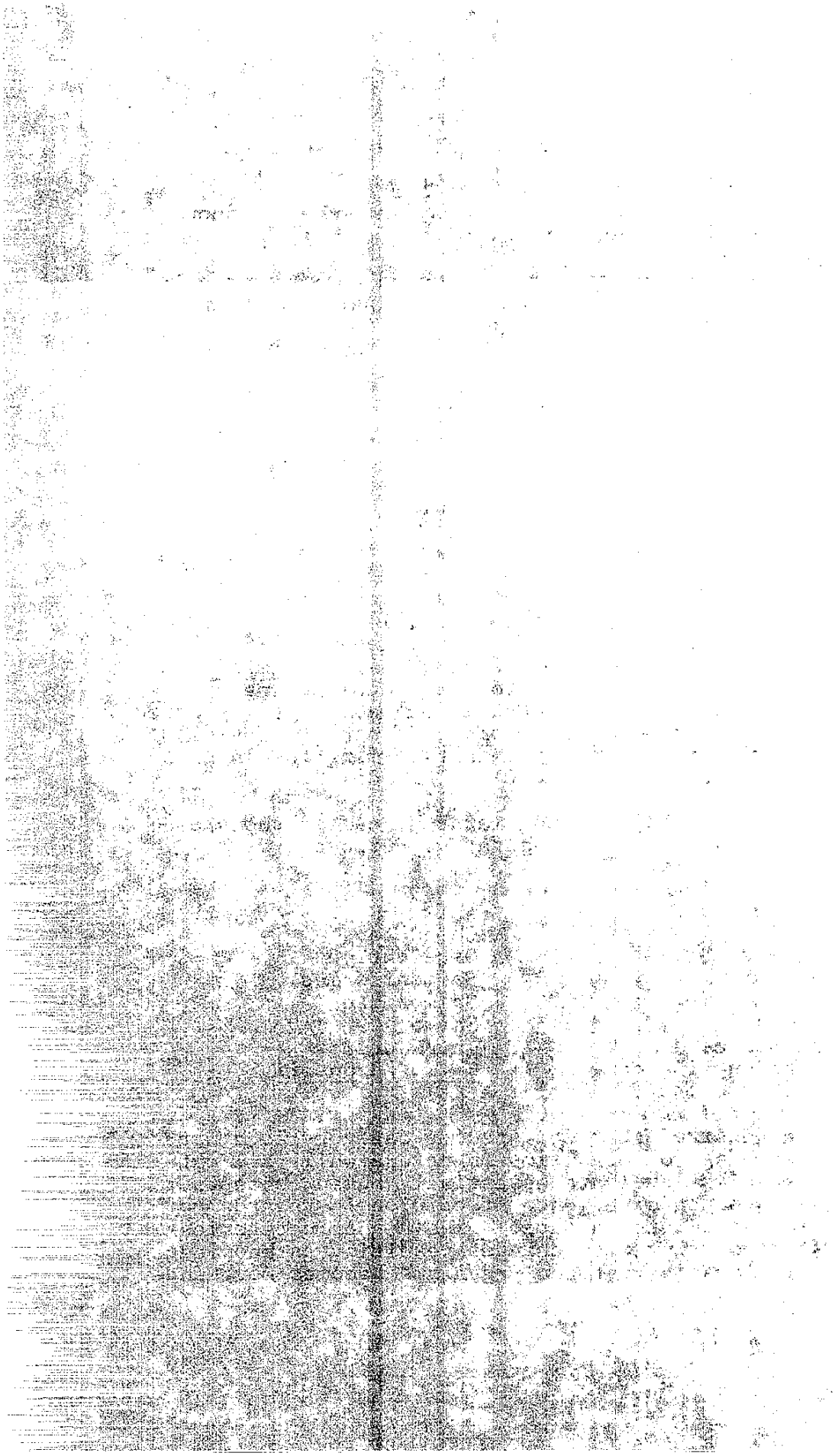
The system of biological nomenclature is used to name organisms and is based on a system of groups and super groups. The inherent pecularities or characters of organisms are the basis of this classification. The species is the basic building block of this classification and is defined as a group of natural populations which are reproductively isolated having many characters in common and differing from all other forms in one or more ways.

In the classification scheme similiar species with common characteristics are grouped into genera (singular: genus). Similiar genera with shared common characters are grouped into families while similiar families are grouped into more encompassing orders. As before, orders with particular characters in common are grouped into classes and similiar classes into phyla (singular: phylum) All of the animal phyla are brought together forming the Animal Kingdom, which is comparable with the Plant Kingdom.

An example of the classification hierarchy can be shown using the common Rainbow Trout for illustrative purposes:

Kingdom	Animal
Phylum	Chordata
Class	Osteichthyes
Order	Salmoniformes
Family	Salmonidae
Genus	Salmo
Species	gairdnerii
Scientific name	Salmo gardnerii

It should be emphasized that the species category is a naturally occuring assemblage of organsims in nature while all categories above the species level are essentially human concepts. As a result, there is often divergence of opinion in regards to how certain organisms should be grouped. The higher categories are always in a state of flux with changes resulting as knowledge accumulates and relationships between organisms becomes more understood.



This manual was compiled to facilitate identification of the orders and families of selected aquatic insects found in California. An attempt was made to keep the keys as simplistic as possible for use by personnel not familiar with entomological terminology and techniques. In cases where technical terms are necessary the user will find them defined in the glossary and illustrated where applicable.

The list of references at the end of this manual consist of many works that will serve as aides in identification processes. Many of these references have been used as a source of illustrations and technical assistance. The authors would like to thank the various publishers for the use of illustrations and drawings found in this compilation.

The keys found in this manual are based on the "dichotomy" concept, that is, they are arranged in couplets with each couplet consisting of a set of opposing characters. Examination of the specimen in hand will determine which of the two opposing characters in each couplet best describes the specimen. Each part of the couplet ends with a number directing the investigator to a new couplet. The process continues until the organism is identified.

Most often each couplet will have an accompanying illustration but be careful in using these aides. The illustrations were chosen to show general appearance of an order or family characteristic. The beginning worker should keep in mind the vast array of insect species (over 700,000 species of beetles alone), and the problem of variability. For example, some species of a family may have wings while others do not. Immature aquatic insects often do not look like later developmental stages or the adults. This key will allow the identification of fairly well developed immature aquatic insects.

It should be noted these keys do not follow a natural arrangement and the families are arranged in the manner in which they key out most easily. As a worker progresses in his identification ability, ordinal characters will become second nature and the worker will often dispense with ordinal keying and go directly to the family keys. Hopefully, most workers will progress to the point where families will be readily identified and the investigator will learn to key out the lower more numerous and difficult taxonomic catagories.

There will be cases where specimens being worked will be unidentifiable for one of numerous reasons. For example, damaged, very small, newly hatched, and terrestrial insects are unidentifiable in many cases. In some instances the key will not be adequate for the identification of some rarer insect groups. If you are unable to key a specimen, assistance can be obtained from the Biology Unit at the Transportation Laboratory (Translab).

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FIELD AND LABORATORY PROCEDURES

General

As in all environmental impact studies, the macroinvertebrate study must be carefully thought out and planned to be a success. Ideally, the design of these studies should be based on study objectives which may have to be tempered by available resources, time limitations and the type of area to be studied.

Information for designing a study, selecting sampling methods, equipment and data evaluation can be found in the Federal Highway Administration's Final Report, Water Quality Manual, VOL. V, "Chemical, Bacteriological, and Ecosystem Analysis of Water from Highway Sources for Environmental Impact Studies". Further information is very well presented in EPA's, "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents"(1973), and the United States Geological Survey's "Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples"(1973). The American Public Health Association's, "Standard Methods for the Examination of Water and Wastewater (14th ed.)"(1975), has additional information.

Field Procedures

When field samples are taken by one of the many sampling devices and methods available, they should be preserved immediately in the field. If subsequent sorting will be accomplished very shortly after sample acquisition,preservation can be deferred until that time. When selecting the collection container, the appropriate sized container is a must. Collection containers should be filled no more than one-half full of sample material (not including preservative). This will ensure an adequate preservative to sample ratio for complete preservation. The appropriate sized container will minimize sloshing and possible damage to collected organisms.

The aquatic stages of nearly all insects are usually best preserved in vials of 70 to 80 percent ethyl alcohol (ethanol). If ethyl alcohol is unavailable, 40 percent isopropyl alcohol (rubbing alcohol) will suffice until ethanol can be secured. If the specimens are not to be examined for a period of time, replacement of the original preserving fluid after two or three days with fresh ethanol is recommended. Formalin is not recommended as a preservative.

Labeling

Each sample must be labeled for proper identification in the laboratory. Labeling must be done at collection time. Sample labels of water-resistant paper should be placed inside the sample container. If the container is too small, the label should be secured to the outside of the container. All information should be written in soft lead pencil or some absolutely water proof ink.

Minimum information required on the sample label is a sample identification (log) number. The log number identifies the sample in a field notebook where the name of the water body, station number, date, sampling device used, name of collectors, substrate characteristics, and other environmental information are placed. An example of an aquatic field notebook sheet, and a field sample label are in the appendix.

Sorting and Subsampling

Once a sample is taken, the organisms must be removed and separated from extraneous materials. Laboratory sorting of insects can be time consuming and tedious. The authors have found preliminary sorting in the field to be an effective method to reduce laboratory processing time. As a sample is taken, the sample or a small portion of the sample, is placed in a white enamel laboratory pan or tray filled 1/3 full of water and the organisms picked as they contrast themselves with the white background. Through dispersion of the s mple in the water will facilitate sorting procedures. Field picking or sorting is sometimes not possible due to time limitations and/or inclement weather.

Many samples, especially benthic samples, contain large numbers of organisms. Sorting time can be reduced considerably by subdividing the sample before laboratory analysis. Before sorting, the entire sample is evenly distributed on the bottom of a laboratory pan or tray. The pan is divided into equal quarters and opposite quarters sorted.

As organisms are picked from extraneous materials they should be separated into similiar groups. Very quickly the worker will be sorting out the mayflies, beetles, etc., into aggregations. Once the major groups are sorted the many different types of insects in each major group can be further broken down into similiar sub-groups (families). Each similiar group or type of insect should be kept in separate alcohol filled vials and labeled (log number) for later identification. A laboratory taxonomic bench sheet is helpful in keeping records and identifications in a coherent form. An example of a laboratory bench sheet can be found in the appendix.

Data

Recorded macroinvertebrate data should include:

1. Collection Method- quantitative or qualitative?
2. Biomass (standing crop)- Weight of organisms per unit area.
3. Number of taxonomic categories (taxa) represented.
4. Percentage composition of each taxon.
5. Total number of organisms per taxon and total sample.
6. Number of sampling replicates.

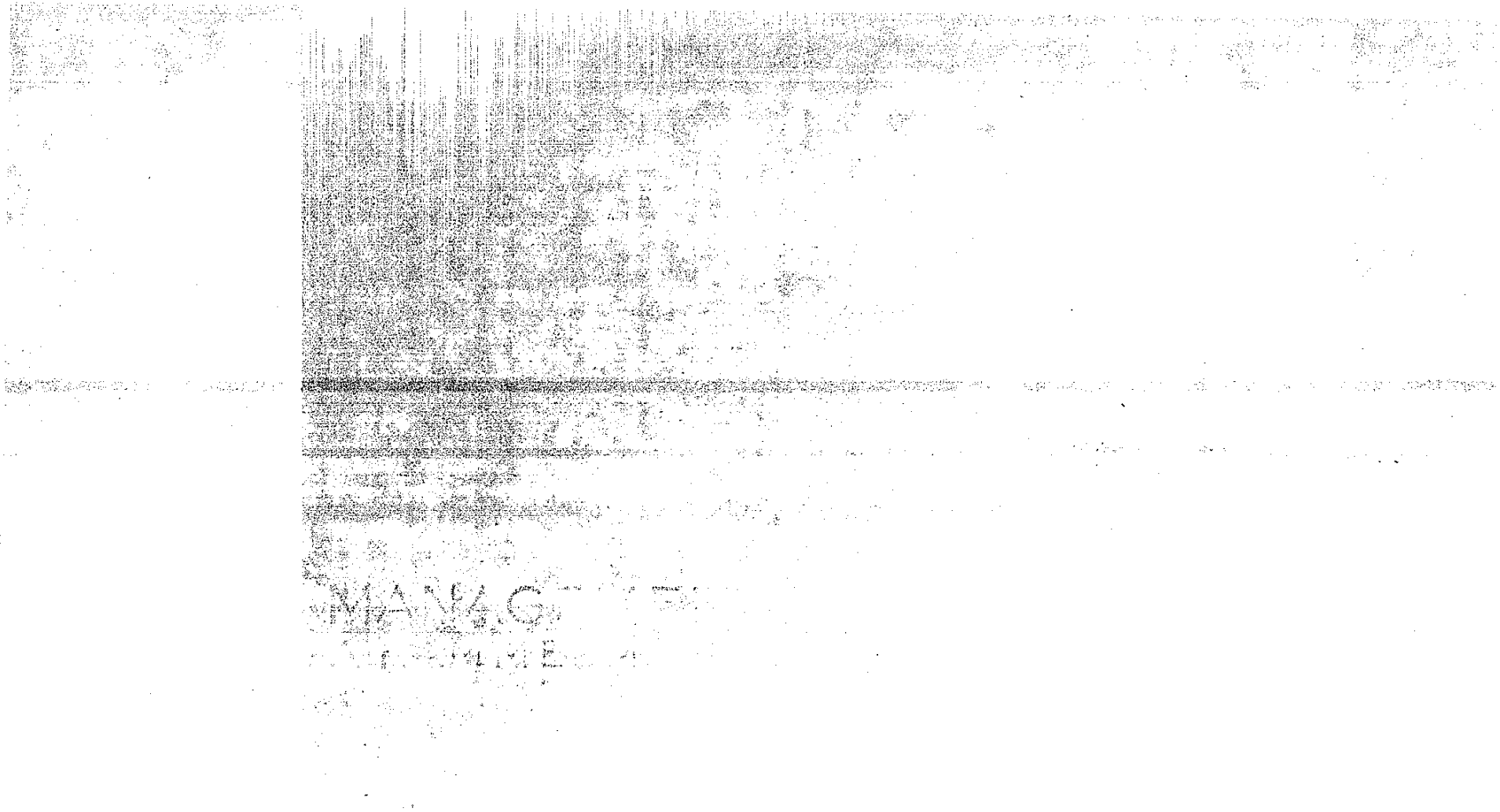
Keying Instructions

The first section of this key is to the orders of aquatic insects. In using the key, couplets are given which give the worker a dichotomous choice. For example, beginning with the "Key to the Orders of Aquatic Insects" (page 1), the worker starts with couplet 1. Couplet 1a, "wings or developing wings present", if so proceed to couplet 2. If the insect has "no evidence of wings or wing development", proceed to couplet 26. If the specimen in question has wings of some type couplet 2 will give you a choice of "wings developing as external flaplike appendages (wing pads); broad base of attachment to the thorax, wings non-functional" or wings well developed and functional". If the specimen had wings which were well developed you would proceed to couplet 3, if not, proceed to couplet 15. Continue using the key in this manner until the "order" of the aquatic insect is determined.

The key to the "families" of aquatic insects begins on page 10 and the procedure for using these keys is the same for the "order" determination. An example, for the identification of the order and family of an aquatic Stonefly (Plecoptera, Perlodidae) follows:

1a Wings or developing wings present..... 2
1b No evidence of wings or wing development..... 26

2a Wings well developed and functional..... 3
2b Wings developing as external flaplike appendages (wing pads); broad base of attachment to the thorax; wings non-functional..... 15



15a Body mummy-like with appendages encased in sheath which may be free or fused to the body..... 16
15b Body not mummy-like.....(21)

21a Hind femora greatly enlarged for jumping.... ORTHOPTERA
21b Hind femora not greatly enlarged for jumping.....(22)

22a Mouth parts form a piercing-sucking beak..... HEMIPTERA
22b Mouthparts not forming a beak, developed for biting and chewing.....(23)

23a Labrum (lower lip) forms a scoop-like, extensible, elbowed, grasping organ..... ODONATA
23b Labrum not as above.....(24)

24a Tarsi with 1 claw; sides of abdomen usually with plate-like or leaf-like gills; 2 or 3 "tails" at the end of the abdomen..... EPHEMEROPTERA
24b Tarsi with 2 claws; sides of abdomen usually without plate-like or leaf-like gills; 2 "tails" at the end of the abdomen..... PLECOPTERA

In the case of the Plecoptera determination above, its characteristics fit couplets 1a,2b,15b,21b,22b,23b, and 24b. In the example the correct couplet portion is in parentheses to make them readily discernable.

To determine the family of the example proceed to page . A short discussion of the Plecoptera is followed on page by the "Key to the Families of California PLECOPTERA Nymphs". Using Perlodidae as an example, the keying sequence follows:

1a Glossae and paraglossae about equal in length..... 2
1b Glossae much shorter than paraglossae..... (4)

4a Profusely branched gills at the lower corner of the thorax.....PERLIDAE
4b Branched gills absent from the thorax..... (5)

5a Hind wing pads nearly parallel to the axis of the body; cerci not more than 3/4 length of the abdomen.....CHLOROPERLIDAE
5b Hind wing pads set an an angle to the axis of the body, cerci usually as long or longer than the abdomen.....PERLODIDAE

KEY TO THE ORDERS OF CALIFORNIA AQUATIC INSECTS

KEY TO THE ORDERS OF AQUATIC INSECTS

1a Wings or developing wings present (figs.1,9,44 53,104)..... 2
1b No evidence of wings or wing development (figs. 14, 67,69,71,144)..... 26 (nymphs)

2a Wings well developed and functional (figs.1-8,43, 98,104)..... 3 (adults)
2b Wings developing as external flaplike appendages (wing pads); broad base of attachment to the thorax; wings non-functional (figs.9,10,13,15,33,44,53)..... 15 (nymphs pupae)

3a Forewings horny or leathery, at least at the base (figs.43,53,104)..... 4
3b Forewings completely membranous (figs.1-8)..... 6

4a Hind femora greatly enlarged for jumping (fig.43)..ORTHOPTERA
4b Hind femora not greatly enlarged for jumping..... 5

5a Front wings without veination and forming a hard cover over the abdomen (fig.104).....COLEOPTERA
5b Front wings membranous at the tip and leathery at the base; mouthparts form a piercing-sucking beak (fig.53).....HEMIPTERA

6a One pair of wings..... 7
6b Two pairs of wings..... 8

7a Two or three long "tails" at the end of the abdomen (as in fig.1, buth with one pair of wings.....EPHEMEROPTERA
7b No "tails" at the end of the abdomen (fig.2).....DIPTERA

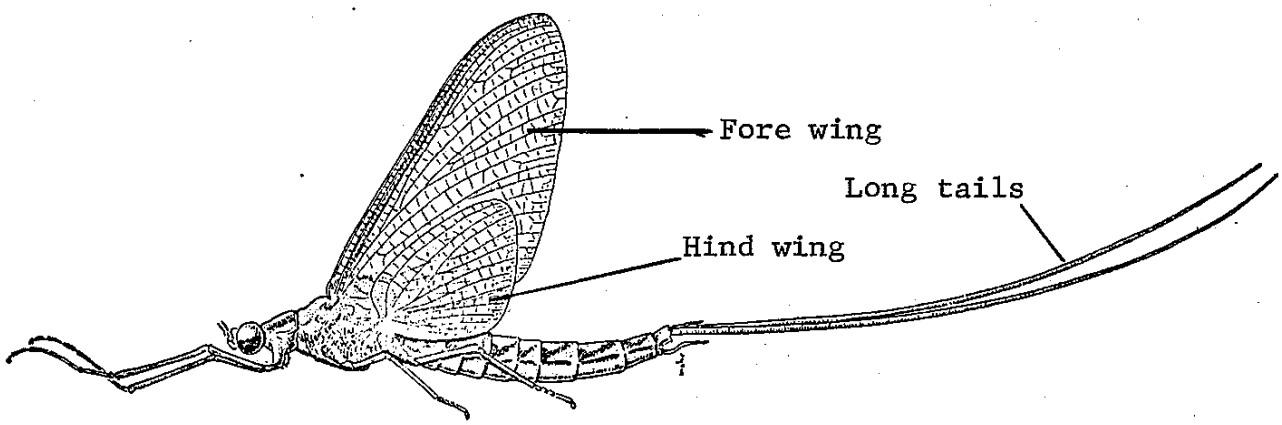


Fig. 1. Ephemeroptera
Adult in lateral view.

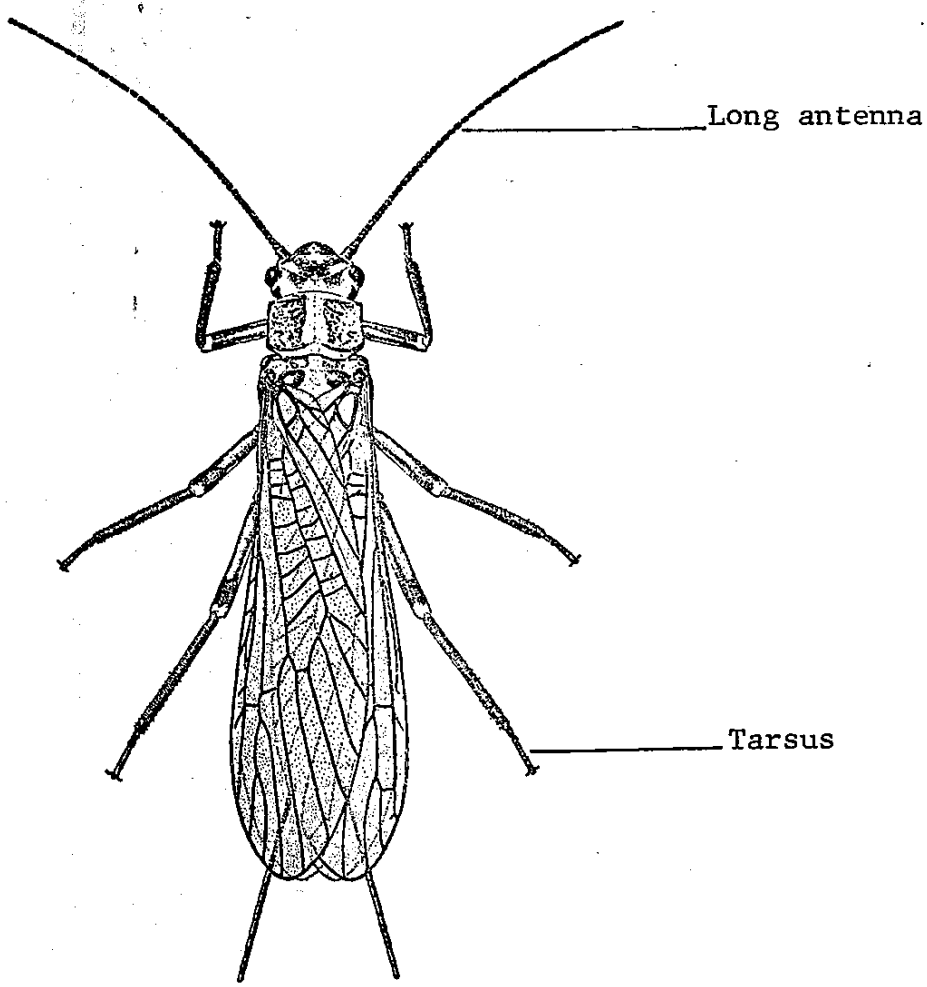


Fig.3. Plecoptera. Dorsal view of an adult. The two pairs of wings are folded over the body in this illustration. (Pennak, 1953).

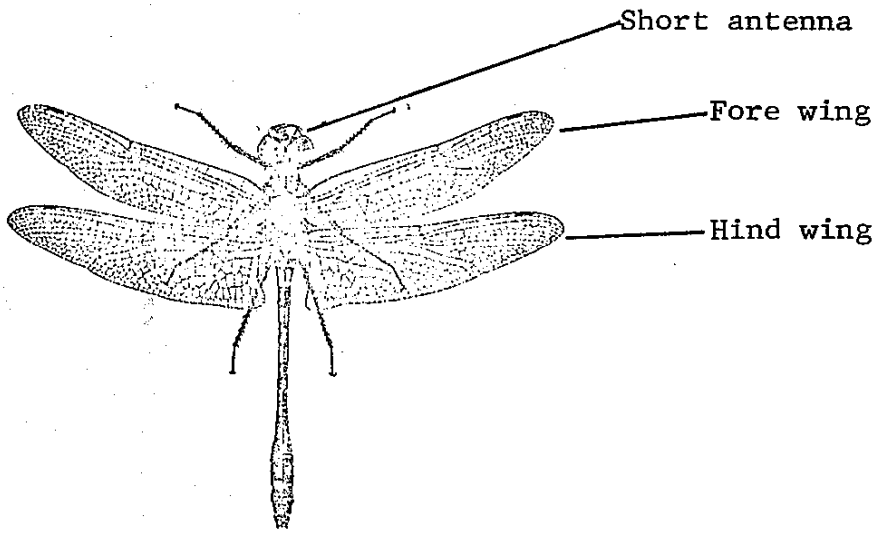


Fig. 4. Odonata. Adult in dorsal view. (Kennedy, 1915).

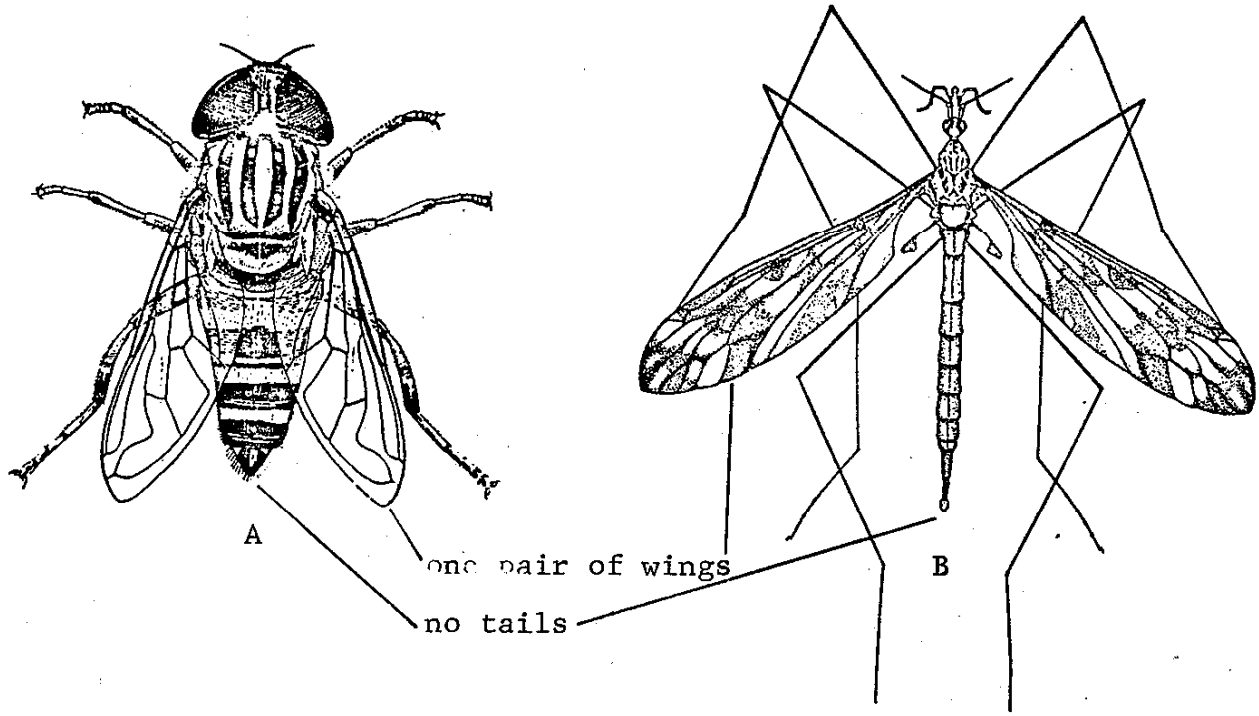


Fig. 2a,b. Diptera. Dorsal view of two species.*
(Williams,1939, b. Alexander in Curran,1934).

8a Abdomen distinctly constricted at the base and narrowly joined to the thorax (fig. 98) .....HYMENOPTERA
8b Abdomen broadly joined to the thorax 9

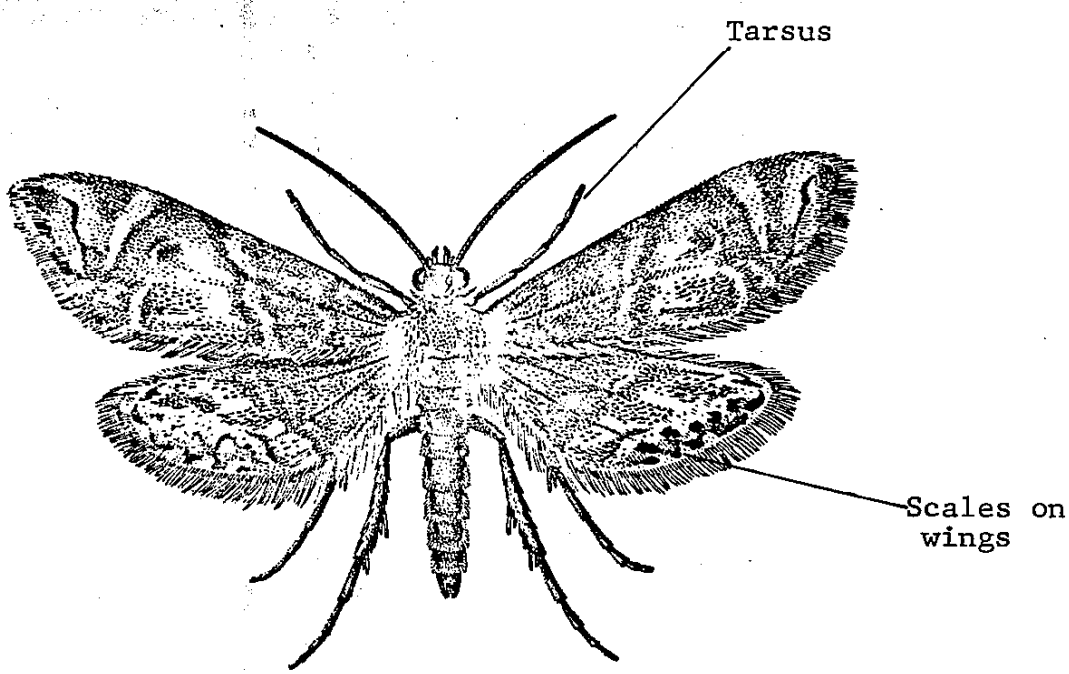
9a Tarsi 3-segmented (figs. 3,4) 10
9b Tarsi 4 or 5 segmented (figs. 5,6,7) 11

10a Two pairs of wings not equal in size; antennae long (fig. 3) .....PLECOPTERA
10b Two pairs of wings equal in size; antennae short (fig. 4) .....ODONATA

11a Wings covered by scales or hairs (figs. 5,6) 12
11b Wings with few scales or hairs (figs. 7,8) 13

12a Wings covered with scales (fig. 5) .....LEPIDOPTERA
12b Wings covered with hairs (fig. 6) .....TRICOPTERA

* Diptera possesses two pairs of wings but one pair is usually reduced to simple balancing organs called halter



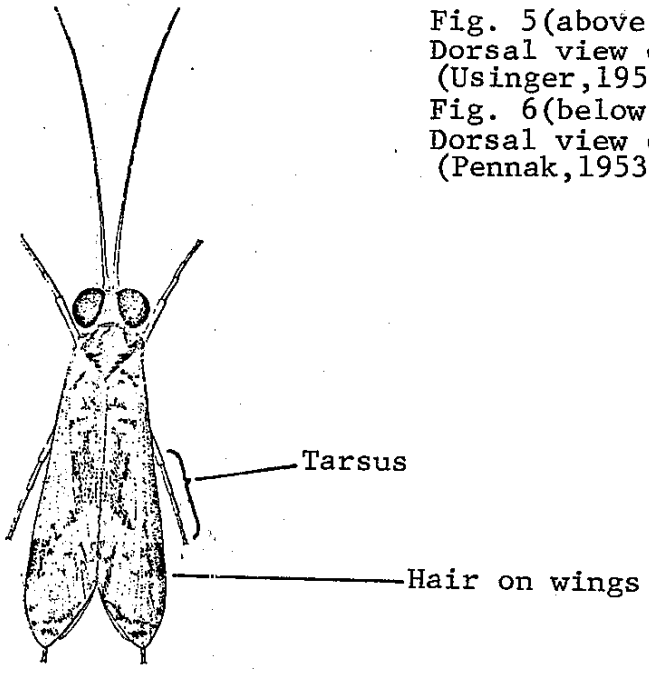


Fig. 5(above) Lepidoptera
Dorsal view of adult
(Usinger,1956).
Fig. 6(below left). Tricoptera
Dorsal view of adult.
(Pennak,1953).

13a Two pairs of wings about equal in size (figs. 7,8).....14
13b Hind pair of wings much smaller than the front pair of wings; 2 or 3 long "tails" at the end of the abdomen (fig. 1) .....EPHEMEROPTERA

14a Pronotum small and inconspicuous; wings folded tent-like over the body (fig. 7) .....NEUROPTERA
14b Pronotum large and conspicuous; wings folded along the body (fig. 8) .....MEGALOPTERA

15a Body mummylike with the appendages encased in sheaths which may be free or fused to the body (figs. 9,10 12,13) .....16 (pupae)
15b Body not mummylike and the appendages not fused to the body (fig. 15) .....21 (nymphs)

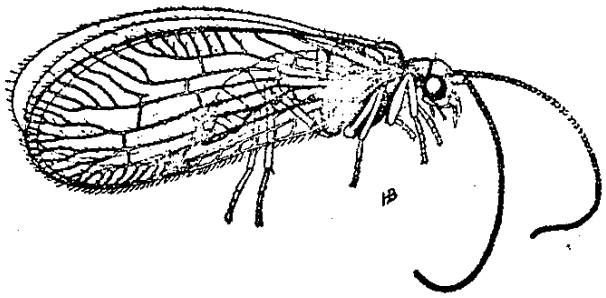


Fig. 7. Neuroptera
Side view of adult
(Brown,1952).

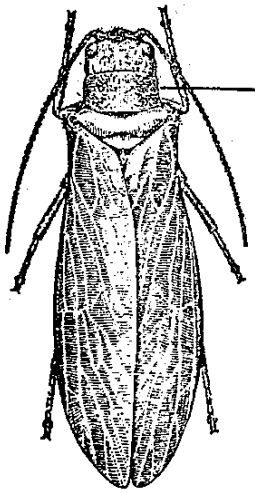
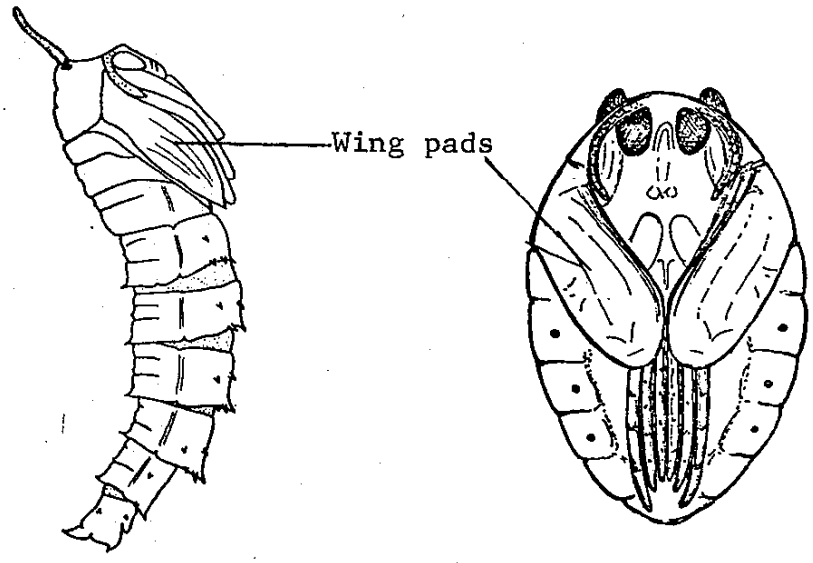


Fig.8. Megaloptera
Dorsal view of an adult
(Ross and Frisson,1937).

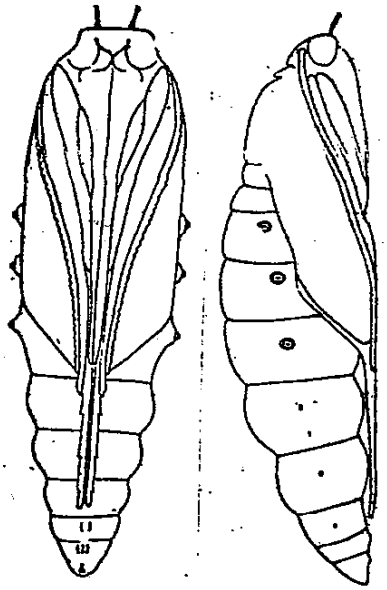
16a Body with 1 pair of wing pads (fig. 9).....DIPTERA
16b Body with 2 pairs of wing pads 17

17a Appendages (wing pads, antennae, legs) appearing to be fused to the body (fig. 10) .....LEPIDOPTERA



a b

Fig. 9a,b. Diptera. Side (a) and Front (b) views of two pupae.(Quate,1955).



a b

Fig. 10a,b. Lepidoptera. Front and side (b) views of a pupae. (Welsh,1916).

18a Abdomen with a paired series of plates bearing hooks; mandibles curved, usually projecting forward and crossing each other (figs. 11,12).....TRICOPTERA

18b Other abdominal characters; mandibles never overlapping or crossing each other 19

Fig. 11. Tricoptera. Front view of the head of a pupae. (Hickin,1967).

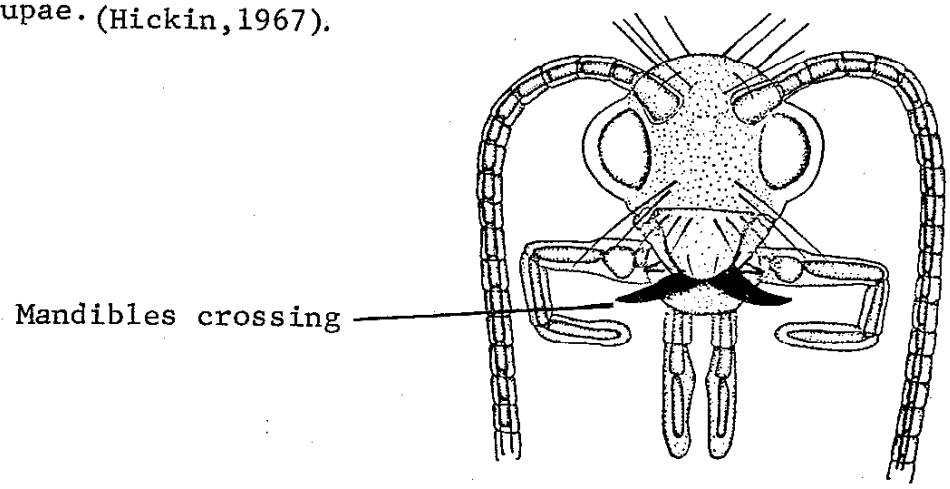
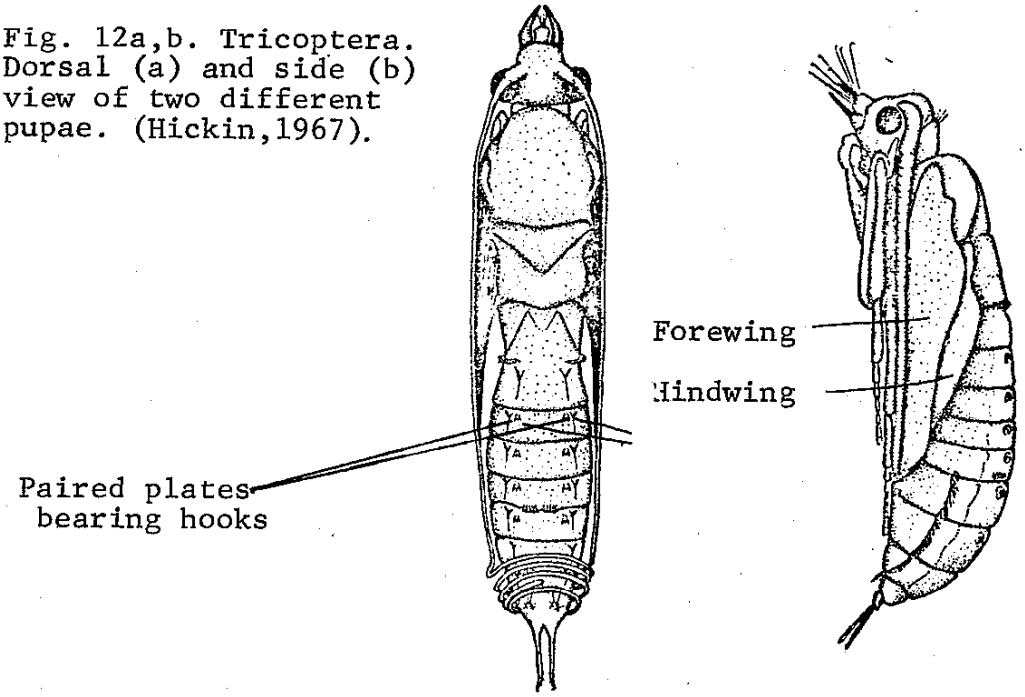


Fig. 12a,b. Tricoptera. Dorsal (a) and side (b) view of two different pupae. (Hickin,1967).



19a Pads of the fore wings thickened, leathery; antennae with less than 15 segments (fig. 13).....COLEOPTERA
19b Pads of the fore wings no thicker than the hind wing pads; antennae with more than 20 segments 20

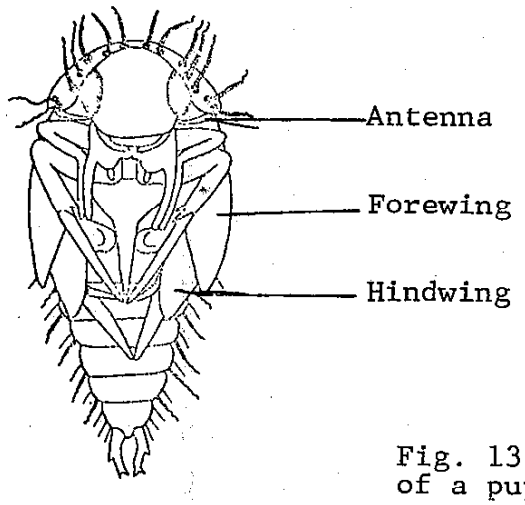


Fig. 13. Coleoptera. Front view of a pupa. (Wilson,1923).

20a Size small, 10 mm(millimeters) or less .....NEUROPTERA
20b Size large, 12 mm or more.....MEGALOPTERA

21a Hind femora greatly enlarged for jumping (fig. 43) .....ORTHOPTERA
21b Hind femora not greatly enlarged for jumping 22

22a Mouthparts forming a piercing-sucking beak (figs. 53,55) .....HEMIPTERA
22b Mouthparts not forming a beak, developed for biting and chewing 23

23a Labium (lower lip) forms a scooplike, extensible, elbowed, grasping organ (figs. 33,34) .....ODONATA
23b Labium not as above 24

24a Tarsi with 1 claw; sides of abdomen usually with platelike or leaflike gills; 2 or 3 "tails" at the end of the abdomen (figs. 15,32).....EPHEMEROPTERA
24b Tarsi with 2 claws; sides of abdomen usually with out platelike or leaflike gills; 2 "tails" at the end of the abdomen (fig. 44).....PLECOPTERA

25a Thorax without jointed legs; prolegs may be present on the ventral side of the prothorax and abdomen (figs. 139,144,153) .....DIPTERA
25b Thorax with jointed legs (fig. 69) 26

26a Abdomen with ventral "springing" apparatus; abdomen 6-segmented or less (fig. 14) .....COLLEMBOLA
26b Abdomen without a "springing" apparatus; abdomen with 6 or more segments 27

27a Mouthparts forming a long, slender, sucking tube about 1/2 as long as the body (fig. 69) .....NEUROPTERA
27b Mouthparts not forming a long, slender, sucking tube 28

28a Ventral side of the abdomen with at least two pairs of prolegs, each with a ringlet of small hooks around it (fig. 97) .....LEPIDOPTERA
28b No prolegs on the abdomen 29

29a End of the abdomen with terminal hook-bearing lobes (figs. 68,71,135) 30
29b End of the abdomen without terminal hook-bearing lobes 32

30a End of the abdomen with 1 median lobe bearing 4 hooks (fig. 135) .....COLEOPTERA
30b End of the abdomen with 2 lateral lobes, each bearing 1 or 2 hooks 31

31a Each lateral lobe with 2 claws (fig. 68) .....MEGALOPTERA
31b Each lateral lobe with 1 claw (fig. 71) .....TRICOPTERA

32a Tarsi with 2 claws; end of the abdomen with a long, slender, median process like a "tail" (fig. 67) ..... MEGALOPTERA
32b Tarsi with 1 or 2 claws; no slender, median process at the end of the abdomen (figs. 119,132) .....COLEOPTERA

Order: COLLEMBOLA
Common Name: Springtails

Springtails are primitive wingless insects that do not undergo metamorphosis. The transition from young to adult involves a change in color and an increase in segmentation of the appendages. Springtails are small, rarely reaching 10 mm in length. They inhabit stagnant water and rain pools, with a few species occurring along the intertidal area of the coast. Some springtails are bright red in color while others are colorless. These insects have no gills and obtain their oxygen by diffusion through the skin. Even though members of this family live in water they do not lay their eggs there. Their food consists of decaying plant and animal matter. The so-called "spring" from which the common name is derived is attached to the abdomen. It can be drawn under the body and suddenly released to propel these insects up to a few inches in the air. Springtails are worldwide in distribution.

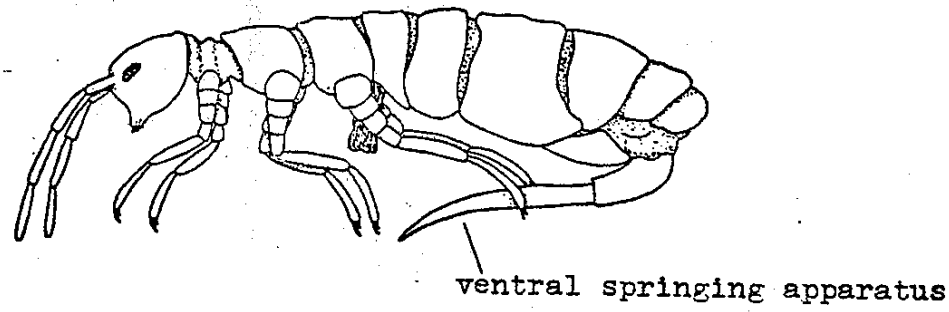


Fig. 14. Collembola.
Lateral view.
(Pennak,1953).

KEY TO THE FAMILIES OF CALIFORNIA

EPHEMEROPTERA (MAYFLIES)

Order: EPHEMEROPTERA (=briefly winged)
Common Name: Mayflies

Mayflies are worldwide in distribution and can be found in and near freshwater ponds, lakes, streams, and rivers. Adult mayflies are easily recognized by their transparent, delicate wings held vertically over the body and by their 2 or 3 very long, slender "tails". Fly fishermen have tied imitations of mayfly adults for centuries, for it is well known that they are a favorite food of many game fish. Mayfly nymphs are primarily herbivores although a few species are carnivorous. Nymphs serve as a food source for almost all the groups of predatory aquatic organisms. After emergence the adults, as well, serve as food for bats, birds, fish, dragonflies, and many other animals.

Mayfly nymphs can be distinguished from other aquatic organisms by the presence of gills on the abdominal segments and a single claw at the end of each leg. The form of the gills among mayfly species is quite variable and can be used to distinguish different families. Nymphs can be found in a variety of habitats including aquatic vegetation, mud, rocks, and debris. Nymphal development occurs over a period of several months to 2 years. Most nymphs develop in 1 year. When the nymph is ready to emerge it crawls out of the water and clings to vegetation or a rock. At this time it undergoes a molt to a form, called the subimago, that closely resembles the adult. Within 2 days it molts again, this time into the reproductive adult called the imago. Mayflies are the only order of aquatic insects to have this double molt before adulthood. In California, mayflies emerge from February to November. Most adult mayflies live only for a few hours. Mating swarms, mostly of males, can be seen in the evenings. Females fly into these swarms for mating. Usinger(1956) states that swarms of many millions of mayflies occur in the Sacramento Valley, but such large flights are rather rare in other parts of California. Female mayflies deposit their eggs on the water surface and the eggs sink to the bottom. In a few species the female is known to crawl underwater to attach the eggs to rocks.

As the arrangement and forms of the gills of the nymphs are important in identification, it is suggested that one count forward from the 10th abdominal segment to determine from which segments the gills arise.

Order: EPHEMEROPTERA

Synopsis of the California Families

Family: Ephemeridae

Members of this family are the most common mayflies in many areas of the United States. Only a single species, Hexagenia limbata, is known from California. Nymphs are found in lakes, rivers and streams, where they may comprise an important food source for fish. Nymphs of this family usually burrow in the bottom.

Family: Tricorythidae

Only one species from this family, Tricorythodes fallax, is known from California. It is common in the north coastal region of the state. These small mayflies do not exceed 7 mm in length. The nymphs can be found in still water along stream margins.

Family: Caenidae

Nymphs in this family are small, from 2 to 4 mm in length. They inhabit silty bottoms of river eddies and stagnant pools. One genus, Caenis, is known from California.

Family: Isonychiidae

Members of this group have, until recently, been classified as a subfamily of the Siphlonuridae. The habits of adults and nymphs of this family are similar to the Siphlonurids. A single species, Isonychia velma, is known from northern California.

Family: Ephemerellidae

Some of California's most common mayflies are found in this family. Twenty-two species are now recorded from the state. The somewhat flattened nymphs are found in rivers, fast-flowing streams and lakes, where they hide on the bottom among rocks and debris. Nymphs found in fast-flowing Sierran streams may crawl into crevices or under boulders to escape strong currents.

Family: Leptophlebiidae

Mayflies of this family inhabit ponds, as well as still to rapidly flowing water in streams. Nymphs often crawl around the bottom among the gravel and debris. Some species are strong swimmers while others are not. Many species from this group occur in California.

Family: Heptageniidae

Members of this family are found throughout California. The eyes of nymphs are dorsal and the body is flattened, and in many species the flattened body serves to act as a suction devise to facilitate placement of the body in rapid currents.

In collecting, some species are often difficult to remove from rocks. Most species are found in rapid currents in streams. A few are found along stream margins where there is little current.

Family: Siphlonuridae

Nymphs are found in fast flowing rivers and steams, as well as standing pools detached from the streams. Nymphs of some species reach 20 mm in length. Most nymphs are excellent swimmers. Some members of this family, unlike most mayflies are predaceous. This family is widely distributed in California.

Family: Baetidae

This family is widespread in California and commonly collected. Nymphs inhabit shallow water ranging from the standing waters of lakes and ponds to very rapid streams. The nymphs in this family are capable of swimming for short distances against very rapid currents. Male and female nymphs are often difficult to identify because they often are very different in appearance.

Key to the Families of California EPHEMEROPTERA Nymphs

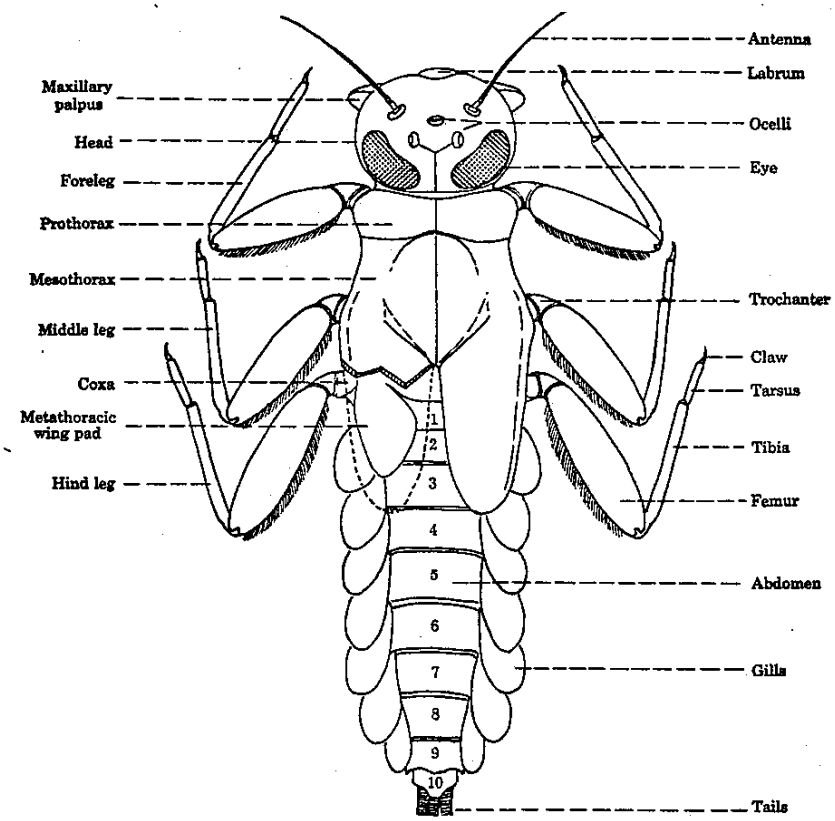


Fig. 15. Dorsal view of a mayfly nymph. (Burks,1953).

1a Mandible with tusk projecting forward and visible from above the head (fig. 16) .....EPHEMERIDAE
1b Mandible not as above 2

2a Gills on abdominal segment 2 large and covering the succeeding pairs (figs. 17,20) 3
2b Gills on abdominal segment 2 either absent or similar to those on the following segments (figs. 22,32) 4

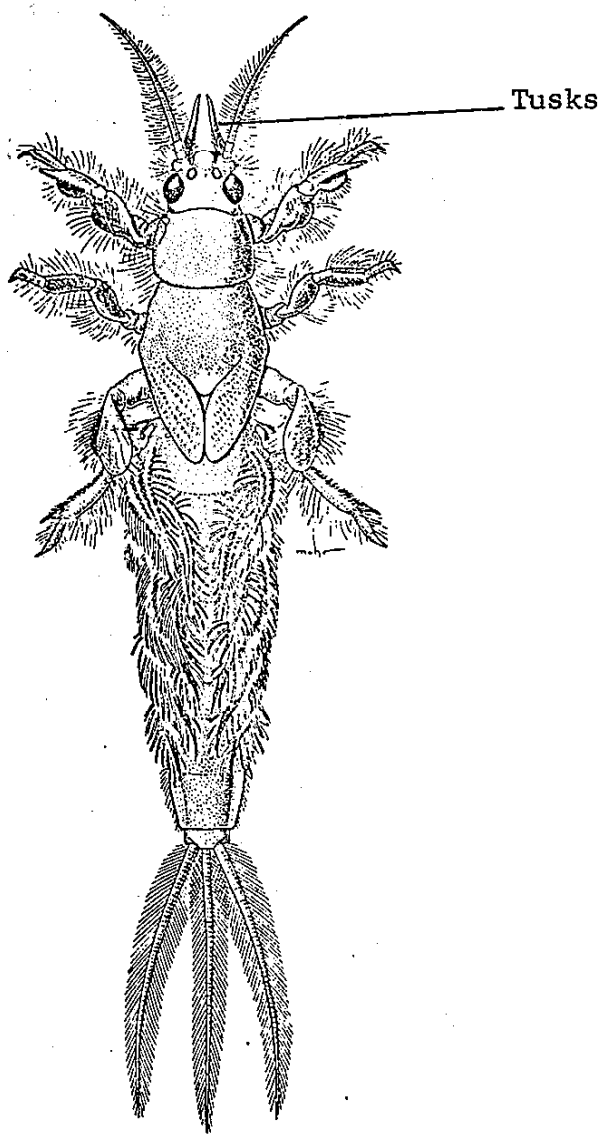


Fig. 16. Ephemeridae. Dorsal view of a nymph. (Burks,1953).

3a Large gills on abdominal segment 2 in number, triangular or oval with a fringed margin (figs 17,18a); gills on the following abdominal segments without fringed margins (fig 18b) .....TRICORYTHIDAE

3b Large gills on abdominal segment 2 in number, quadrate (figs 20a,21); gills on the following abdominal segments with fringed margins (fig. 20b) .....CAENIDAE

4a Fore legs with a dense row of long setae on the inner surface (fig. 19) .....ISONYCHIIDAE

4b Fore legs with setae not as above 5

5a Gills on abdominal segments 1 to 5, usually to segment 7 6

5b Gills lacking on abdominal segment 2, gills may or may not be present on abdominal segments 1 and 3; gills present on abdominal segments 4 to 7 (fig. 22) ....EPHEMERELLIDAE

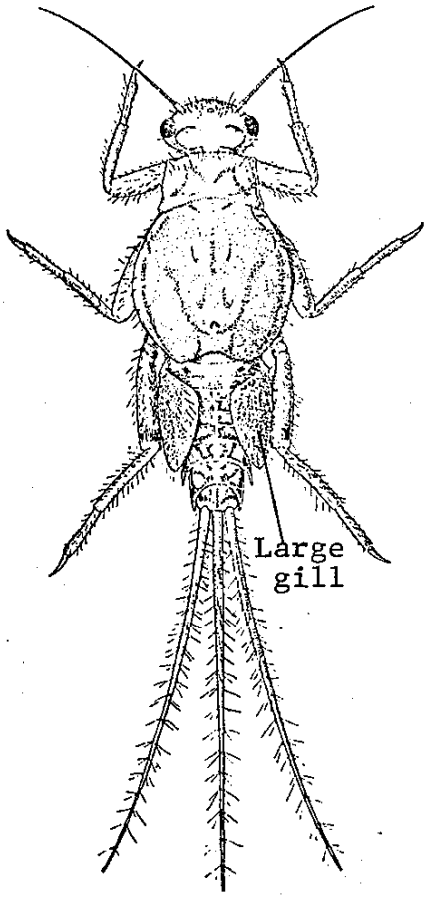


Fig. 17. Tricorythidae. Dorsal view of a nymph. (Burks,1953).

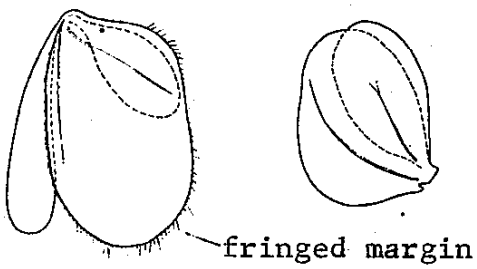


Fig. 18a,b. Tricorythidae
a. Large fringed gill of segment 2.
b. Unfringed abdominal gill (Burks,1953).

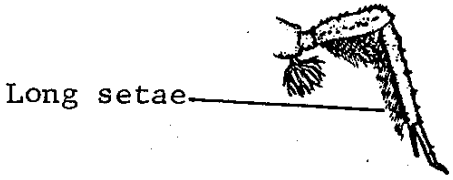


Fig. 19. Isonychiidae Fore leg of a nymph.

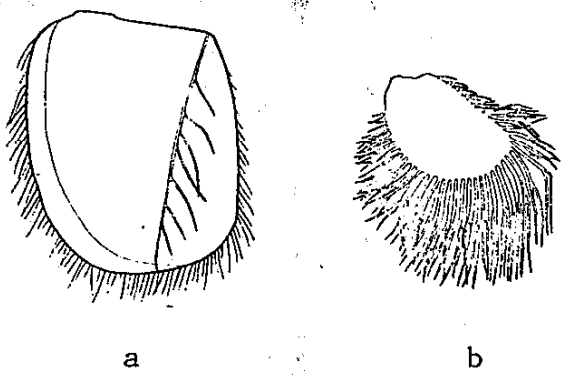


Fig. 20a,b. Caenidae.
a. Fringed gill of abdominal segment 2.
b. Fringed gills of other abdominal segments.
(Burks,1953).

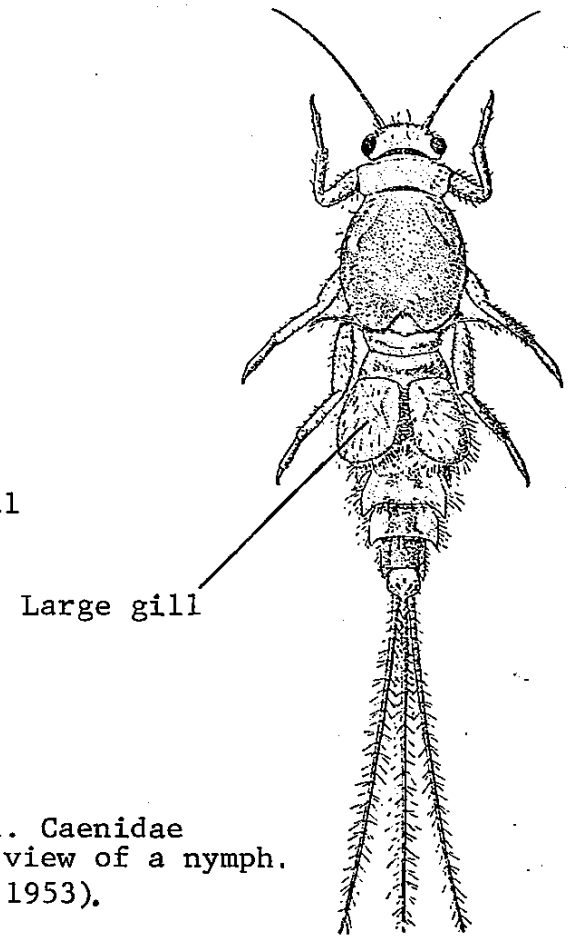


Fig. 21. Caenidae
Dorsal view of a nymph.
(Burks,1953).

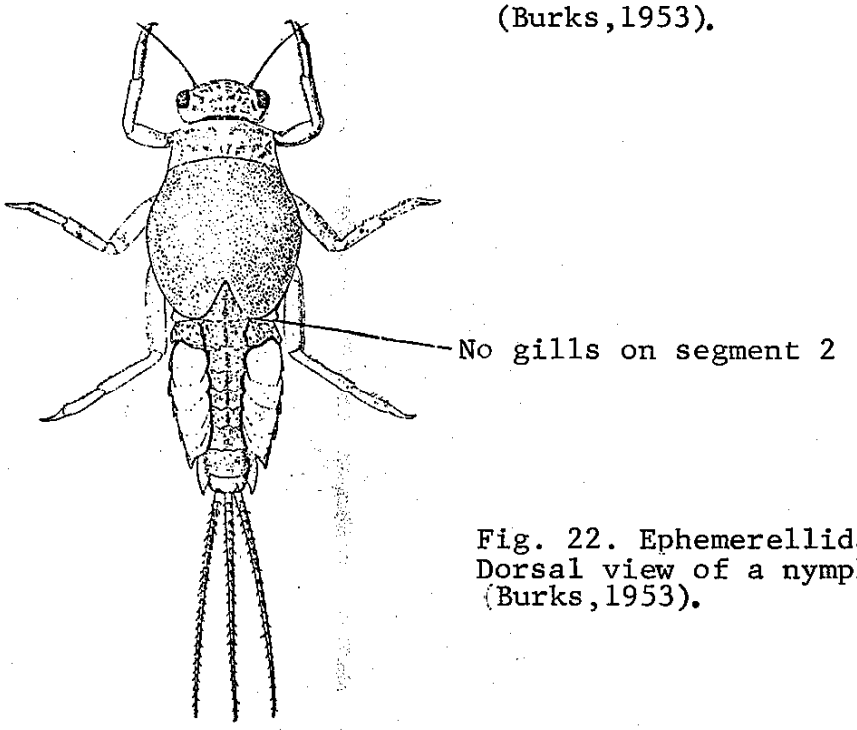


Fig. 22. Ephemerellidae
Dorsal view of a nymph.
(Burks,1953).

6a Gills of many types; may be forked, in clusters of filaments, fringed, divided at the apex, but never platelike (figs. 24a-d,25,26) .....LEPTOPHLEBIIDAE

6b Gills platelike, may have a filament-like tuft at or near the base (figs. 23a-g) 7

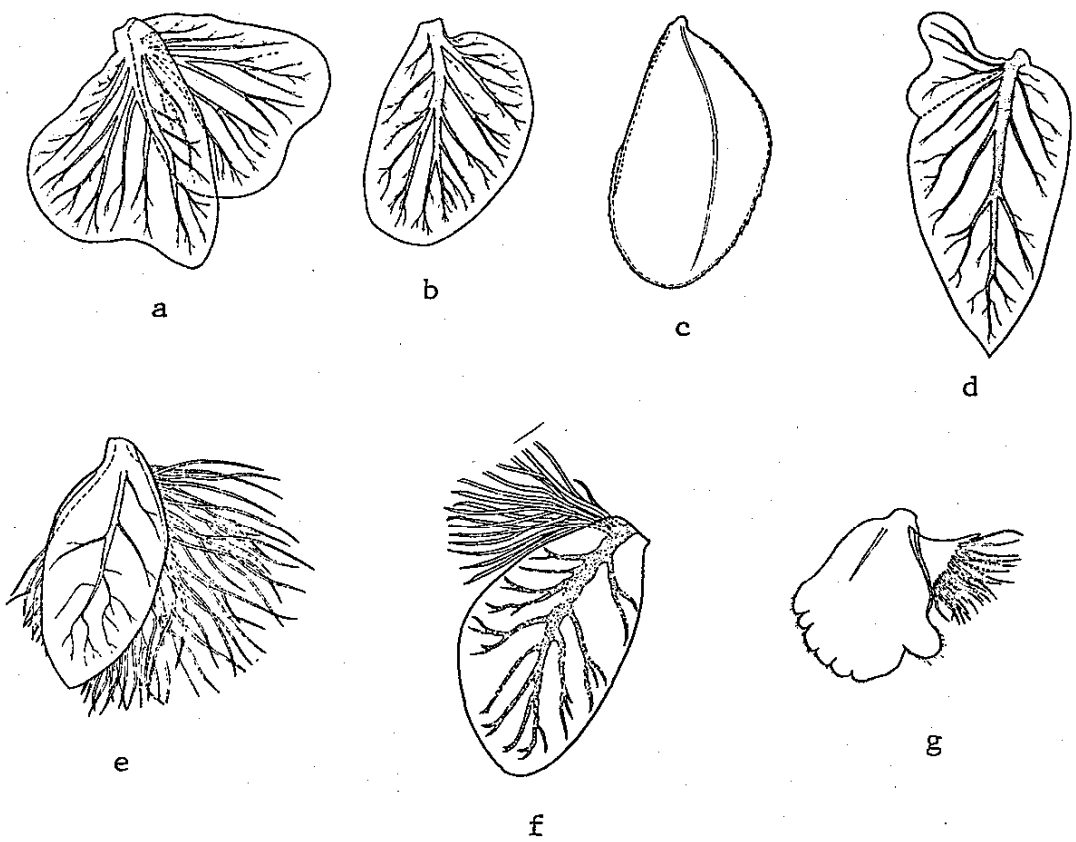


Fig. 23a-g. Appearance of gill fitting couplet 6b. (Burks,1953).

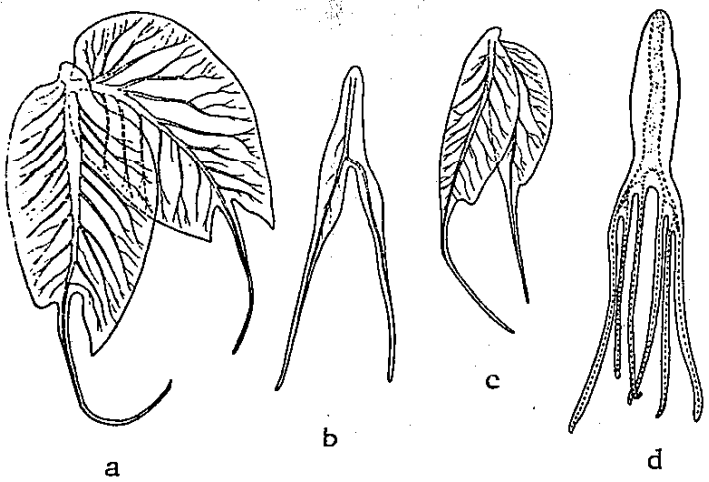


Fig. 24a-d. Leptophlebiidae. Types of nymphal gills. (Burks, 1953).

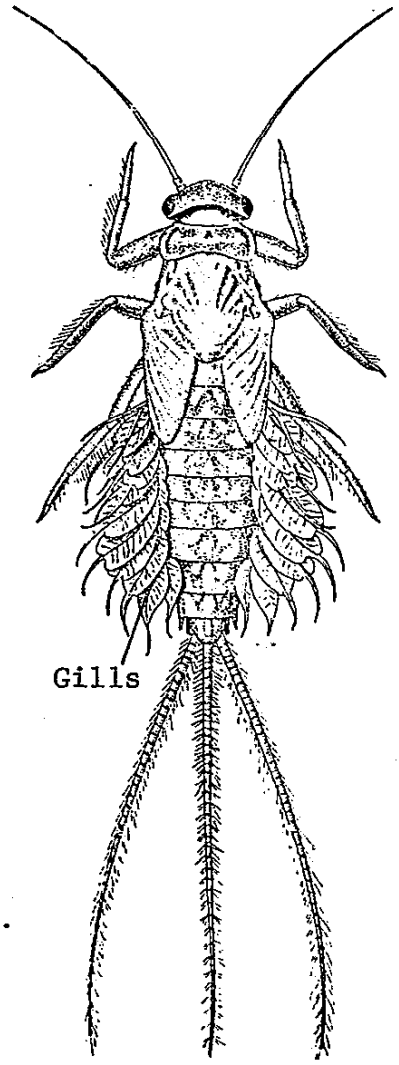


Fig. 25. Leptophlebiidae. Dorsal view of a nymph. (Burks, 1953).

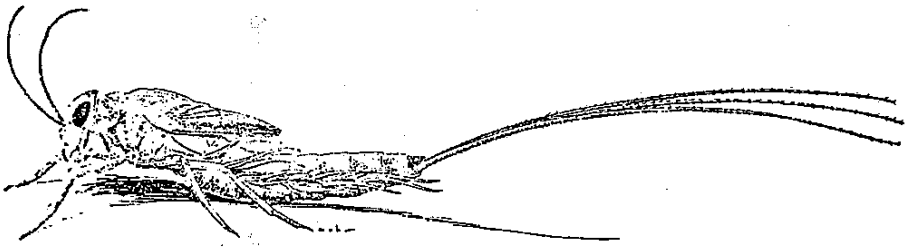


Fig. 26. Leptophlebiidae. Side view of a nymph. (Burks, 1953).

7a Nymphs strongly flattened with eyes and antennae on the dorsal surface of the head (fig. 27a,b)..HEPTAGENIIDAE

7b Nymphs not flattened; eyes and/or antennae toward the lateral margin of the head 8

8a Posterolateral angles of abdominal segments 8 and 9 prolonged into distinct, flattened, lateral spines (fig. 28b); front margin of labrum with a broad, shallow emargination (fig. 29a) ..... SIPHLONURIDAE

8b Posterolateral angles of abdominal segments 8 and 9 without distinct, flattened, lateral spines (fig. 28a); front margin of labrum with a distinct notch (figs. 29b,31,32) .....BAETIDAE

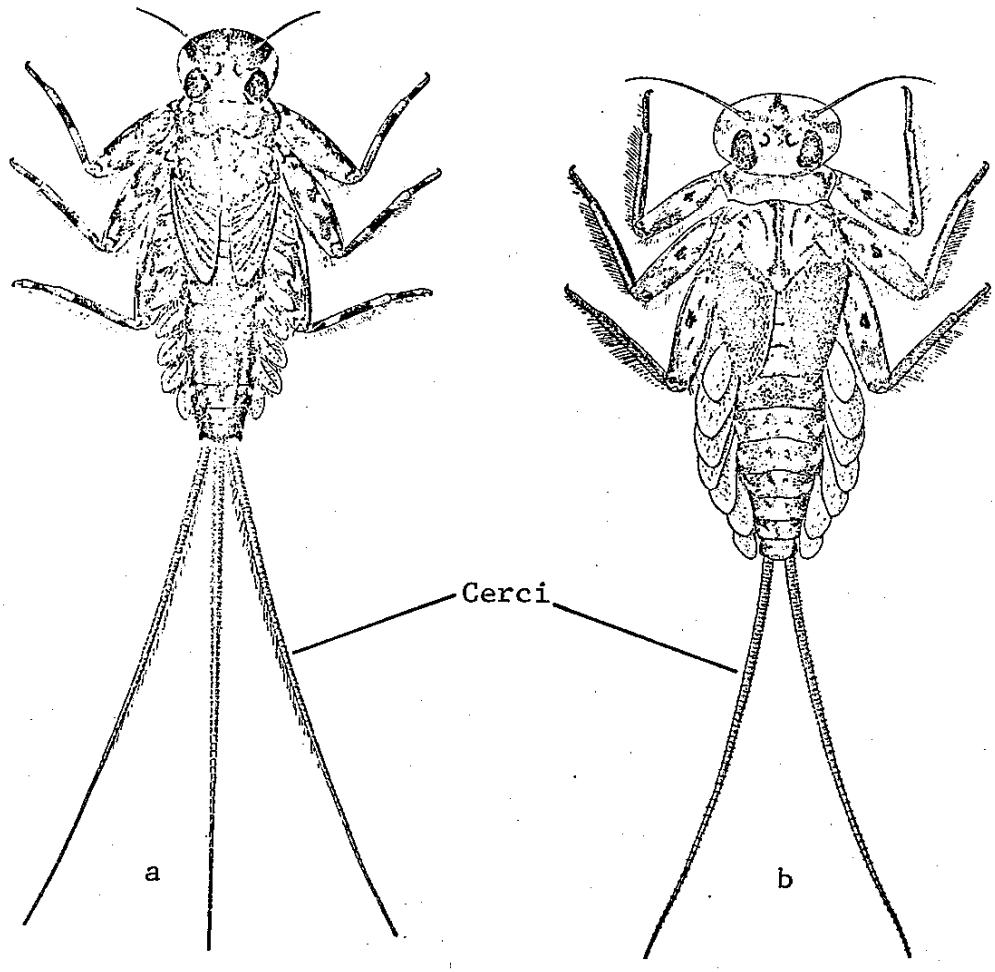


Fig. 27a,b. Heptageniidae. Dorsal view of two nymph species. (Burks,1953).

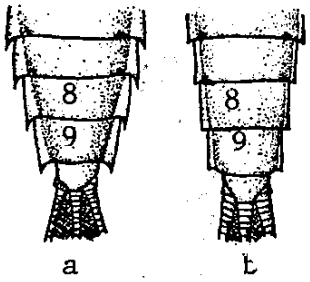


Fig. 28a,b. Posterior abdominal segments of two nymphs. a. Baetidae b. Siphlonuridae. (Burks,1953).

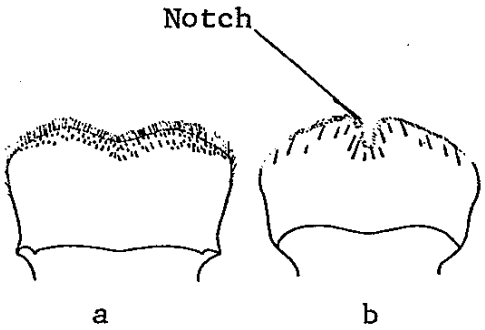


Fig. 29a,b. Labrums of two nymphs. Siphlonuridae b. Baetidae. (Burks,1953).

Fig. 30. Siphlonuridae. Side view of a nymph. (Burks,1953).

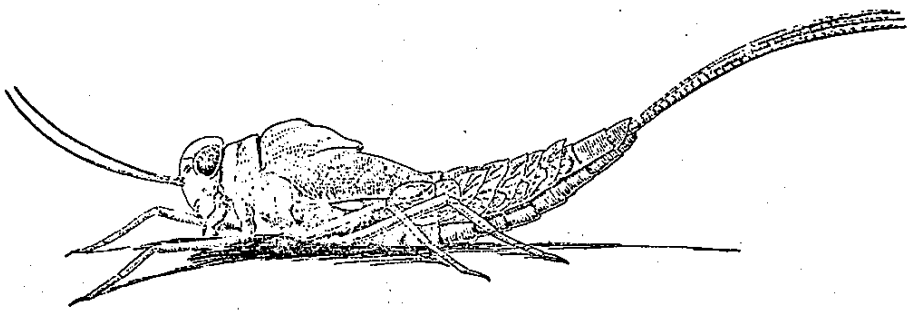


Fig. 31. Baetidae. Side view of a nymph. (Burks,1953).

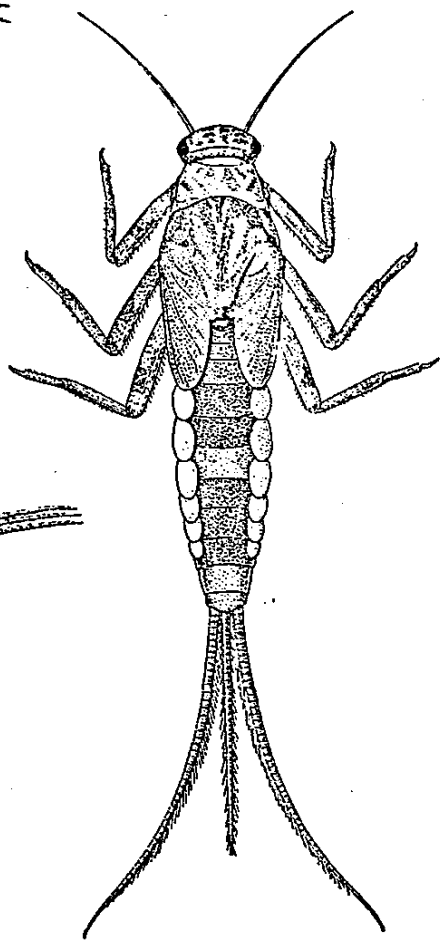


Fig. 32. Baetidae. Dorsal view of a nymph. (Burks,1953)

KEY TO THE FAMILIES OF CALIFORNIA
ODONATA (DRAGONFLIES)

Order: ODONATA (=toothed)
Common Name: Dragonflies and Damselflies

Dragonflies and Damselflies are, perhaps, the best known of the aquatic insects. Adults are often brightly colored in reds, greens, and blues. They are often seen flying erratically over ponds, lakes, streams, and rivers. Adult dragonflies (suborder Anisoptera) when at rest usually hold their wings in a horizontal position, while the damselflies (suborder Zygoptera) hold their wings in a vertical position or folded along the body. Many species in this order are quite large and for this reason the group has received many superstitious names such as mosquito hawk, devil's darning needle, snake doctor, and horse stinger. Dragonflies and damselflies are harmless to man.

The immature forms of this order are all predaceous and are called naiads. Some forms actively stalk their prey, while others lie in ambush in the bottom debris. Naiads detect their prey by sight and they may attack any organism small enough to handle. Naiads serve as an important food source for fish, and they are eaten to a lesser extent by frogs, birds and other aquatic organisms.

The adults feed on a variety of insects which they catch in flight and hold with their legs. Adult dragonflies have been known to catch trout fry. Adult dragonflies and damselflies are, in turn, eaten by birds, frogs, lizards, spiders, and even other Odonata.

The eggs of this group are deposited on objects in the water or simply dropped into the water. Naiads may take from less than one year to five years to develop, depending on the species.

Order: ODONATA

Synopsis of the California Families

Family: Calopterygidae (broad-winged damselflies)
Some species within this family are among the largest damselflies. Adults have wings that are colored from black to red and bodies that may be metallic green to brown. The naiads are camouflaged and remain clinging to the roots and stems of submerged aquatic plants. Members of this group are found along streams.

Family: Lestidae (spread-winged damselflies)
This family contains the largest damselfly species in North America. Members in this group are found along ponds, lakes, marshes, bogs, and slow flowing streams where there is abundant emergent aquatic vegetation. Adults are slow flying and have colorless wings. The adults can often be seen resting on vegetation near the water margin.

Family: Coenagrionidae (narrow-winged damselflies)
The small, clear-winged adults of this family have bodies of many colors including red, orange, black, blue, yellow, brown, and green. The naiads are usually green or brown. These damselflies can be found in a variety of habitats from ponds, lakes, and streams, to desert alkaline pools and brackish water. Some species prefer thick vegetation along streams while others are commonly found in open areas. Members of this group are common throughout North America.

Family: Gomphidae (clubtails)
This family derives its common name from the enlarged caudal end of the adult males. Adults are brown, yellow or black in color with clear wings. Adults and naiads are found in streams, ponds and lakes. The naiads are burrowers in the soft mud bottoms. This group ranges widely over North America.

Family: Petaluridae (graybacks)
This rare family of dragonflies has only 2 species in the United States. The only western species is found along small streams or boggy areas in mountain forests. The adults are gray or black in color. Naiads live in the bottom mud. The western species, Tanypteryx hageni, has been found in northern California.

Family: Aeshnidae (darners)
The largest North American dragonfly, Anax walsinghami, is found in this family. This large species has a wing length to 125mm and a body 250mm long. It is found in California. Other adults in this family are large, strong fliers. Darners are usually found along ponds and lakes that have abundant aquatic vegetation. The naiads live among the aquatic plants and may take as long as 3 years to develop. The predaceous naiads have been known to stalk their prey

and attack almost anything they come across including small fish and other naiads.

Family: Cordulegastridae (biddies)
This small, uncommon family of dragonflies usually occurs along small wooded streams. Adults are large brown to black in color tion and covered with scattered yellow markings. The naiads lie buried in the mud of the stream bottom and have a thick hairy covering that is usually covered with silt and so makes them difficult to see. Naiads may take 4 years to develop.

Family: Macromiidae (belted skimmers, river skimmers)
These brown to black dragonflies are found along large rivers, lakes and boggy pond shores. The naiads live on the bottom and are well camouflaged. The adults are large, strong fliers. Some adults have bright green eyes.

Family: Libellulidae (common skimmers)
These common dragonflies are the ones most commonly seen around ponds and lakes. The adults are brightly colored and the naiads are usually camouflaged. The naiads are found in a variety of habitats from mud bottoms to thick growths of aquatic plants. Some species occur in brackish waters. Adults vary in size from about 2.5 cm to 10 cm long. This family of dragonflies is worldwide in distribution and common in California.

Key to the Families of California ODONATA Naiads

1a Three flat external gills at the end of the abdomen (fig. 33a,b); head width greater than width of the thorax and abdomen(fig. 33a) .. ZYGOPTERA (Damselflies)

1b No flat external gill at the end of the abdomen; head width about the same width as the thorax and abdomen (fig. 34) .....ANISOPTERA (Dragonflies)

2a First antennal segment as long as or longer than the 6 following segments combined (fig. 3) .....CALOPTERYGIDAE

2b First antennal segment much shorter than the 6 following segments combined (fig. 36) 3

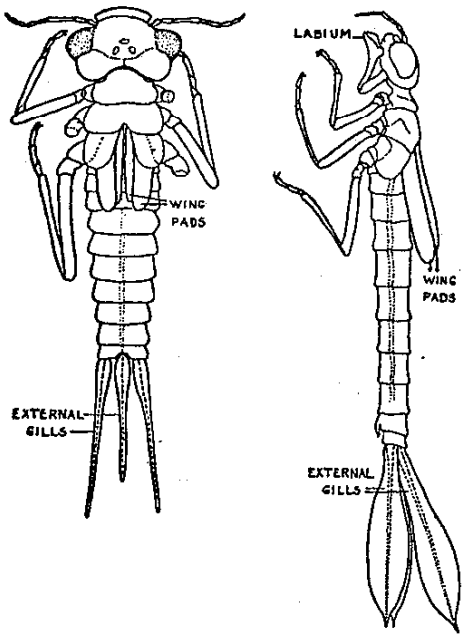


Fig. 33a,b. Zygoptera. Coenagrionidae. a. Dorsal view of naiad. b. Side view of a naiad. (Wright and Peterson,1944).

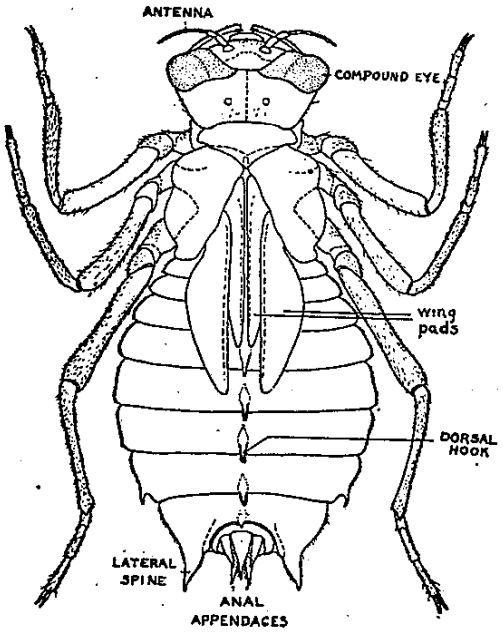
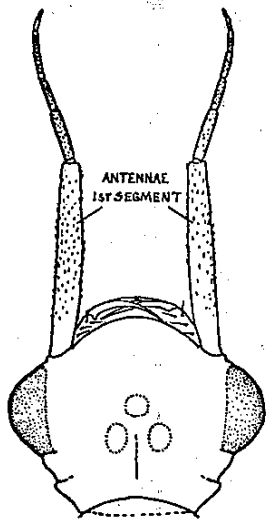


Fig. 34. Anisoptera. Libellulidae. Dorsal view of a naiad. (Wright and Peterson,1944).



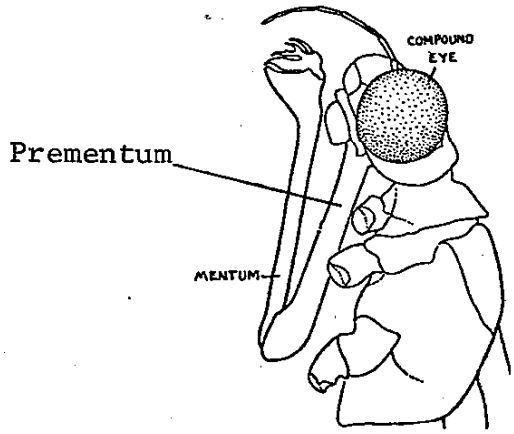


Fig.35. Calopterygidae.
Dorsal view of naiad head.
(Wright and Peterson,1944).

Fig. 36. Lestidae
Side view of the head
and thorax of a naiad.
(Wright and Peterson,1944).

3a Prementum when folded along the thorax reaches to the base of the second pair of legs or beyond (fig. 36).. .....LESTIDAE

3b Prementum when folded along the thorax reaches just beyond the first pair of legs but not to the second pair (fig. 33b) .....COENAGRIONIDAE

4a Labium flat or nearly so (fig. 37) 5

4b Labium spoon-shaped and covering the face to the base of the antennae (fig. 38) 7

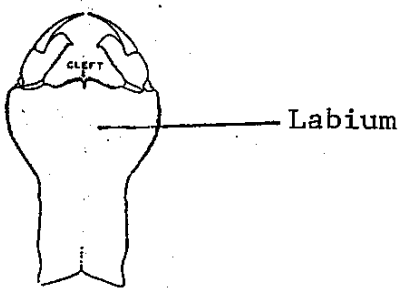


Fig. 37. Aeshnidae.
Dorsal view of labium.
(Wright and Peterson,1944).

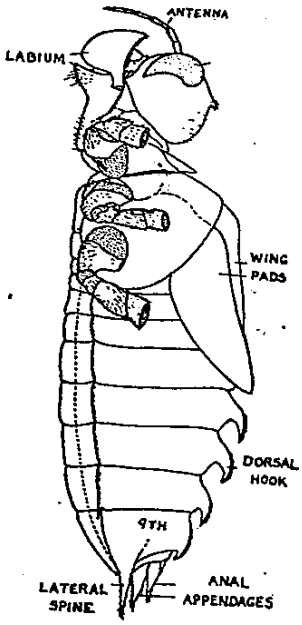


Fig. 38. Libellulidae.
Side view of a naiad.
(Wright and Peterson,
1944).

5a Antennae with 6 or 7 segments (fig. 40a,b) 6
5b Antennae with 4 segments (fig. 39a-c).....GOMPHIDAE

6a Antennae with a thick covering of setae (fig. 40b) ....
.....PETALURIDAE
6b Antennae without a thick covering of setae (fig. 40a)..
.....AESHNIDAE

7a Labium with large, irregular, deeply incised teeth on lateral lobes (fig. 41) .....CORDULEGASTRIDAE
7b Labium with lateral lobe smooth or with small even teeth (fig. 42a-c) .....LIBELLULIDAE

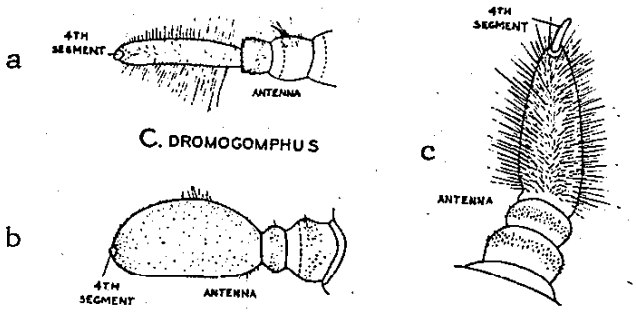


Fig. 39a-c. Gomphidae. 4-segmented antennae. (Wright and Peterson, 1944).

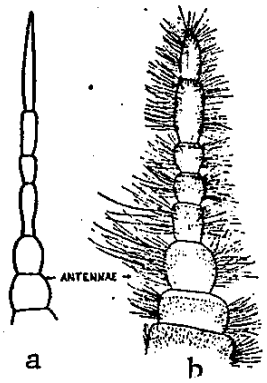


Fig. 40a,b. 6 and 7-segmented antennal types.
a. Aeshnidae
b. Petaluridae
(Wright and Peterson, 1944).

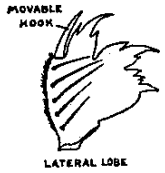


Fig. 41. Cordulegastridae. Lateral lobe of a naiad. (Wright and Peterson, 1944).

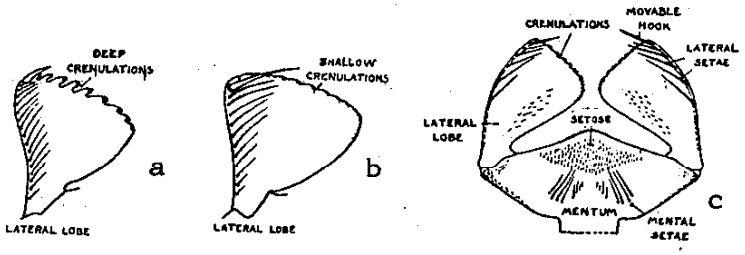


Fig. 42a-c. Libellulidae Lateral lobe types. (Wright and Peterson, 1944).

Order: ORTHOPTERA (=straight-winged)
Common Name: Grasshoppers and Crickets

Family: Tridactylidae (pigmy molecrickets)

Members of this family are semi-aquatic in habit. Very little is known about these rather rare crickets. They are known from California. Molecrickets seldom exceed 10 mm in length. They inhabit the margins of streams and lakes where they burrow in the moist sand. The femora are greatly enlarged and the front tibia is expanded for digging. The hind tibia has special plates that are modifications for swimming. One author mentions that they can jump about on the water surface. This is the only aquatic family in the order.

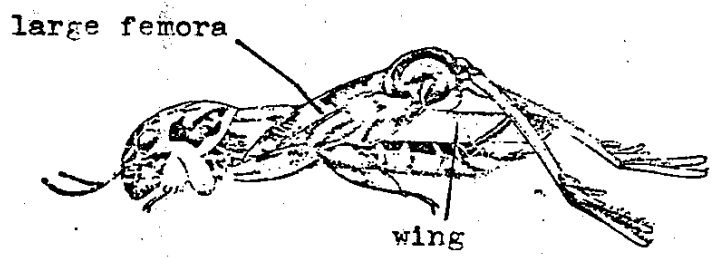


Fig. 43. Tridactylidae.
Lateral view of a molecricket.
(Usinger, 1956).

KEY TO THE FAMILIES OF CALIFORNIA PLECOPTERA (STONEFLIES)

Order: PLECOPTERA
Common Name: Stoneflies

Stoneflies are world-wide in distribution. The majority of species occur in well-oxygenated streams and rivers, and a few species occur along the margins of cool, wave-washed oxygen enriched lakes. Stoneflies can be found under rocks, gravel, and among detritus on stream bottoms.

Two distinct groups of stoneflies are recognized. The vegetarian and omnivorous stoneflies (sub-order Filipalpia) feed on algae and detritus, and they usually are diurnal in activity. The carnivorous stoneflies (sub-order Setipalpia) feed on aquatic organizms such as mayfly nymphs and diptera larvae, and the are primarly nocturnal in habit. Stoneflies, in turn, serve as an important food source for fish, especially trout.

Adult stoneflies, when at rest, have their wings folded over the back. The abdomen ends in two segmented cerci and the head has long, slender antennae. Adult stoneflies are poor fliers and they only live a few weeks. Eggs are deposited in several ways. They may be dropped into the water while in flight or deposited on the water surface. In some cases the female may actually crawl underwater to deposit them. The females of some species may lay over 1000 eggs.

Stonefly nymphs take from 1 to 3 years to develop, the normal period is 1 year. Nymphs may emerge from November to August in temperate climates. Newly emerged adults of the family Nemouridae can be found, in California, crawling over the snow near streams during the winter.

Order: PLECOPTERA

Synopsis of the California Families

Family: Pteronarcidae (giant stoneflies)
Stoneflies in this family may reach 65 mm in length. Members in this group can be found in rivers where the nymphs feed on plant material. The adults can be found during the spring and summer months. This family is restricted to North America, Siberia and China.

Family: Peltoperlidae
Little is known about this uncommon family. Members in this group are known to occur in North America and eastern Asia. The nymphs are roachlike in appearance.

Family: Nemouridae (spring, winter, and rolled-winged stoneflies)
Members of this family occur throughout the world and are found in streams and rivers. The nymphs of all species are herbivorous as are the adults. Some adults feed on flowers and others on algae. Adults can be found from November through June depending on the species. Adults range up to 15 mm in length.

Family: Perlidae (common stoneflies)
Some species in this family reach 40 mm in length and are the most common of the stoneflies. Nymphs in this family are usually carnivorous. This family is the largest in the order and members are found worldwide.

Family: Chloroperlidae
Adults are yellow to green in color and 6 to 24 mm in length. The adults can be found during the spring months. Nymphs occur in small streams.

Family: Perlodidae
Some species in this family are common. Nymphs are found in streams of various types and adults can often be seen scurrying over vegetation at the water's margin. The adults, which are herbivorous, appear in spring or summer. Adults range up to 25 mm in length.

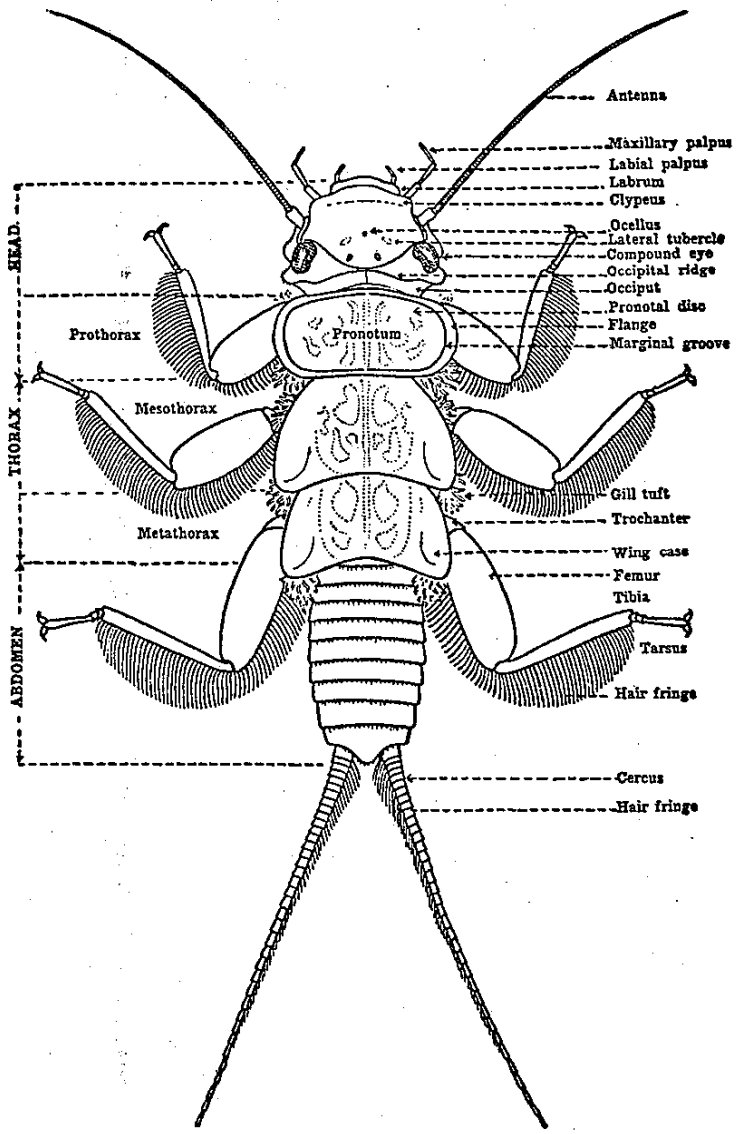


Fig. 44. Dorsal view of a stonefly nymph showing the structures used in classification. (Claassen,1931).

1a Glossae and paraglossae about equal length (fig. 45a,b) 2

1b Glossae much shorter than paraglossae in length (fig. 46a,b) 4

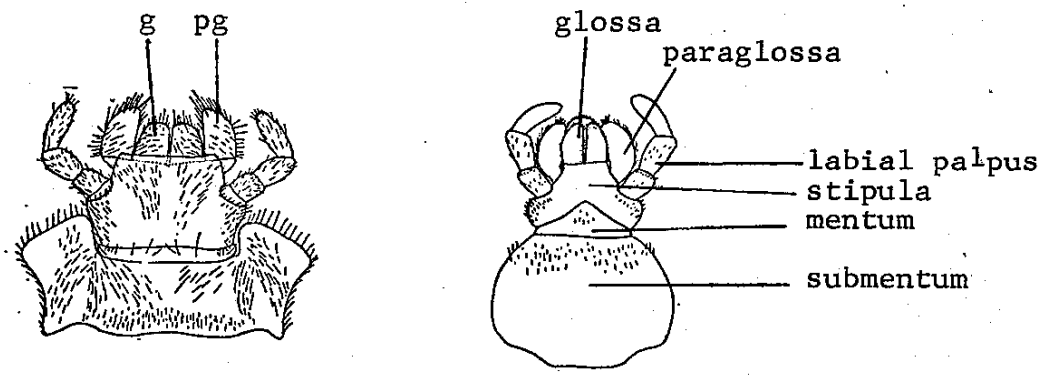


Fig. 45a,b. Appearance of the labium with the glossae and paraglossae of equal length. (Claassen,1931).

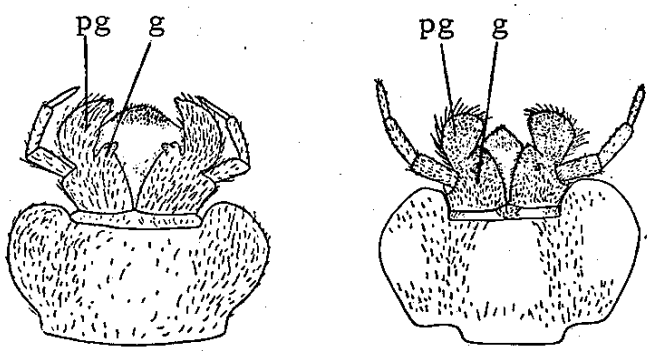


Fig. 46a,b. Appearance of the labium with the glossae shorter than the paraglossae. (Claassen,1931).

2a Branched gills present on the ventral side of abdominal segments 1 and 2, sometimes 3 (fig. 47)..... .....PTERONARCIDAE

2b Branched gills absent from the ventral side of the abdomen 3

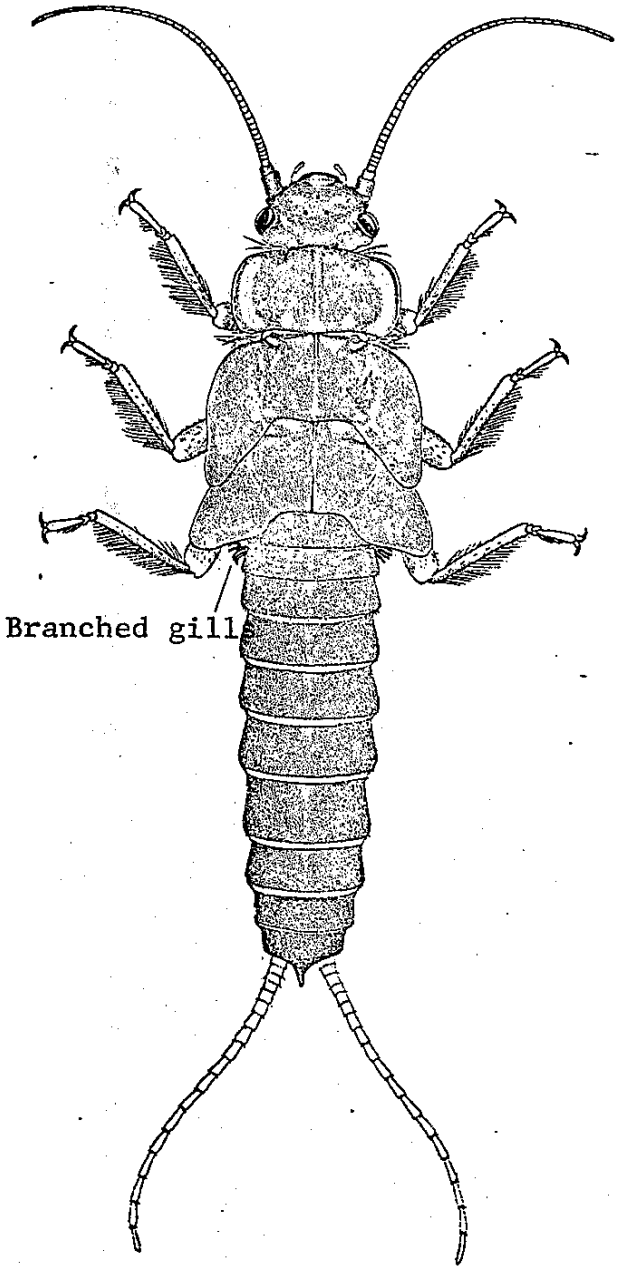


Fig. 47. Pteronarcidae. Dorsal view of a nymph. (Claassen,1931).

3a Two ocelli; thoracic sterna produced posteriorly to overlap the segment behind (fig. 48a,b) ..PELTOPERLIDAE

3b Three ocelli; thoracis sterna not produced posteriorly (fig. 49a-c) .....NEMOURIDAE

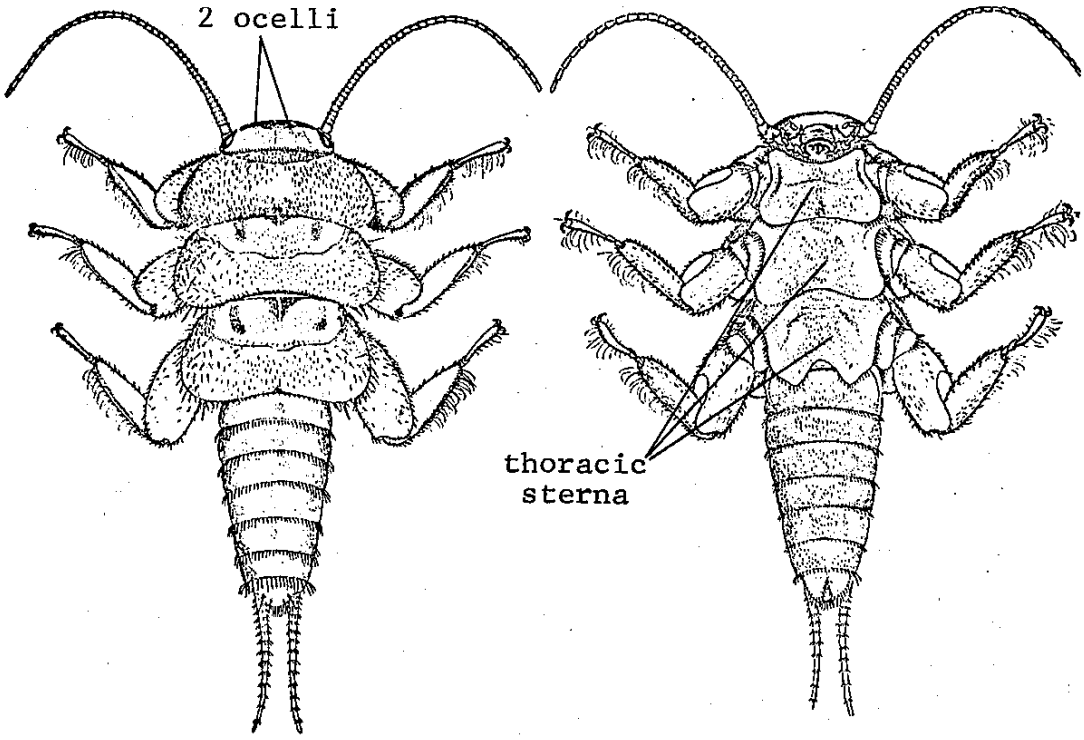


Fig. 48a,b. Peltoperlidae. Dorsal (a) and ventral (b) view of a nymph. (Claassen,1931).

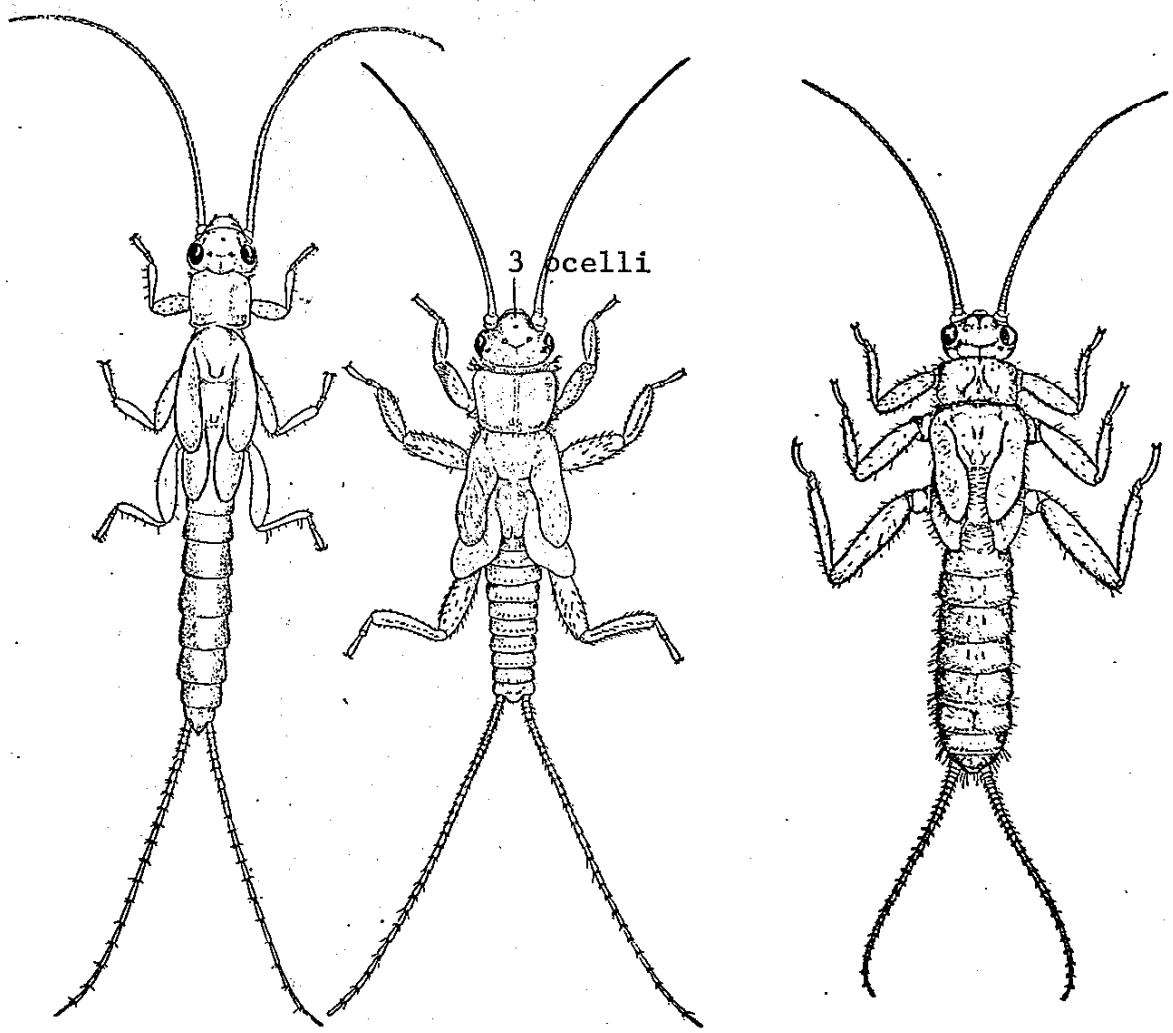


Fig. 49a-c. Nemouridae. Dorsal views of three different species of nemourid nymphs. (Claassen, 1931).

4a Profusely branched gills at the lower corner of the thorax (fig. 50) .....PERLIDAE

4b Branched gills absent from the thorax 5

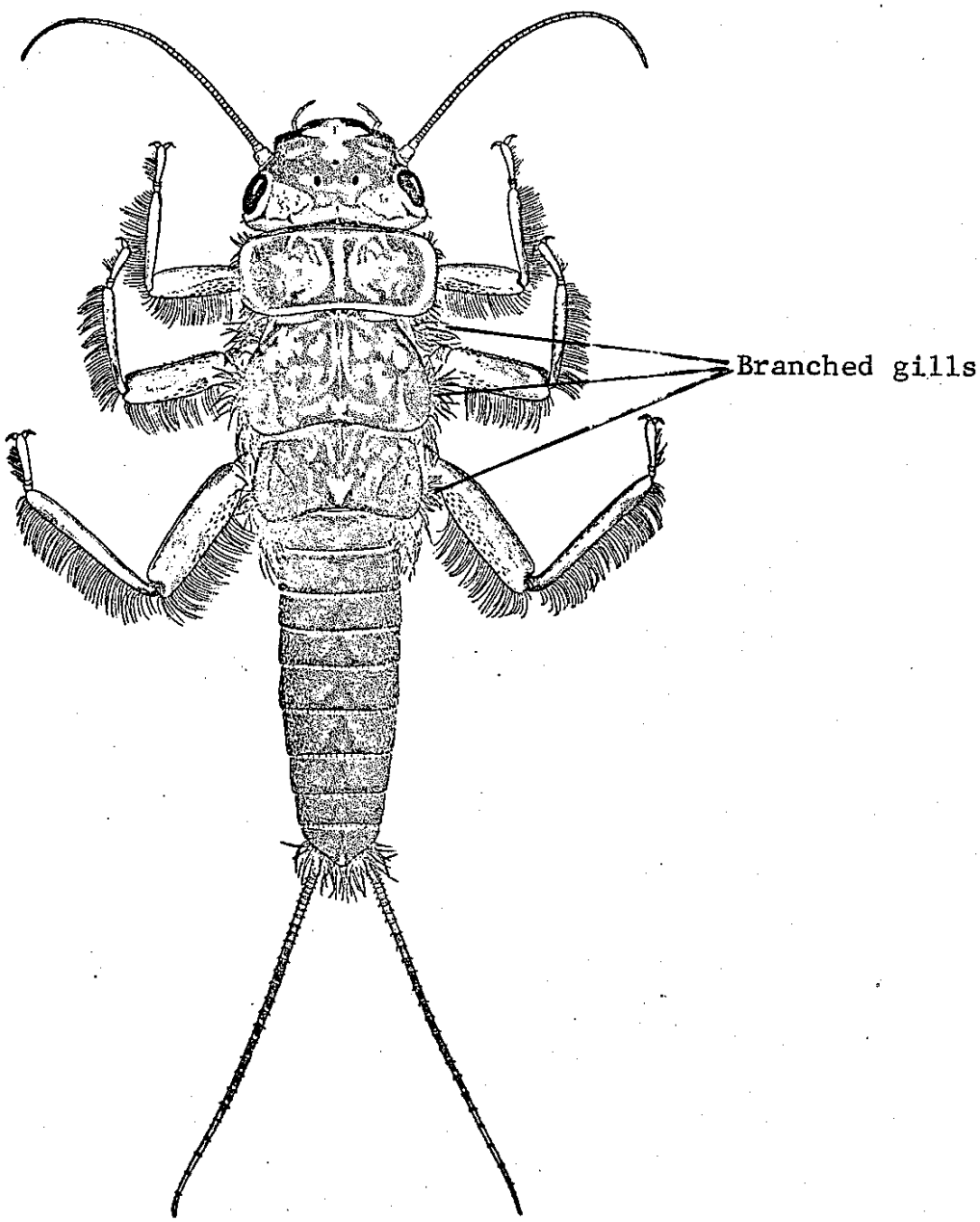


Fig. 50. Perlidae. Dorsal view of a nymph. (Claassen,1931).

5a Hind wing pads set nearly parallel to the axis of the body; cerci not more than 3/4 the length of the abdomen (fig. 51a,b) .....CHLOROPERLIDAE

5b Hind wing pads set at an angle to the axis of the body; cerci usually as long or longer than the abdomen (fig. 52a,b) .....PERLODIDAE

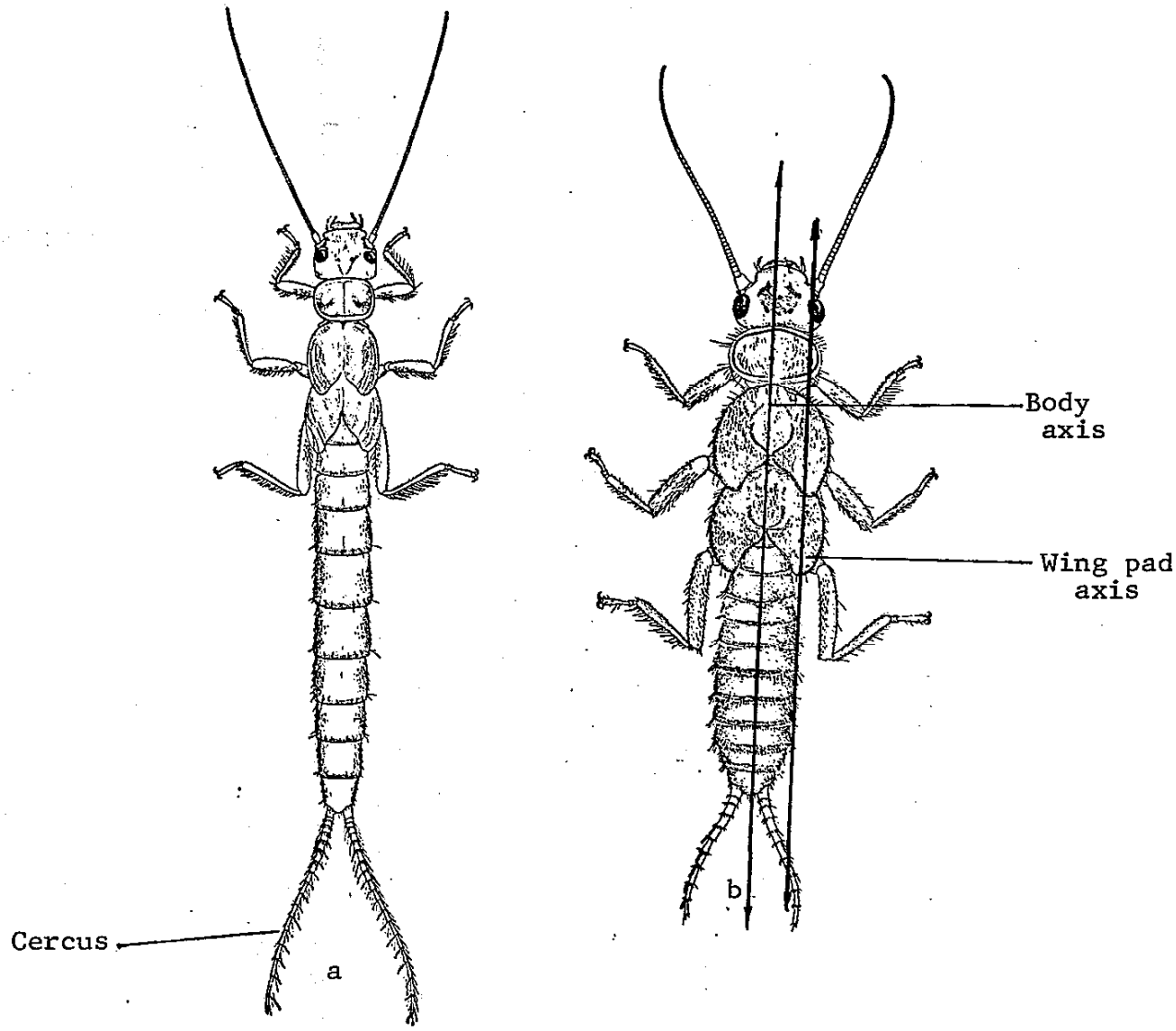


Fig. 51a,b. Chloroperlidae. Dorsal view of two chloroperlid species of nymphs. (Claassen,1931).

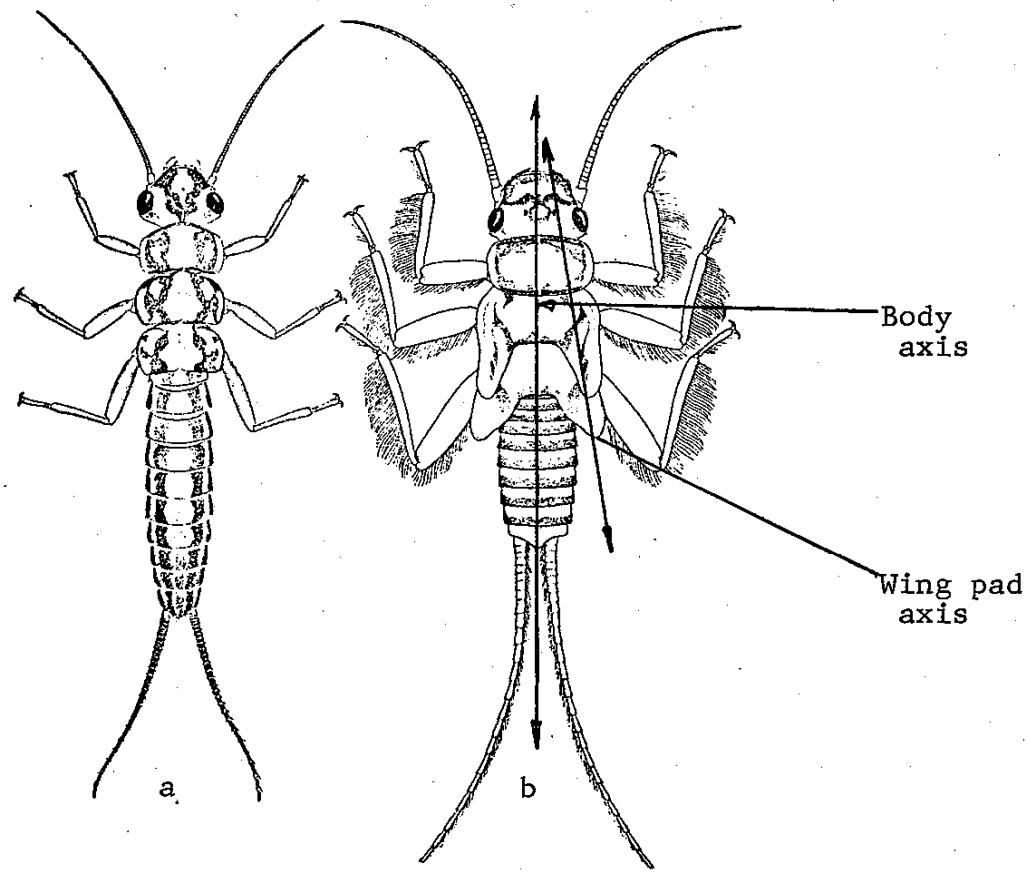


Fig. 52a,b. Perlodidae. Dorsal view of two perlodid species of nymphs. (Claassen,1931).

KEY TO THE FAMILIES OF CALIFORNIA

HEMIPTERA (TRUE BUGS)

Order: HEMIPTERA (= half-winged)
Common Name: True Bugs

The Hemiptera are found in a variety of habitats throughout the world. Water bugs are known from desert hot springs, saline lakes, the open ocean, freshwater streams, rivers, ponds, and lakes. All Hemipterans have in common sucking mouthparts in the form of a 3 to 4-segmented beak, which they use for piercing the body of their prey and sucking out the body fluids. All water bugs are predaceous to some extent. They feed primarily on aquatic and terrestrial insects, but also on other aquatic organisms.

Water bugs usually overwinter as adults and lay their eggs in the spring. The female attaches the eggs to objects underwater, and in some species to the backs of the males. Some members of the family Corixidae deposit eggs on crayfish, snails and dragonfly nymphs.

Most Hemipterans can fly, although some species have lost their wings, and other species have members with or without wings. Sound production is also known for a few species.

Water bugs obtain their air for respiration from the surface. They can not remain underwater for long periods without returning to the surface to secure a new air supply. One hundred seventeen species of hemipterans are known from California.

Order: HEMIPTERA

Synopsis of the California Families

Family: Gelastocoridae (toad bugs)
Members of this family are worldwide in distribution and can be found along the sandy or muddy margins of streams and ponds. The family derives its common name from the hopping motion of some of its members. Toad bugs are predaceous on other insects.

Family: Corixidae (water boatmen)
Water boatmen comprise a large, common family found throughout the world. These bugs occur in a variety of habitats including the ocean, brackish waters, inland saline lakes, freshwater ponds, lakes, and slow flowing streams. Water boatmen have been recorded from below sea level to near 15,000 feet. Bugs in this family are primarily omnivorous, feeding on algae, protozoans and aquatic insects. Corixids often are an important fo d item in the diets of fish, and in some areas of the world they are eaten by man.

Family: Notonectidae (backswimmers)
Backswimmers, as the common name implies, swim and float on their backs with their heads pointed down into the water. These bugs can be found in slow flowing streams, lakes, ponds, and stagnant pools. Backswimmers are predaceous and feed on anything they can handle including other aquatic insects, crustacea and small fish. If not handled carefully they can give a sharp bite similar to a bee sting. Some members of this family make chirping sounds. These insects are found worldwide.

Family: Nepidae (water scorpions)
Water scorpions resemble the terrestrial "walking sticks". These rather uncommon water bugs are voracious predators and feed on crustacea, aquatic insects and even small fish. Water scorpions are usually found in a tangle of aquatic vegetation in ponds where they lie in ambush for their prey. They can inflict painful bites. The eggs of these bugs are inserted into plant tissues for development.

Family: Belostomatidae (giant water bugs, toe biters)
Large species in this family reach 50 mm in length. The term toe biter refers to the painful bite they can inflict to the unwary individual. Giant water bugs inhabit ponds and occassionally the back eddies of slow flowing streams, where they hide among the vegetation. As predators they feed on aquatic insects, crustacea, arthropods, and fish. Females of some genera lay their eggs on the backs of males, who in turn carry them around until they hatch. Some species when removed from the water become rigid and feign death. In Asia, giant water bugs are used for food by man.

Family: Naucoridae (creeping water bugs)
These bugs are found in streams, rivers, ponds, lakes, hot springs, and desert saline waters. Creeping water bugs are predators that feed on a variety of aquatic invertebrates. These bugs can give a painful bite. The eggs are deposited on stones in the shallows of lakes and streams.

Family: Ochteridae
These rather rare shore bugs occur along the margins of ponds and slow flowing streams. The adults are predaceous. The eggs of one eastern species are deposited on plants or debris along the water margin. The immature stages are reported to camouflage themselves by carrying sand grains on their bodies.

Family: Hydrometridae (marsh treaders)
These delicate water bugs occur in or near the aquatic vegetation of ponds. Marsh treaders often walk across the surface of the water. They feed on aquatic insects and other aquatic invertebrates. The eggs of these bugs are attached to objects just above the water surface. Marsh treaders are found over most of the United States.

Family: Gerridae (water striders)
Water striders are the commonly seen bugs skimming over the water surface of ponds, lakes, streams, and rivers. One genus is found in the open ocean and around reefs of tropical islands. These bugs are predaceous and feed upon aquatic organisms as well as terrestrial animals that fall into the water. Water striders are also cannabalistic. Some of the species in this group lack wings while others have wings fully or only partially developed.

Family: Veliidae (small water striders, riffle bugs)
Adults of this family seldom exceed 5 mm in length. They are found in a variety of habitats including ponds, streams and mangrove swamps. These water striders skim over the water surface as do members of the family Gerridae. Their food consists of aquatic and terrestrial invertebrates.

Family: Herbridae (velvet water bugs)
Little is known about the North American members of this small, rather rare family of water insects. Adults are less than 3 mm in length and can be found in debris along the margins of streams and ponds or on floating aquatic vegetation. Their food is primarily small insects. Velvet water bugs have soft hairy coverings over the body, hence the common name of this family. The particular family is cosmopolitan in nature.

Family: Mesoveliidae (water treaders)
The stand ing waters of ponds and lakes that have abundant aquatic vegetation are the preferred habitat of these small water bugs. Water treaders usually feed on small insects

that they capture on the water surface. Their eggs are deposited ithin plants that grow near the water margin. Members in this family are distributed from Canada to Brazil, including the West Indies.

Family: Macroveliidae

Macrovelia is the sole genus in this family. Taxonomists often combine this family with Veliidae. The species Macrovelia hornii occurs throughout California and usually inhabits streams where it is found in moss along the water's margin. This species does not have the ability to walk on water as do the related water striders.

Family: Dipsocoridae

These rare ground bugs usually are found in debris and under rocks and rotten logs. A few species are semi-aquatic and occur along the margins of streams. A soft hairy covering over the body prevents them from getting wet. Little is known about the life history of the North American species. Members of this group have been found along the margins of hot springs in California.

Family: Saldidae (shore bugs)

Bugs in this family are not truely aquatic but are often associated with water. In California, shore bugs have been found along the margins of freshwater lakes, ponds and streams as well as hot springs, salt marshes, and ocean beaches. These bugs are predaceous on small insects. Many are brightly colored in black and yellow. Shore bugs are widely distributed in North America and have been collected as far north as Alaska.

Key to the California Families of HEMIPTERA

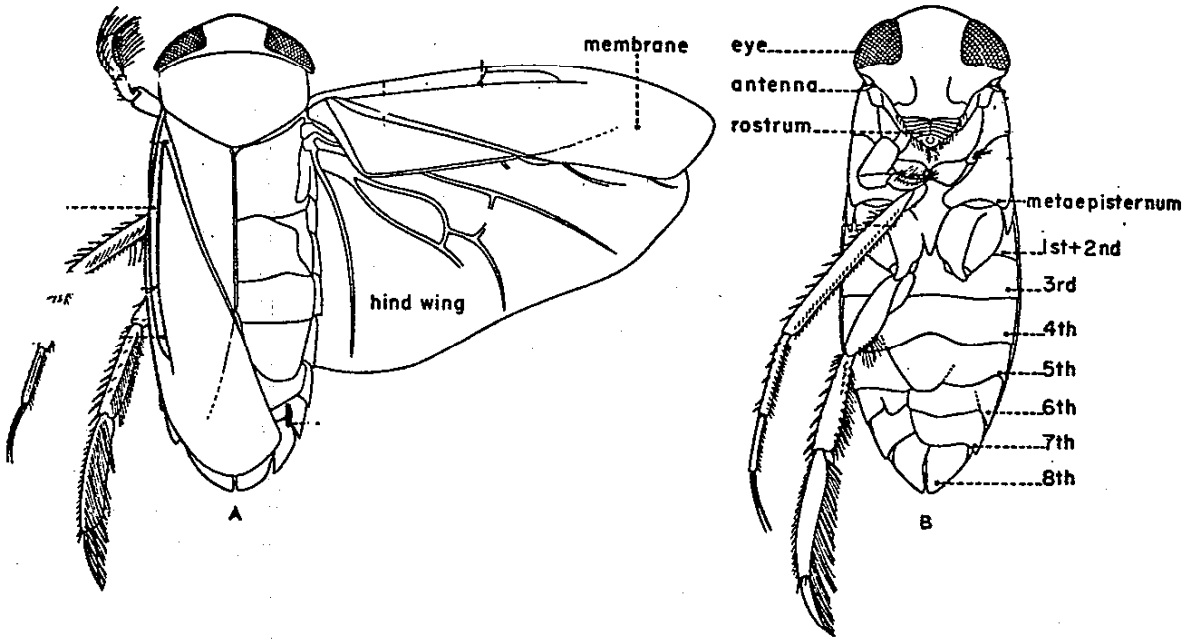


Fig. 53a,b. Corixidae. Dorsal (a) and ventral (b) views of a typical Hemipteran to show the structures used in classification. (Usinger,1956).

1a Antennae not visible from above the head (As in fig. 53a) 2
1b Antennae visible from above the head (As in fig. 63)... 7

2a Ocelli present (fig. 54) ..... GELASTOCORIDAE
2b Ocelli absent 3

3a Tarsi of rear leg with two distinct claws (figs. 56, 57,58) 5
3b Tarsi of rear leg without distinct claws (figs. 53a, 55a) 4

4a Base of the head overlapping the front margin of the pronotum; beak not distinctly segmented (fig. 53a,b) .. ..CORIXIDAE
4b Base of the head not overlapping the front margin of the pronotum; beak distinctly segmented (fig. 55a,b)... .....NOTONECTIDAE

5a Abdomen with a pair of posterior appendages (figs. 57,58) 6
5b Abdomen without a pair of posterior appendages; front femora greatly enlarged (fig. 56) .....NAUCORIDAE

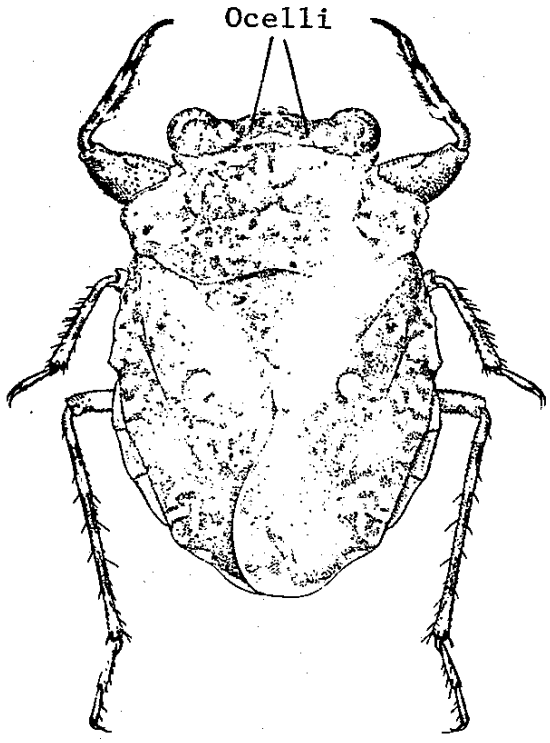
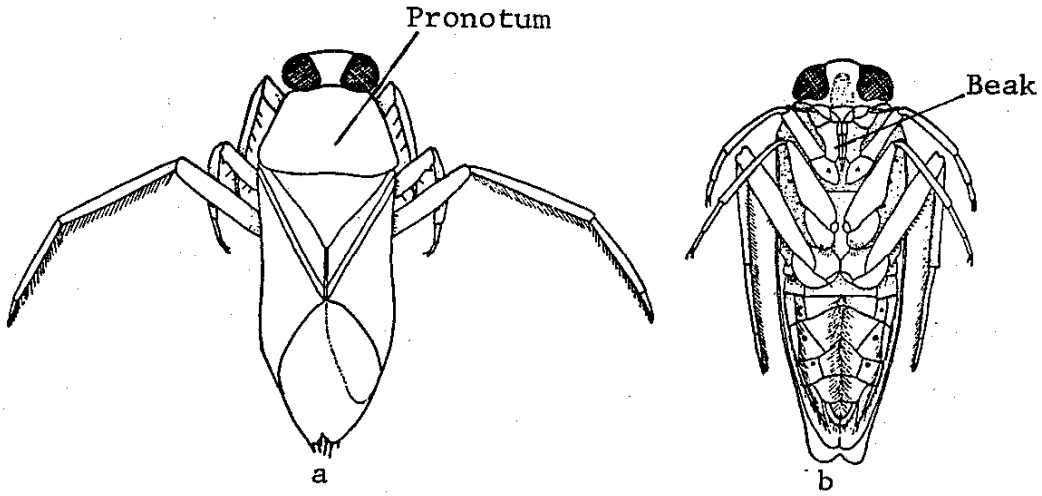


Fig. 54. Gelastocoridae
Dorsal view of an adult
(Usinger,1956).

Fig. 55a,b. (below).
Notonectidae. Dorsal (a)
and ventral (b) view of
an adult. (Usinger,1956).



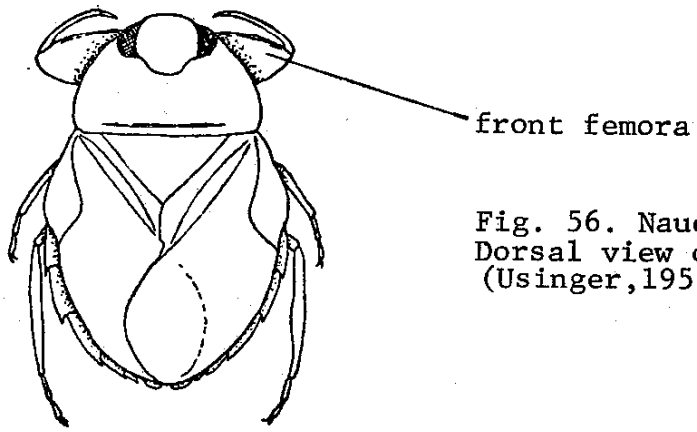


Fig. 56. Naucoridae.
Dorsal view of an adult.
(Usinger,1956).

6a Posterior appendages of abdomen long and slender (fig. 57) .....NEPIDAE
6b Posterior appendages of abdomen short and flat (fig. 58) .....BELOSTOMATIDAE

7a Antennae shorter than the width of the head (fig. 59) .....OCHTERIDAE
7b Antennae longer than the width of the head (figs. 60 to 66) 8

8a Body long and cylinderical with the head nearly 3 times as long as the width across the eyes (fig. 60) ....HYDROMETRIDAE
8b Head short and broad 9

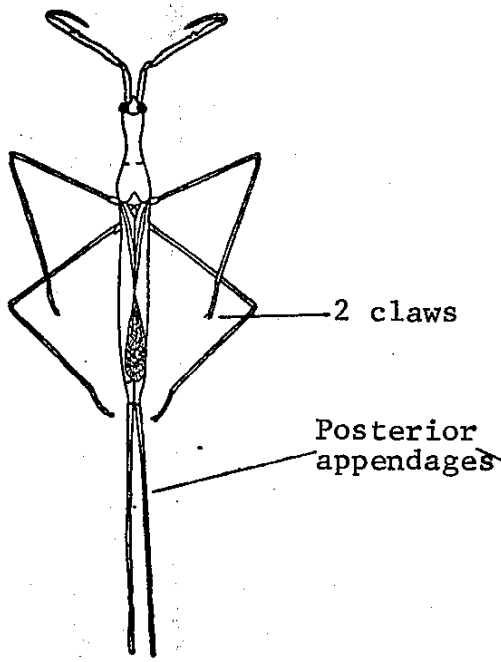


Fig. 57. Nepidae. Dorsal view of an adult. (Pennak,1953).

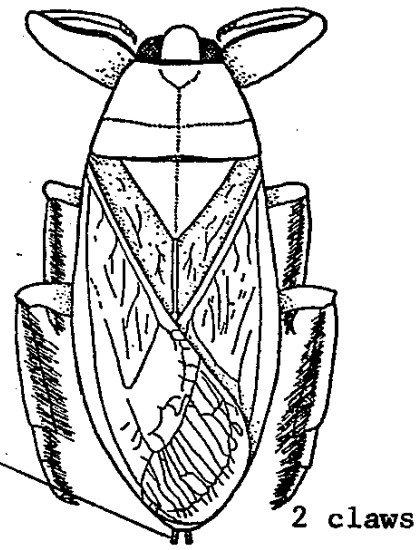


Fig. 58. Belostomatidae Dorsal view of an adult. (Pennak,1953).

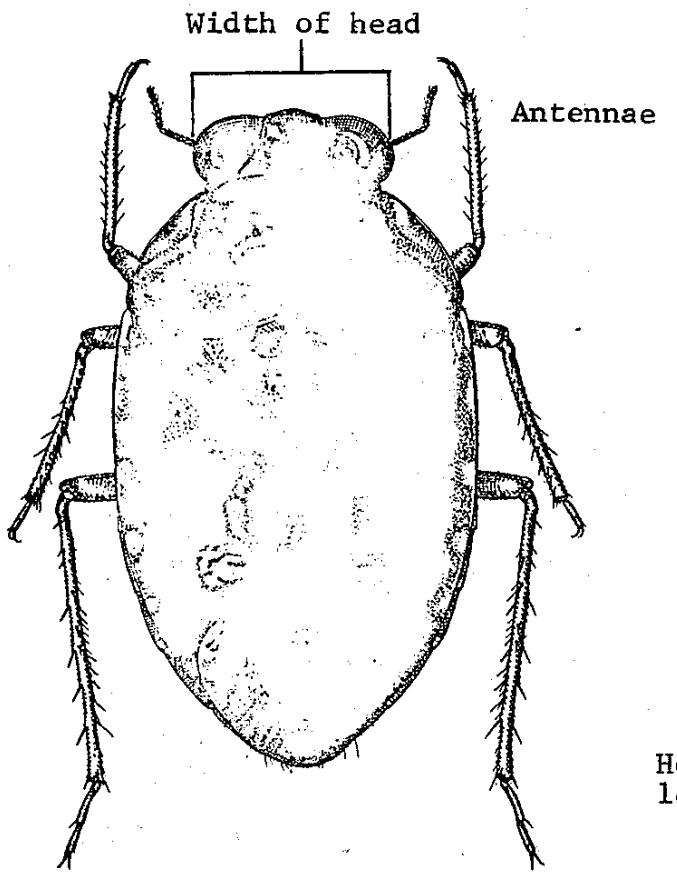


Fig. 59. Ochteridae.
Dorsal view of an adult.
(Usinger,1956).

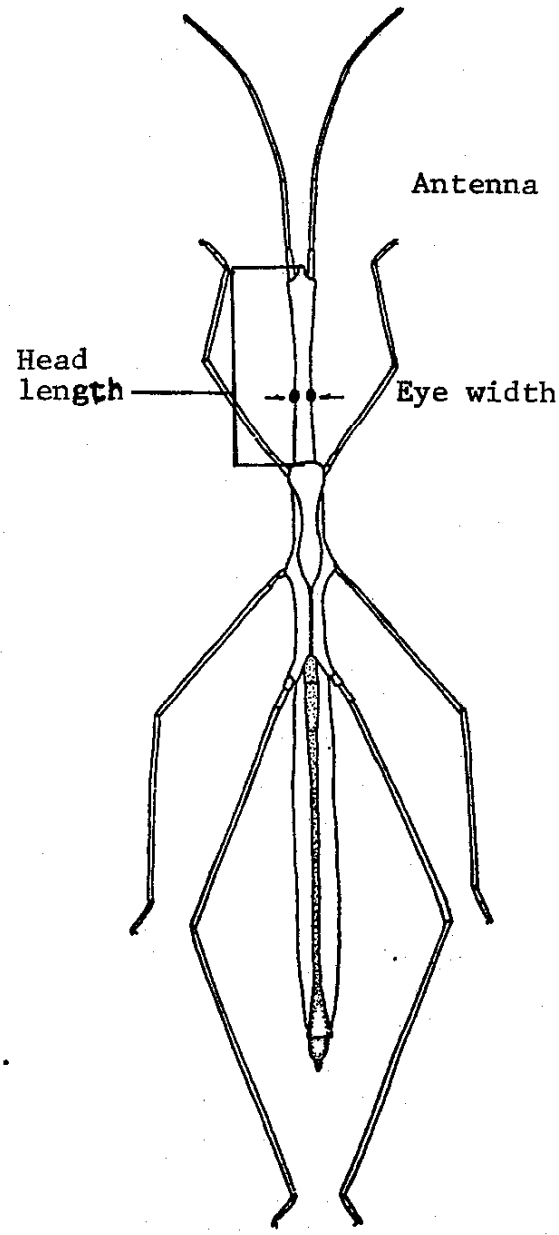


Fig. 60. Hydrometridae
Dorsal view of an adult.
(Pennak,1953).

9a Claws of front tarsi inserted before the apex (figs. 61,62) 10
9b Claws of front tarsi inserted at the apex (figs. 63 to 66) 11

10a Hind femora very long, extending beyond the end of the abdomen (fig. 61) .....GERRIDAE
10b Hind femora not long and scarcely, if at all, extending beyond the end of the abdomen (fig. 62) .....VELIIDAE

11a Adults with 2-segmented tarsi; the underside of the head with a deep groove (fig. 63) .....HEBRIDAE
11b Adult with 3-segmented tarsi; the underside of the head without a groove 12

12a Coxae of the hind leg short and freely movable 13
12b Coxae of the hind leg long and broadly joined to the sides of the thorax (thoracic pleura) 14

13a Scattered stiff, black bristles on the legs (fig. 64) . .....MESOVELIIDAE
13b No scattered stiff, black bristles on the legs (fig. 65) .....MACROVELIIDAE

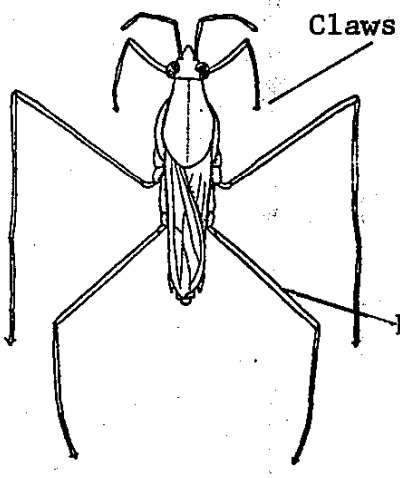


Fig. 61. Gerridae.
Dorsal view of an adult.
(Pennak,1953).

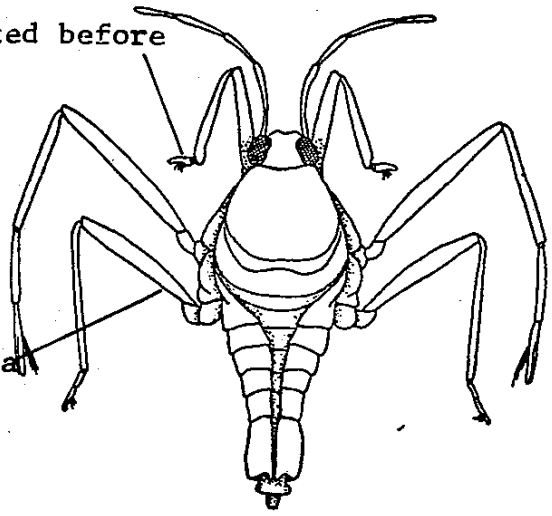


Fig. 62. Veliidae
Dorsal view of a wingless adult.(Pennak,1953).

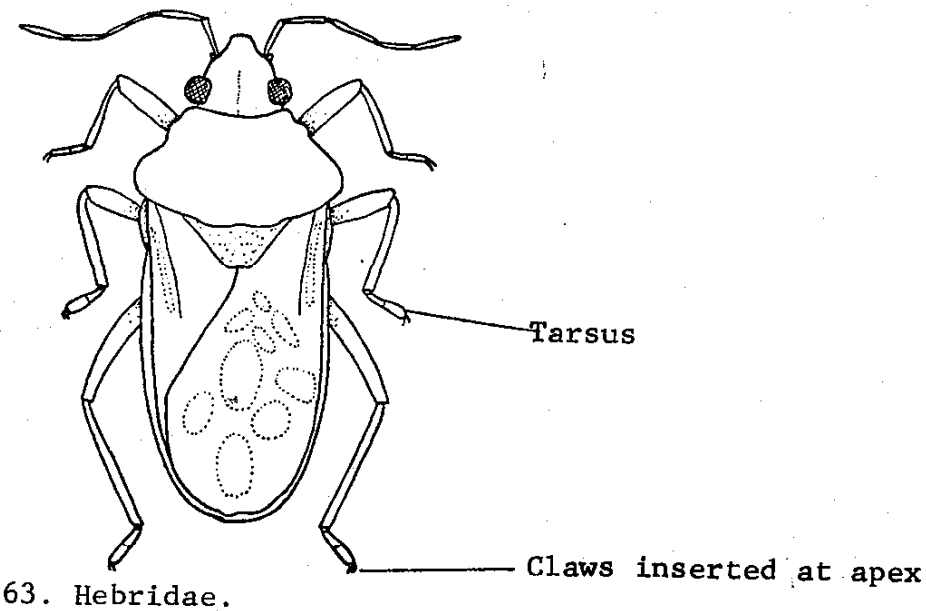


Fig. 63. Hebridae.
Dorsal view of an adult.
(Pennak,1953)

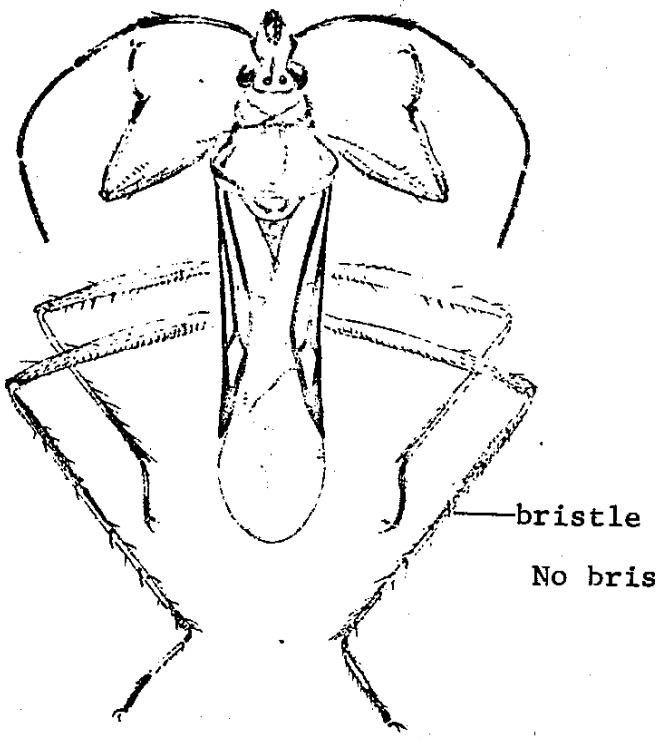


Fig. 64. Mesoveliidae.
Dorsal view of an adult.
(Usinger,1956).

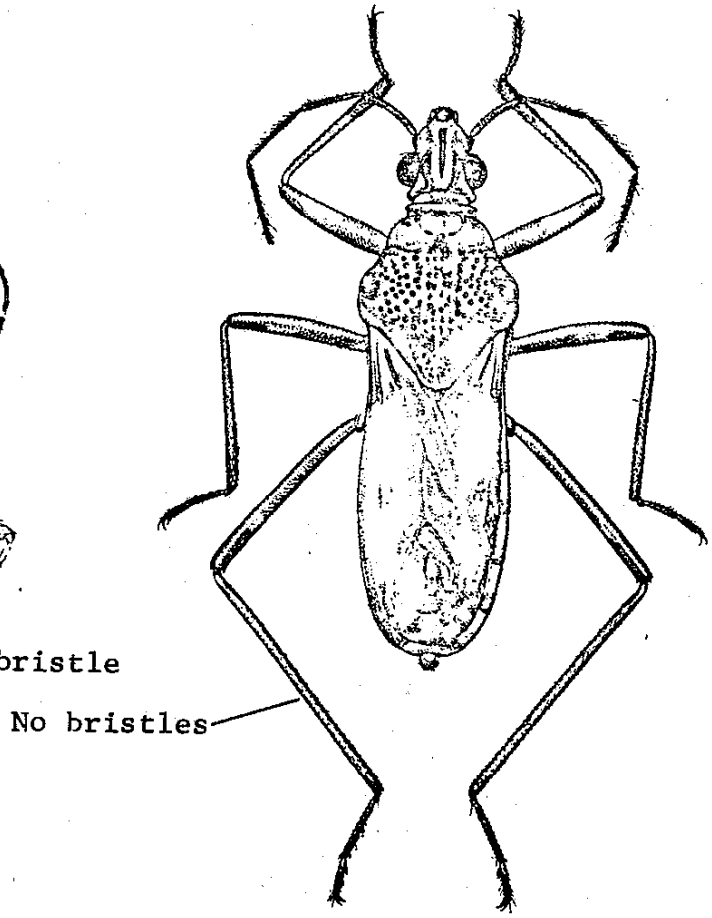


Fig. 65. Macroveliidae.
Dorsal view of an adult.
(Usinger,1956).

14a Ocelli nearer to eyes than to each other (not illustrated) .....DIPSOCORIDAE

14b Ocelli nearer to each other than to the eyes (fig. 66) .....SALDIDAE

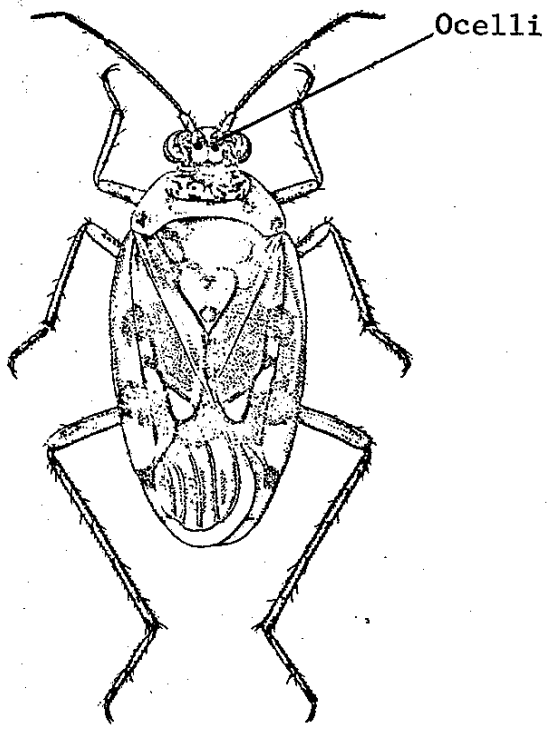


Fig. 66. Saldidae
Dorsal view of an adult.
(Usinger,1956).

KEY TOE THE FAMILIES OF CALIFORNIA

MEGALOPTERA

Order: MEGALOPTERA
Common Name: Dobsonflies, Alderflies, Fishflies

Megalopterans are distributed worldwide but there are relatively few species. Adults in North America range from 10-17 mm in length. The adults are poor fliers and when at rest their wings are held rooflike along the body. The adults in the spring and early summer near streams, ponds and lakes. They live only a few days. Eggs are laid in rows of several thousand on plants or other objects that overhang the water. When the eggs hatch the larvae drop into the water for development The larvae are predaceous and develop for 2 to 3 years. The larvae leave the water to pupate. They crawl as far as 50 meters from the water to build a pupation chamber under a rock.

Synopsis of the California Families of MEGALOPTERA

Family: Sialidae (alderflies)
Adult alderflies are gray to black and less than 20 mm long. The larvae are found in running water and back eddies of streams. The larvae are predaceous but the adults appear to feed little. The larvae leave the water to pupate in the ground. Alderflies are weak fliers and they will often run along the ground rather than fly when disturbed.

Family: Corydalidae (Dobsonflies, fishflies)
The larval stage of these insects are called hellgrammites and are commonly used as fishing bait. The larvae are predaceous and will eat any aquatic organism they can handle. The adult males of some species have large mandibles that overlap when closed. The largest dobsonflies have a wing span of over 150 mm. Dobsonflies and fishflies prefer rivers and streams with coarse, rocky bottoms, although a few species are found on mud bottoms and in stagnant water. This family is found throughout the world.

Key to the California Families of MEGALOPTERA Larvae

1a Last abdominal segment with a long median filament (fig. 67) .....SIALIDAE

1b Last abdominal segment without a long median filament; anal prolegs at the end of the abdomen with 2 hooks on each (fig. 68) .....CORYDALIDAE

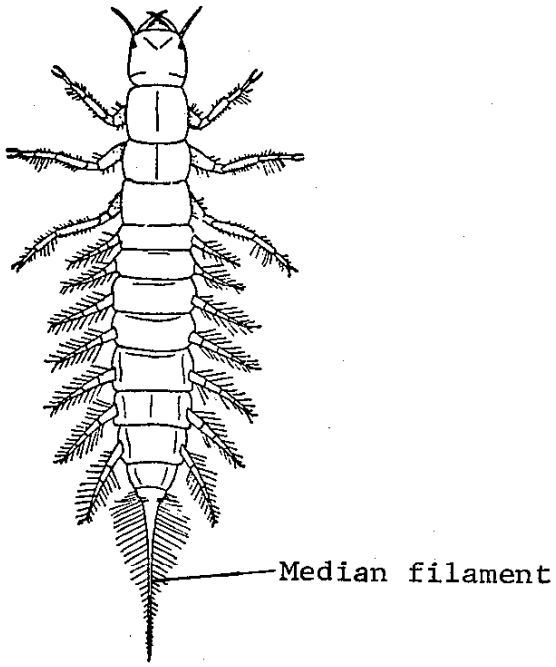


Fig. 67. Sialidae.
Dorsal view of a larva.
(Ross,1937).

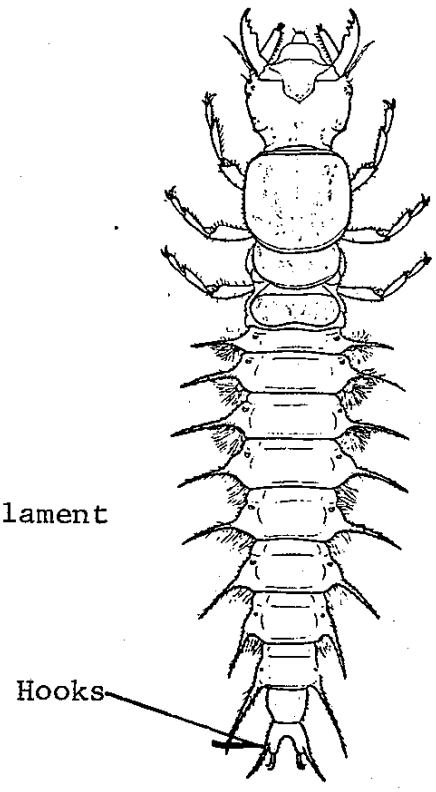


Fig. 68. Corydalidae.
Dorsal view of a larva.(Hellgrammite)
(Edmondson,1959).

Order: NEUROPTERA (= nerve-winged)
Common Name: Spongilla-flies

These interesting insects are parasites on freshwater sponges. The larvae crawl into host sponges and pierce the tissue with their mouthparts. By means of two drinking siphons they suck in juices from the living sponge tissues. The larvae which match their color to that of their host sponge, may be green to light brown in color. The adults resemble small, delicate lacewings and lay their eggs on objects which overhang the water. A single family, Sisyridae, is found in California.

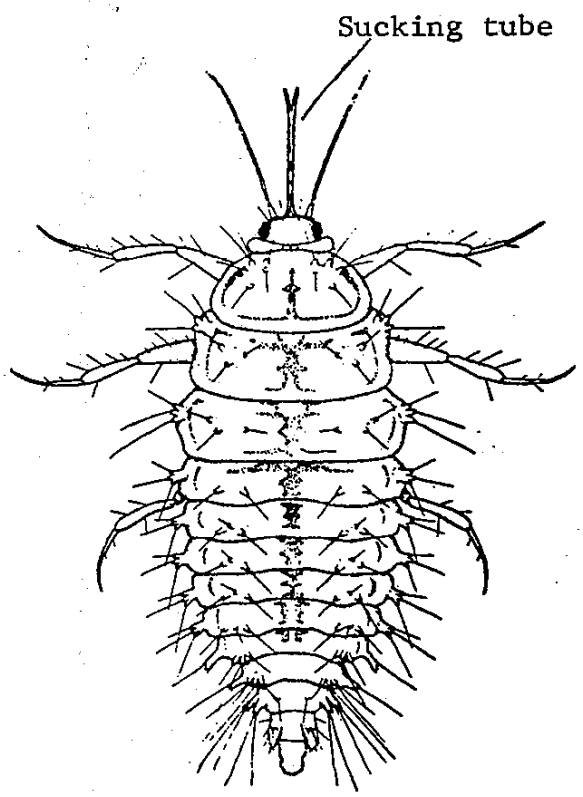


Fig. 69. Sisyridae. Dorsal view of a larva. (Brown,1952).

KEY TO THE FAMILIES OF CALIFORNIA TRICOPTERA (CADDISFLIES)

Order: TRICOPTERA (= hairy-winged)
Common Name: Caddisflies

The caddisflies appear to be related to the butterflies and moths (order Lepidoptera). Adult caddisflies have wings with hair-like setae and some species have wings with a few scales as in lepidopterans. Adults are secretive in habit. Eggs are deposited in strings or masses in or near the water.

Usinger(1956) states that only about 15% of the larvae have been associated with the adults. This makes specific, and often generic identification of the larvae very difficult. The larvae are aquatic and build some type of case or they may be free living without a case. The free-living species are carnivorous, while the case builders are herbivorous. A description of the larval types by Ross(1944) include:

Free-living Forms. The larvae of the genus Rhyacophila are completely free living, having no case or shelter; they lay a thread trail and have many modifications for free life in flowing water, including widely spaced, strong anal hooks. For pupation they form a stone case or cocoon. Many Hydroptilidae instars are free living.

Net-Spinning Forms. Larvae of Hydropsychidae, Philopotamidae, and Psychomyiidae spin a fixed home which is fastened to plants or other supports in the water, sometimes in still water but more frequently in running waters. The three common types of these structures are found, all of them spun from silk and forming some sort of net; whem taken out of water they collapse into shapeless string. There is always an escape exit at the end of the tube.

1. Finger nets. These are long, narrow pockets of fine mesh, with the front end anchored upstream, the remainder brailing behind with the current. They are built by the Philopotamidae.
2. Trumpet nets. In this type the opening of the net is funnel-shaped, and is fastened in such a way that the water movement distends the net into a trumpet-shaped structure. This type net is used extensively by the Psychomyiidae.
3. Hydropsychid net. Peculiar to the family Hydropsychidae is the habit of erecting a net directly in front of a tubelike retreat concealed in a crevice or camouflaged by bits of wood, leaves, or similar material. These nets may be erected between two supports in the open, as in the case of Potamyia, or the net may be constructed as one side of an antechamber, as in the case of many species of Hydropsyche.

Tube-Making Forms. Some psychomyiid larvae, notably of the genus Phylocentropus, burrow into sand at the bottom of streams, cementing the walls of the burrow into a fairly rigid structure

which may be dug out intact. The mechanics of food gathering in this group are not well understood.

Saddle-Case Makers. Larvae of the rhyacophilid subfamily Glossosomatinae make a portable case which consists of an oval top made of stones and a ventral strap made of the same material. The larva proceeds with its head and legs projecting down in front of the strap and the anal hooks projecting down at the back of the strap. For pupation, the strap is cut away and the oval dome is cemented to a support, the pupa being formed in the stone cell produced.

Purse-Case Makers. Following the designs of the above group are many cases of the family Hydroptilidae. In general they resemble a purse. The larva occupies the case with the head and legs projecting out of a slit in the front margin while the anal hooks project out of a slit in the posterior margin. For pupation, the case is cemented along one side to a support and the slits are cemented shut to form the pupal chamber. Not all Hydroptilidae have cases of this type, some of them have true cases.

Case Makers. All caddisfly larvae except those listed above make portable cases which the larvae drag with them in their daily movement. The cases are usually made of pieces of leaves, bits of twigs, sand grains or stones which are cemented or tied together with silk. Rarely, the case is made entirely of silk. Case construction varies a great deal from one group to another, from one species to another within the same genus, and frequently within the same species. In general, cases subject to the greatest stream currents are the most solidly constructed, whereas those in small ponds where there is little current often are quite loosely constructed. In pupation the case is anchord to a support and a top is added to the case; the pupa is formed inside this shelter and no additional cocoon is made.

Order: TRICOPTERA

Synopsis of the California Families

Family: Hydropsychidae, including Arctopsychidae (net-spinning caddisflies)

Members of this group build a cup-shaped net in streams. The net is open on the upstream end and serves to strain food from the water. The larvae live in a chamber at the edge of the water. The adults are usually found along streams and their margins. These families are widely distributed and are fairly common.

Family: Philopotamidae (finger-net caddisflies)

The larvae of this family build long, silken nets of fingerlike design in rapidly flowing streams. The adults are about 6 to 9 mm in length and black in color. When the larvae pupate they build cases of small stones and debris that are attached to the underside of larger rocks. This family has only a few members but is worldwide in distribution.

Family: Psychomyiidae, including Polycentropidae (trumpet-net and tube-net caddisflies)

These families contain many species and are found worldwide. The larvae, which occur along lake shores and rivers make nets that are either trumpet-shaped or tube-shaped. The tube-nets are constructed in burrows in the bottoms of rivers and the sides are cemented with sand grains. Adults range up to 11 mm in length.

Family: Hydroptilidae (microcaddisflies)

Microcaddisflies are usually under 6 mm in length. Larvae do not build cases until their last stage in development. Larval cases are purse-shaped and have both ends open. These caddisflies are found along ponds, lakes and streams where they are often very common. This family is widespread in North America.

Family: Rhyacophilidae

Larvae of the caddisflies in this family do not build cases but rather live free as predators on other aquatic organisms. Larvae and adults can be found in and along cold, rapidly flowing streams. Mature larvae build cases of small pebbles for pupation. This family is large and widely distributed.

Family: Glossosomatidae

Members of this family are found in cold, rapid streams. The larvae construct dome-shaped cases of small stones. During pupation the case is cemented to a stone. Adults seldom reach 7 mm in length and are brown to black in color.

Family: Leptoceridae (long-horned caddisflies)

Some adults of this family have antennae much longer than

the body, hence the common name. These caddisflies can be found in lakes, ponds or streams, and the larvae build cases out of a variety of materials. Cases may be constructed of sand grains or pieces of plants and they vary in design. Adults are under 18 mm in length.

Family: Phryganeidae
Adults in this family are fairly large in size, ranging from 12 to 25 mm in length. The adults and larvae inhabit lakes, marshes and slow flowing streams where submerged plants are found. The larvae build spiral cases from bits of vegetation.

Family: Helicopsychidae
Larvae of this family build their cases out of sand grains in the form of a snail shell. Larvae live in springs and clear streams over much of North America. Adults are only 5 to 7 mm in length.

Family: Brachycentridae
Caddisflies of this family inhabit clear, cool streams and rivers in mountain areas. The larvae build conical cases of sand grains or squarish cases of plant material. Some species build one-half of their case of one type, and the other another. Adults are 6 to 12 mm in length.

Family: Limnephilidae
Species in this family can be found in a variety of habitats including springs, ponds, lakes, and streams. The larvae build cases of many different designs and out of a variety of materials. This family contains many species and is well represented in California.

Family: Lepidostomatidae
This family is widely distributed in North America. Its members are found in streams, rivers, springs, and ponds. Larval cases are of various types including conical cases of sand grains and rectangular cases of plant material.

Family: Calamoceratidae
Members of this family are uncommon. Adults and larvae inhabit springs and fast flowing streams. The larval cases are composed of plant materials and sometimes are triangular in cross section. Hollowed out twigs have also been used as cases.

Family: Odontoceridae
Little is known about this rare family of caddisflies. The larvae build cylindrical tapering cases of small sand grains. Members in this family are found in riffle areas of cold, fast flowing streams.

Key to the California Families of TRICOPTERA Larvae

1a Pro-, meso-, and metanota each with a single sclerotized shield covering the entire notum (figs. 70a,b,71) 2

1b Either meso-, or metanotum or both without a complete sclerotized shield (maybe subdivided into separated sclerites) (figs. 79,92) 4

2a Abdomen with conspicuous branched ventral gills; anal gills present. Larvae construct retreats (fig. 71) ... 3

2b Abdomen without ventral gills; no anal gills; larvae with the abdomen swollen and usually much wider than the thorax; larvae not larger than 5 mm (figs. 70a,b) .....HYDROPTILIDAE

3a Fore trochantin forked or if simple then the gula is triangular or rectangular and of even width (figs. 71,72a,b; 73a,b) .....HYDROPSYCHIDAE

3b Fore trochantin simple and the gula is rectangular but it narrows posteriorly (figs. 72c,73b) ....ARCTOPSYCHIDAE

4a Anal legs projecting beyond the membranous 10th abdominal segment. Larvae free living, or in silken retreats-usually no case (figs. 75,79) 5

4b Anal legs embedded in the side of the 10th abdominal segment and only part of the claws projecting beyond the segment (figs. 86,92) 9

Sclerotized shields

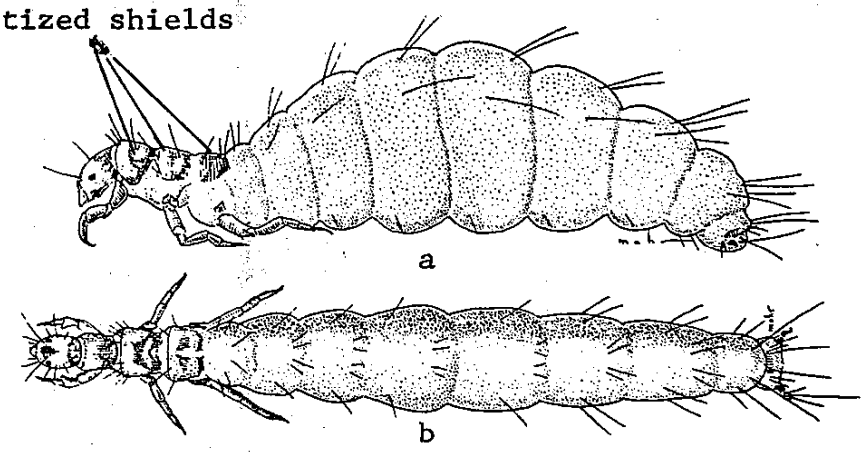


Fig. 70a,b. Hydroptilidae. Lateral (a) and dorsal (b) of a larva.(Edmondson,1959).

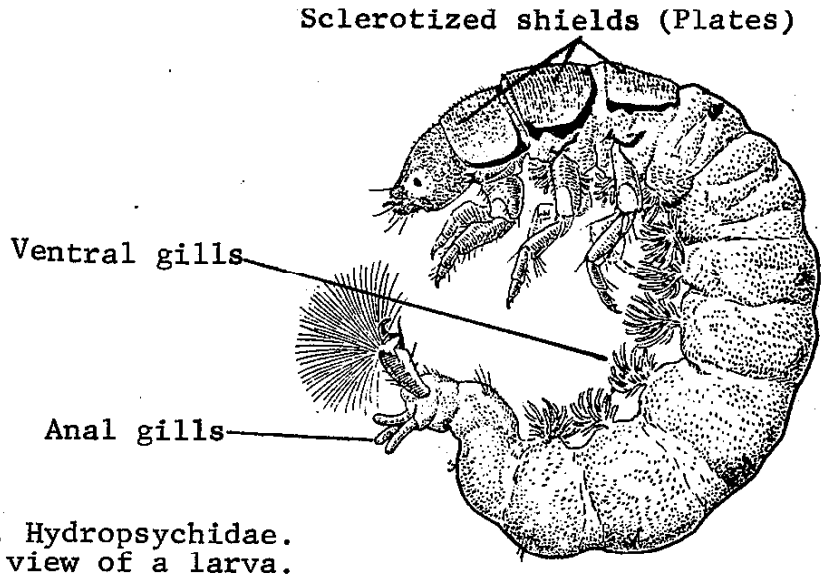


Fig. 71. Hydropsychidae.
Lateral view of a larva.
(Edmondson,1959).

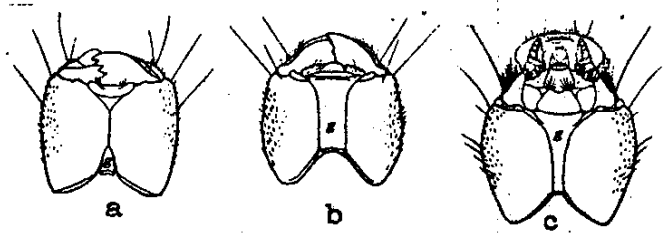


Fig. 72a-c. Ventral views of the head showing the gula(g).
a. Hydropsychidae with triangular gula(g)
b. Hydropsychidae with rectangular gula(g)
c. Arctopsychidae with rectangular gula that narrows posteriorly.
(Edmondson,1959).

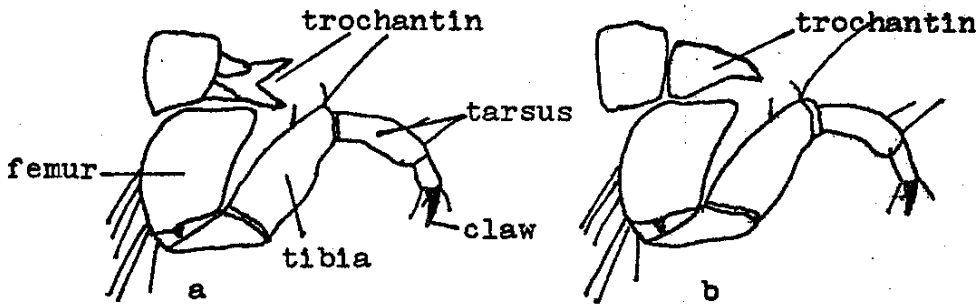


Fig. 73a,b. Fore leg and fore trochantin of two larvae showing the different types of trochantin.
a. Trochantin forked.
b. Trochantin simple(single point).

5a Sclerotized shield on the dorsum of the 9th abdominal segment (fig. 75,77) 6

5b No sclerotized shield on the dorsum of the 9th abdominal segment, the segment completely membranous (figs. 79,81,82) 7

6a Anal claw large and nearly as long as the sclerite on the anal leg. Larvae free-living (figs. 75,75)..... .....RHYACOPHILIDAE

6b Anal claw very small and much shorter than the sclerite on the anal leg. Larvae with a case (figs. 76,77) .....GLOSSOSOMATIDAE

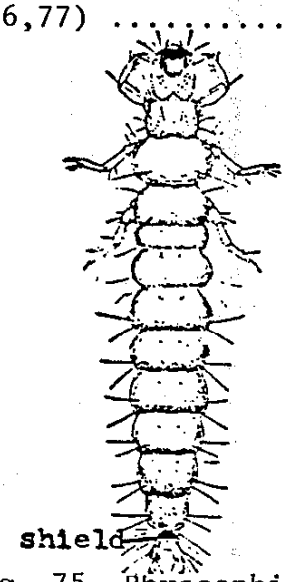


Fig. 75. Rhyacophilidae
Dorsal view of a larva.

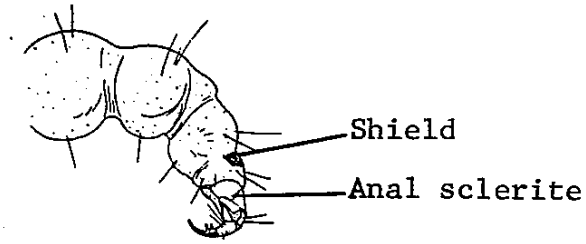


Fig. 74. Rhyacophilidae
Lateral view of the last 6 segments of the abdomen of a larva. (Edmondson,1959).

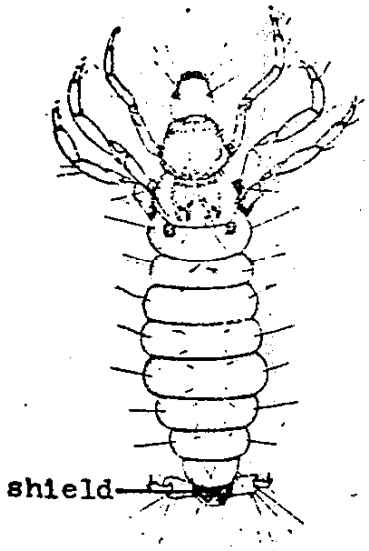


Fig. 77. Glossosomatidae.
Dorsal view of a larva.

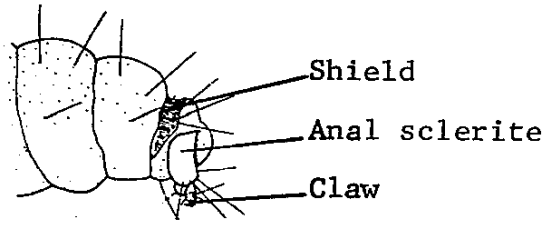


Fig. 76. Glossosomatidae.
Lateral view of the last 7 segments of the abdomen of a larva. (Edmondson,1959).

7a Labrum membranous and expanded distally. Larvae live in silken tubes under rocks (figs. 78a,79) ....PHILOPOTAMIDAE

7b Labrum not expanded distally. Larvae live in retreats under rocks (fig. 78b) 8

Fig. 78a,b. Two types of larval labrums.
a. Philopotamidae.
b. Psychomyiidae and Polycentropidae.
(Edmondson,1959).

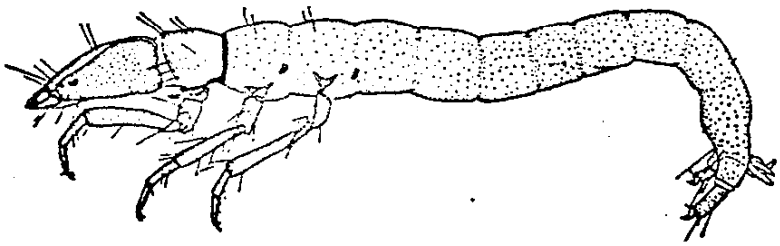


Fig. 79. Philopotamidae.
Lateral view of a larva.

8a Fore trochantin squarish, set off from the pleuron by a ridge visible externally as a black line (figs. 80a,81) .....PSYCHOMYIIDAE

8b Fore trochantin pointed and fused to the pleuron; no black line visible (figs. 80b,82) .....POLYCENTROPIDAE

9a Antennae at least 8 times longer than wide and originating at the base of the mandibles (fig. 83) ... .LEPTOCERIDAE (in part)

9b Antennae not more than 3 or 4 times longer than wide and originating at various points and often difficult to see (figs. 91,93) 10

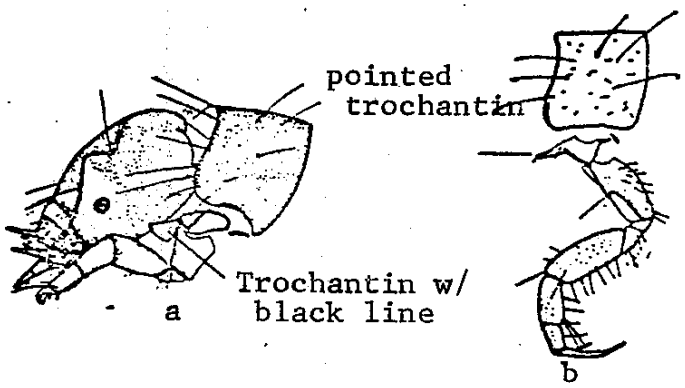


Fig. 80a,b. Lateral view of the fore legs of two larvae showing the appearance of the fore trochanters.

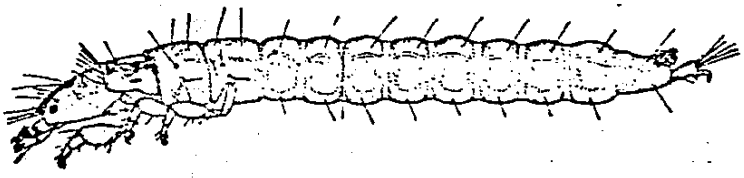


Fig. 81. Psychomyiidae.
Lateral view of a larva.

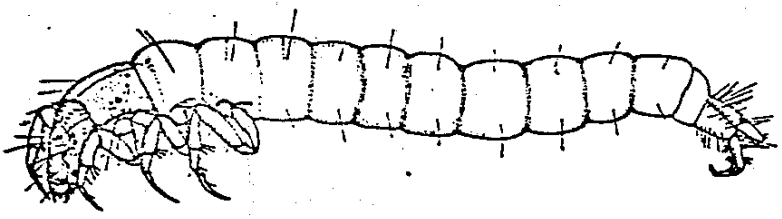


Fig. 82. Polycentropidae.
Lateral view of a larva.

10a Mesonotum membranous except for a pair of parentheses-like sclerotized bars (fig. 84) .....
.....LEPTOCERIDAE (in part)

10b Mesonotum without parentheses-like bars 11

11a Meso-, and metanota without membranous sclerites (fig. 85) .....PHRYGANEIDAE

11b Mesonotum and/or metanotum with some distinct sclerotized plates (Fig. 90,92,95a-d) 12

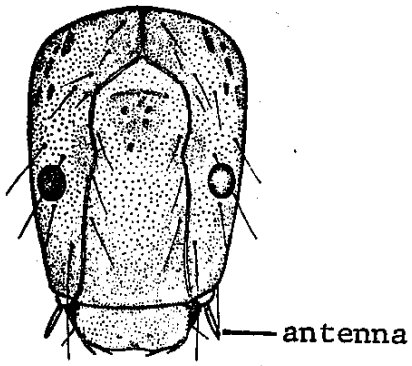


Fig. 83. Leptoceridae. Frontal view of the head of a larva. (Hickin,1967).

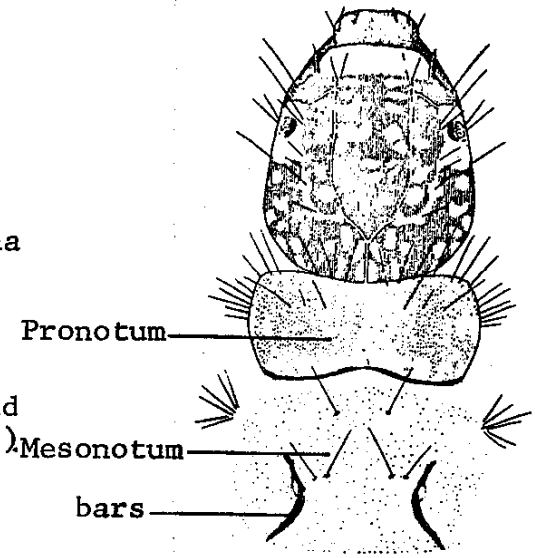


Fig. 84. Leptoceridae Dorsal view of the head and thorax of a larva.

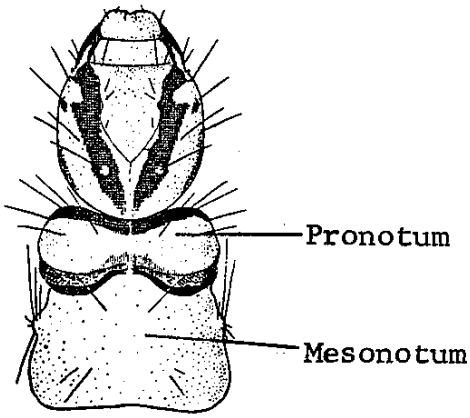


Fig. 85. Phryganeidae. Dorsal view of the head and thorax of a larva. (Edmondson,1959).

12a Teeth of the anal claw are comblike in appearance (fig. 87); The larval case looks like a snail shell (fig. 88) .....HELICOPSYCHIDAE

12b Teeth of the anal claw are not comblike in appearance 13

13a Pronotum in side view with a furrow running in front of a ridge along the posterior margin of the pronotum (fig. 89a) 14

13b Pronotum without the furrow (fig. 89b,c) 16

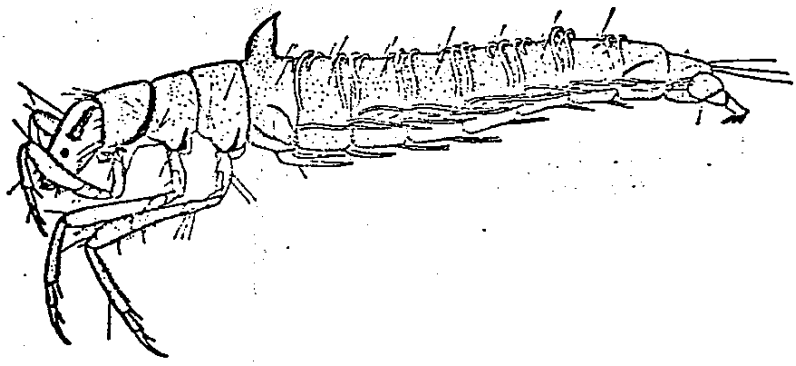


Fig. 86. Phryganeidae. Lateral view of a larva. (Hickin,1967).

Fig. 87. Helicopsychidae Anal claw of the larvae.

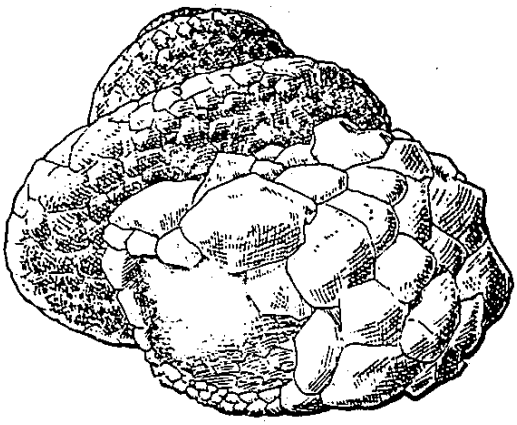


Fig. 88. Helicopsychidae. Larval case. (Ross,1944).

14a Pronotum with a distinct, sharp furrow crossing it near the middle (fig. 90) .....BRACHYCENTRIDAE

14b Pronotum without a furrow or at most with a shallow furrow 15

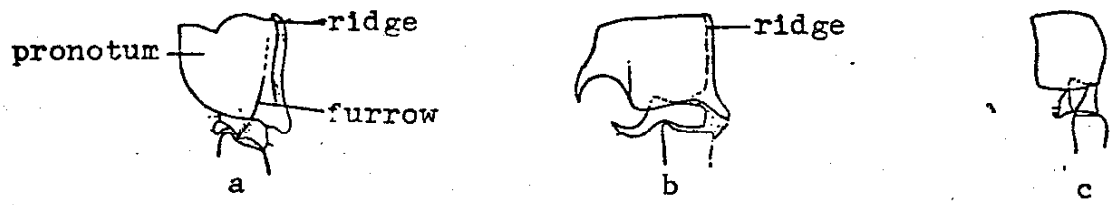


Fig. 89a-c. Lateral views of the pronota of three different larvae.
a. Pronotum with furrow in front of ridge.
b. Pronotum with a ridge but no furrow.
c. Pronotum without a ridge or a furrow.

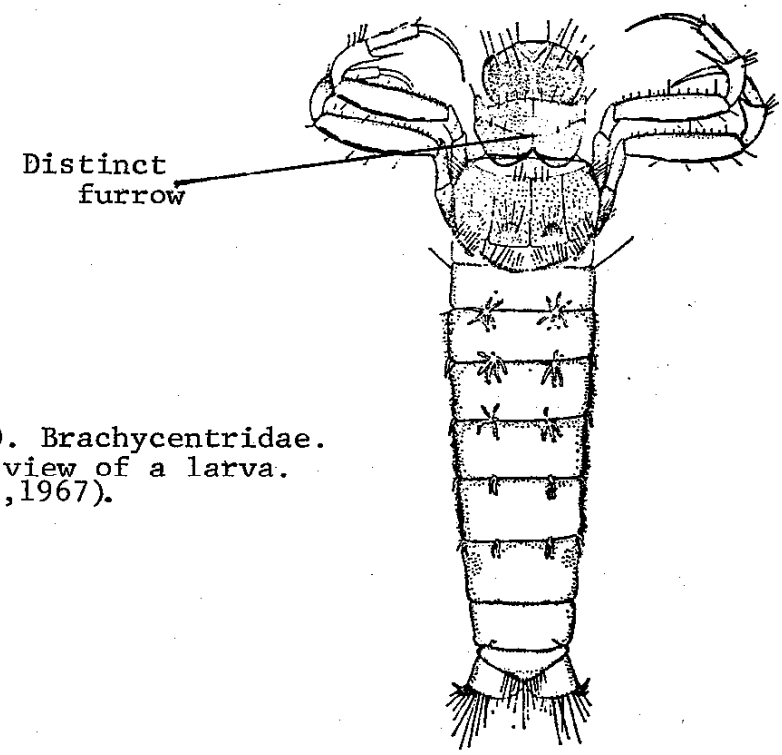


Fig. 90. Brachycentridae. Dorsal view of a larva. (Hickin,1967).

15a A dorsal tubercle on abdominal segment 1 (fig. 92); antennae arising midway between the eyes and the mandibles or closer to the mandibles than to the eyes (fig. 91) .....LIMNEPHILIDAE

15b No dorsal tubercle on abdominal segment 1 (fig. 94); antennae arising very close to the eyes (fig. 93) .....LEPIDOSTOMATIDAE

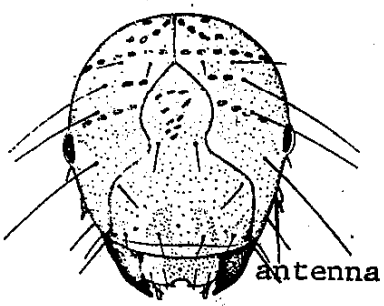


Fig. 91. Limnephilidae. Frontal view of the head of a larva. (Hickin, 1967).

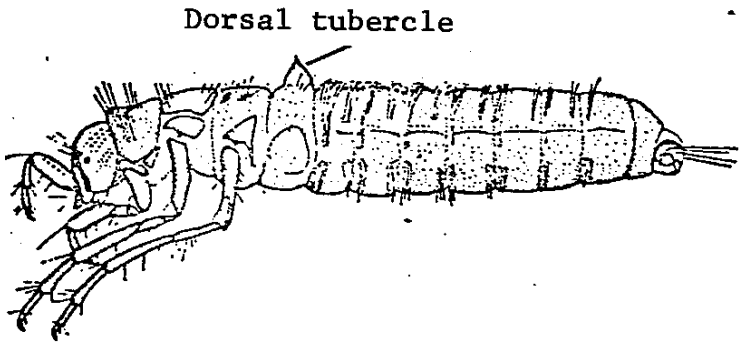


Fig. 92. Limnephilidae. Lateral view of a larva. (Hickin, 1967).

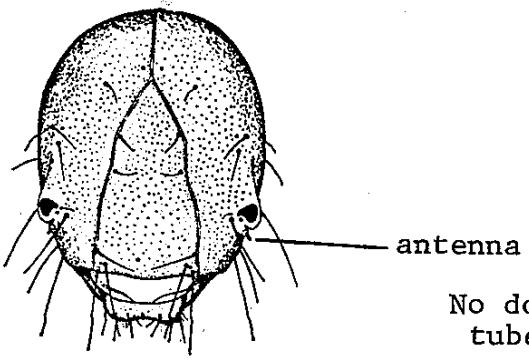


Fig. 93. Lepidostomatidae. Frontal view of the head of a larva. (Hickin, 1967).

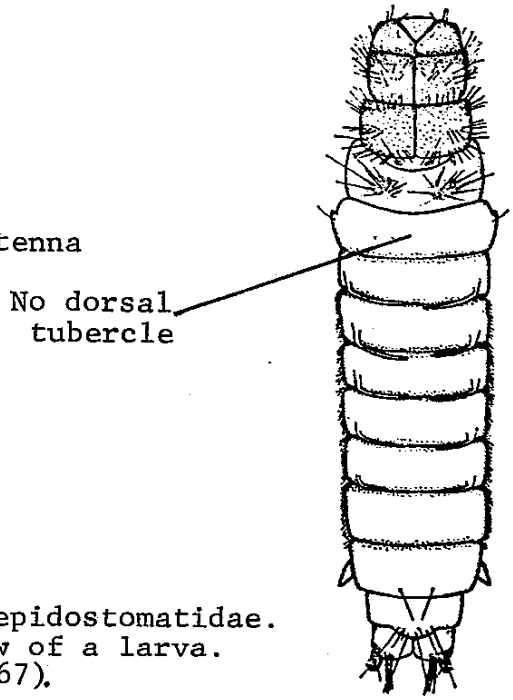


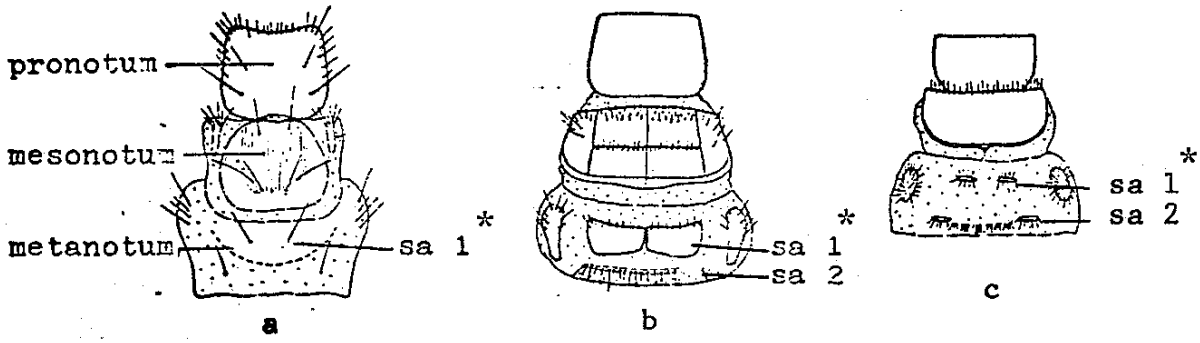
Fig. 94. Lepidostomatidae. Dorsal view of a larva. (Hickin, 1967).

16a Metanotum with sa 1*a single hair (fig. 95a); Larvae living in hollowed out twigs.....CALAMOCERATIDAE

16b Metanotum with sa 1*bearing a row of hairs which may be difficult to see because of their light color (fig. 95b-d) 17

17a Gills in tuffs of fine threads; sa 2*a row of hairs on a thin, faint linear plate (fig. 95b,c)...ODONTOCERIDAE

17b Gills slender and single (fig. 96); metanotum with sa 2*a single setae on a small plate (fig. 95d) ....SERICOSTOMATIDAE



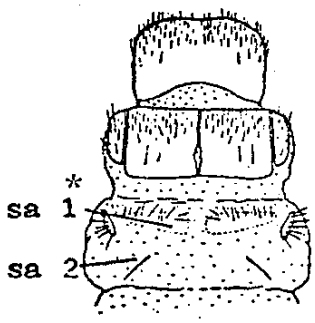


Fig. 95a-d. Dorsal views of the thoraces of 4 different larvae to show the arrangement of plates and hairs.(Edmondson,1959).
a. Calamoceratidae.
b,c. Odontoceridae.
d. Sericostomatidae.

* Note: sa= setal area

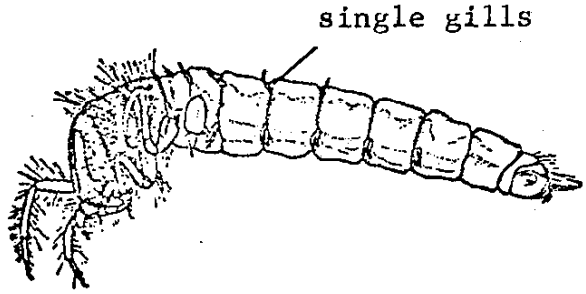


Fig. 96. Sericostomatidae. Lateral view of a larva. (Hickin,1967).

Family: Sericostomatidae

This small family contains less than a dozen species in North America. Adults and larvae are found in lakes and streams. Larvae build cylindrical cases of sand grains.

Order: LEPIDOPTERA (= scale-winged)
Common Name: Butterflies and Moths

Family: Pyralidae (aquatic moths)

The only aquatic moths of the order are in this family. The aquatic members of this family feed on aquatic macrophytes, algae and diatoms. Some species make cases out of the leaves of plants on which they feed. Eggs are usually laid on the underside of floating aquatic plants. The species that feed on diatoms and algae are often found on rocks in swift streams. The adult females of these species swim underwater using their hind legs like oars and lay their eggs on rocks. Some species of wasps parasitize the pupae of these aquatic moths.

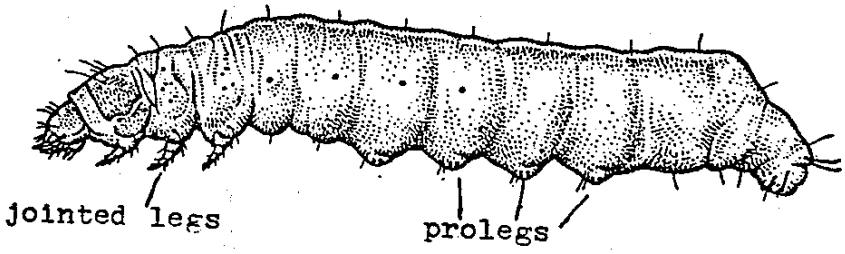


Fig. 97. Pyralidae. Lateral view of a larva.

Order: HYMENOPTERA (= membrane-winged)
Common Name: Wasps

Some species within this order are semi-aquatic in habit. The adults of only a few species enter the water to lay their eggs on or in a host organism. The immature stages of the wasps develop in the host's body, eventually killing it. The aquatic wasps of this order are known to parasitize caddisflies, water bugs, aquatic moths, aquatic beetles, damselflies, shore flies, and semi-aquatic spiders. Observations have shown that some species use their wings and legs to swim underwater, while other species use only their legs. Adults of many aquatic insects are parasitized by wasps when they are out of the water. Knowledge about these interesting semi-aquatic wasps in California is limited.

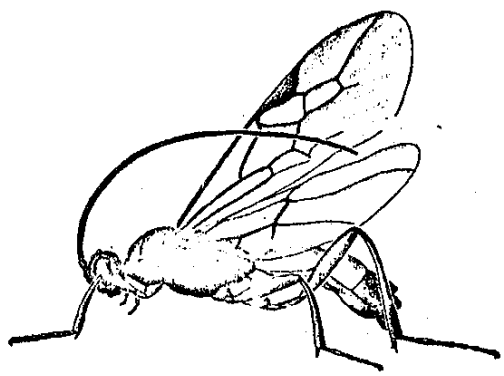


Fig. 98. Hymenoptera.
Lateral view of an adult.

KEY TO THE FAMILIES OF CALIFORNIA

COLEOPTERA ADULTS (BEETLES)

Order: COLEOPTERA (= sheath-winged)
Common Name: Beetles

Beetle are the most numerous group of animals known. As an example there are approximately 300,000 species of beetles known with about 1000 new species being described each year. Within this order, about 5000 species can be described as aquatic at some stage of their life cycle. Aquatic beetles are found in many habitats including freshwater ponds, lakes, streams, rivers, inland saline lakes, and ocean beaches.

Many families of beetles depend on water and are completely aquatic with both the adult and larval stages occuring in water. Other families may have only the larval stage aquatic, and still others may be semi-aquatic with the adults and larvae living along the water's edge.

Adult aquatic beetles depend on atmospheric oxygen for respiration, and they obtain it in two ways. Members of the families Amphizoidae, Haliplidae, Dytiscidae, Noteridae, and Gyrinidae carry an oxygen supply under the elytra (forewings). When they return to the surface to renew their air supply they break the surface with the ends of the elytra and abdomen. Members of the other aquatic beetle families, in addition to carrying air under the elytra, hold a film of air on the ventral side of the abdomen by means of short, dense hairs. This film of air often gives the beetles a silvery appearance when submerged. When the beetles of this group return to the surface, they break the surface with their antennae.

Most beetle larvae leave the water to pupate on land. The larvae, as the adults, are either carnivorous or herbivorous. Both larvae and adults can be harmful to certain crops such as rice. Most species are beneficial to man. In Asia, some of the larger beetles are eaten by man for food and medicine. Beetles comprise an important segment in the diet of frogs, toads, salamanders, aquatic birds, turtles, and fish.

Many species of aquatic beetles fly with some migrating from one water body to another nightly. The forewings of the adults are horny or leathery while the hindwings, if present, are membranous, and folded under the forewings.

Eggs of aquatic beetles are deposited below the surface on plants or other objects.

This key does not include beetle families that are found only along the water margins, or those in the intertidal habitat. If the key characters do not fit the specimen do not attempt to key that particular organism.

Order: COLEOPTERA

Synopsis of the California Families

Family: Gyrinidae (whirligig beetles)

These shiny, black beetles are found on lakes, ponds, and the slow-flowing backwaters of streams. They are often seen on the water surface circling around or just floating quietly. Each eye is divided into two halves, the upper half, when the beetle is on the surface is in the air and the lower half is below the water. When disturbed the adults often dive quickly to the bottom or gyrate rapidly in circles. The adults and larvae are scavengers or predators. This group has been known to feed on worms, dragonfly naiads, other insects, small fish, and dead plant and animal matter. Adult beetles hibernate in the pond or stream bottoms during the winter.

Family: Haliplidae (crawling water beetles)

The crawling water beetles are small, being less than 5 mm in length. This widespread group is found in shallow water areas of ponds, lakes and streams. The adults are herbivorous and carnivorous while the larvae are strictly herbivorous. Some species of adult beetles hibernate during the winter while other remain active even under an ice cover. The eggs of these beetles are laid in and on aquatic vegetation.

Family: Amphizoidae

The adults and larvae of this family inhabit clear streams and rivers. Both adult and larvae crawl rather than swim and are usually found under rocks or in debris at the margins of the water. Their food is thought to be only stonefly nymphs. The eggs are laid in the cracks of floating logs or other debris. All known members of this family are from the western United States and Canada except for a single species described from Tibet.

Family: Noteridae (burrowing water beetles)

The adults of this family are world wide in distribution and are active swimmers. Larvae and adults are found in ponds and lakes having abundant aquatic vegetation. The adults are predaceous while the larvae are thought to be omnivorous. The larvae have legs adapted for rapid burrowing in mud, giving rise to his family's common name. The adults also burrow in bottom debris while the eggs are laid in mud or on the roots of aquatic plants.

Family: Dytiscidae (predaceous water beetles)

Members of this family occupy a wide variety of habitats from streams, rivers, ponds, and lakes, to salt marshes and bogs. Adults of some species are powerful swimmers and propel themselves by using their hind legs like oars. Some

species can fly over considerable distance while others are flightless. Both adults and larvae are carnivorous and have been known to feed on other aquatic insects, microorganisms, small fish, and tadpoles. Some species produce sounds by rubbing the legs against the abdomen. Eggs are usually deposited on or in aquatic plants under the water. This family is worldwide in distribution and even occurs on some oceanic islands.

Family: Hydroscaphidae
These very small beetles are no more than 1mm in length. They have been found along the margins of streams and hot springs where they feed on filamentous algae. Eggs are developed one at a time and are deposited on algae.

Family: Hydraenidae
These small beetles are worldwide in distribution and can be found in a variety of habitats. They have been reported from ponds, lakes, swift flowing streams and rivers, saline waters and hot springs, and the intertidal zone of the ocean. The adults of most species are aquatic but they are not well adapted for swimming. The larvae are littoral and occur in moist areas along shore margins. The adults are usually herbivorous while the larvae are carnivorous.

Family: Hydrophilidae (water scavenger beetles)
Beetles in this large family usually occur along the margins of slow flowing streams or in weedy ponds and lakes. The adults are omnivorous while the larvae are carnivorous. These beetles are an important item in the diet of other animals such as frogs, toads, fish, birds, and ducks. Nearly 200 species are known from the United States and many species are found in California.

Family: Curculionidae (weevils, snout beetles)
The weevils are a large family with most of the members being terrestrial. The aquatic species are associated with aquatic plants on which they feed. One species is a serious pest to rice crops. Most adults and larvae are not truly aquatic but they do bore into the stems of plants below the water to feed and lay eggs. Air filled chambers within the plants protect them from the water.

Family: Chrysomelidae (longhorn leaf beetles)
These beetles are intimately associated with aquatic plants on which they feed. The larvae are aquatic and the adults are known to briefly crawl underwater. Mating occurs out of the water and the eggs are deposited on the emergent parts of the plants or within the plant tissues. Larvae obtain oxygen by directly absorbing it form the water through the skin or by piercing plant tissues and using cellular air.

Family: Helodidae
This family of small beetles is worldwide in distribution.

The adults are all terrestrial but the larvae are aquatic. Larvae can be found in ponds, streams and cavities of trees. The larvae are herbivorous. The mature larvae of most species leave the water to pupate in wet soil.

Family: Ptilodactylidae

Beetles of this small family are found only in North America. The adults can be found along the margins of streams and springs. The larvae are herbivorous.

Family: Limnichidae

These small, uncommon beetles are known only from North America. The adults can be found along the margins of streams under debris. Aquatic larvae occur on stones and debris in clear streams. The adults are covered with a dense mat of short hairs and the body may have a metallic luster to it.

Family: Psephenidae (water pennies)

Water pennies occur in swift water areas of streams, usually on rocks. The adults are littoral in habit and enter the water to deposit eggs. The larvae are oval and flat, like a limpet, which is an adaptation to their swift water habitat. Water pennies are a small family found only in North America. This type of beetles are one of the few aquatic beetle families adapted to fast flowing water.

Family: Dryopidae

None of the aquatic or semi-aquatic beetles in this family can swim, rather they hold tight to plants and debris or crawl slowly over the bottom. Both the adults and larvae are herbivorous. Adults readily enter the water to feed. These beetles have been found in fast flowing streams and rivers as well as water storage tanks. The family is worldwide in distribution.

Family: Elmidae (riffle beetles)

Adult elmids are small beetles only 2 or 3mm in length. Most are found in streams but a few occur in ponds and lakes. Adults usually hide under rocks and logs at the water margin. Larvae cannot swim but rather crawl slowly over the bottom or hold on to vegetation. Both the adult and the larvae are herbivorous. This group is world wide in distribution

Order: COLEOPTERA

Key to the California Families of Coleoptera Adults

1a First visible abdominal sternite completely divided by the hind coxal cavities (fig.99) 2
1b First visible abdominal sternite extending for its entire length behind the hind coxal cavities (fig.100)... 6

2a Eyes divided by the sides of the head and appearing as four(4) (fig.101) .....GYRINIDAE
2b Eyes 2, not divided by the sides of the head 3

3a Hind coxae expanded into large plates which cover the first 2 or 3 abdominal sternites (fig.102)..HALIPLIDAE
3b Hind coxae not expanded into large plates and not covering more than the first abdominal sternite 4

4a Metasternum with a transverse, triangular, antecoxal sclerite separated by a distinct suture; hind tarsi not flattened or fringed with hairs (fig.103).....AMPHIZOIDAE
4b Metasternum without a transverse, antecoxal sclerite separated by a suture; hind tarsi flattened and usually fringed with long hairs 5

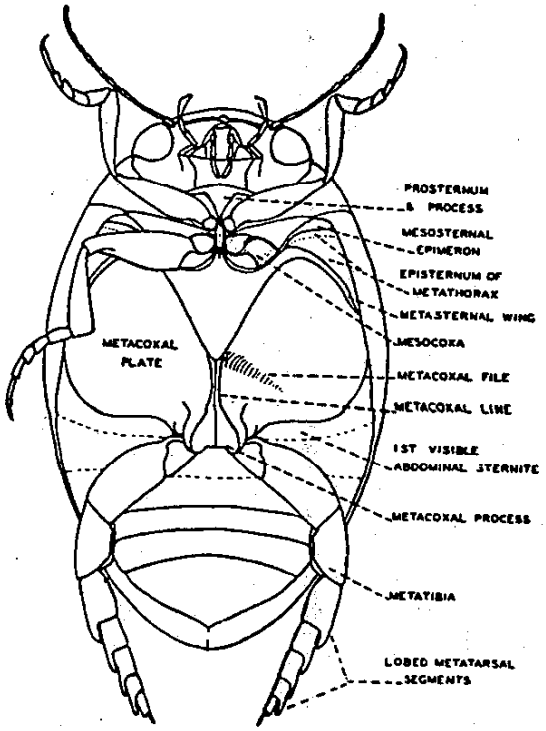


Fig. 99. Dytiscidae
Ventral view of an adult.
(Leech,1948).

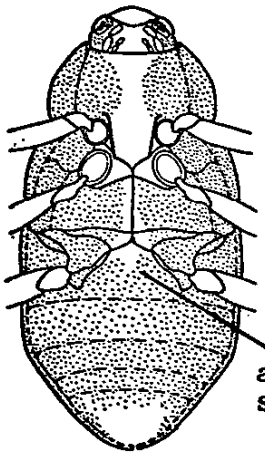


Fig. 100. Dryopidae
Ventral view of an adult.

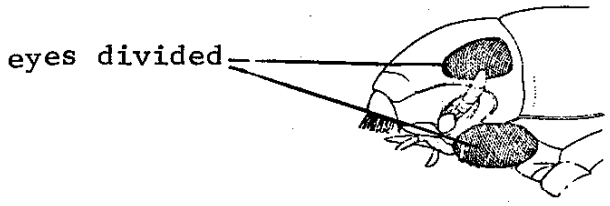


Fig. 101. Gyrinidae.
Lateral view of the head
of an adult. (Edmondson, 1959).

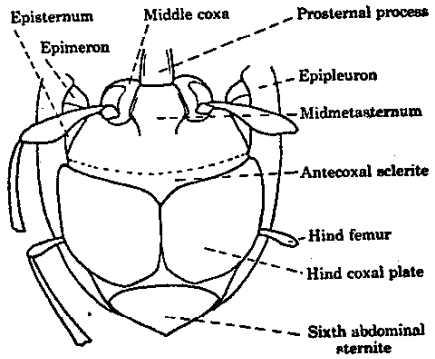


Fig. 102. Haliplidae.
Ventral view of the abdomen
of an adult. (Edmondson, 1959).

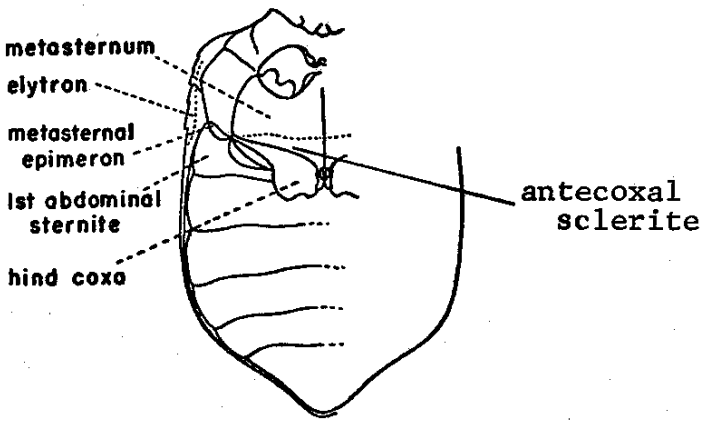


Fig. 103. Amphizoidae.
Ventral view of the abdomen
of an adult.

5a Scutellum covered by the bases of the elytra and the hind margin of the pronotum; hind tarsi with two curved claws (fig.104) .....NOTERIDAE

5b Scutellum visible, or if concealed, the hind margin of the hind tarsal segments produced into lobes, and the anterior tibiae without recurved spines or spurs (fig.99,105).....DYTISCIDAE

6a Hind tarsi 3-segmented; hind coxae widely separated (fig.106) .....HYDROSCAPHIDAE

6b Hind tarsi with more than 3 segments..... 7

7a Antennae short with segment 6 cup-shaped; segments 7 to 11 forming a pubescent club(there may only be 9 segments) (figs.107,108) 8

7b Antennae not as above (figs.111,114) 9

8a Antennal club beyond cup-shaped segment 6, five segmented (fig.107) .....HYDRAENIDAE

8b Antennal club beyond cup-shaped segment 6, three segmented (fig.108) .....HYDROPHILIDAE

9a Head in front of the eyes forming a distinct beak (fig.109) .....CURCULIONIDAE

9b Head formation not as above.....10

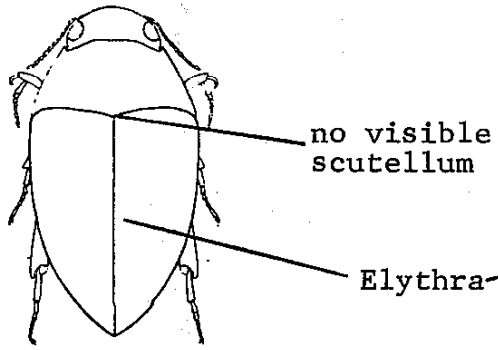


Fig. 104. Noteridae.
Dorsal view of an adult.
(Edmondson,1959).

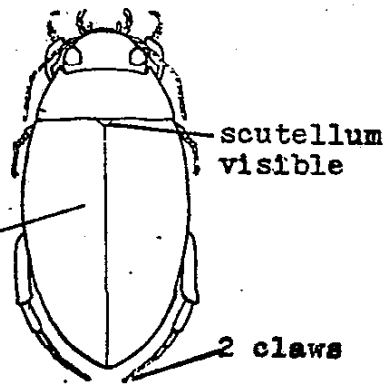


Fig. 105. Dytiscidae.
Dorsal view of an adult.
(Edmondson,1959).

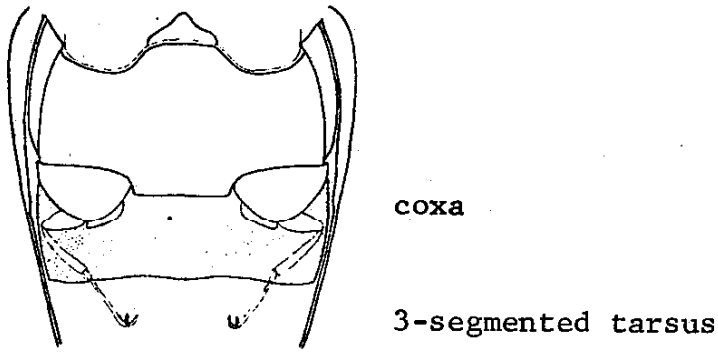


Fig. 106. Hydroscaphidae.
Ventral view of the abdomen of
an adult. (Edmondson,1959).

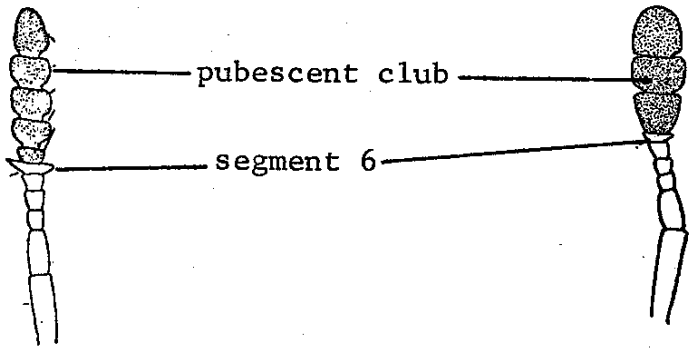


Fig. 107. Hydraenidae
Antennal configuration

Fig. 108. Hydrophilidae.
Antennal configuration.

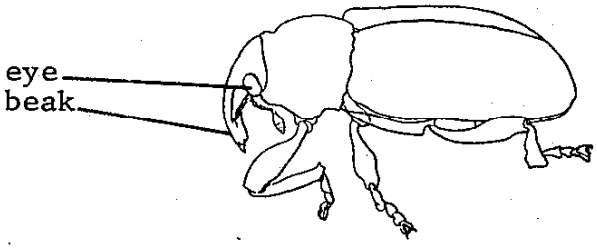


Fig. 109. Curculionidae
Lateral view of an adult.
(Edmondson,1959).

10a Tarsi with 5 segments, the 4th segment is very small and nearly hidden within the lobes of segment 3; first 3 segments expanded with hairy pads beneath (fig.110) .....CHRYSOMELIDAE
10b Tarsi with 5 or fewer segments, but not as above 11

11a Front coxae more or less conically projecting; hind margin of prothorax never crenulate (fig.111) .....HELODIDAE
11b Front coxae variously formed and if they are projecting, then the hind margin of the prothorax is crenulate (figs.112,114,118) 12

12a Antennae long with segments 4 to 10 bearing long basal processes; scutellum heart-shaped, notched anteriorly (fig.112) .....PTILODACTYLIDAE
12b Antennae not as above.....13

13a Middle coxae widely separated and the hind coxae touching or nearly touching(fig.113) .....LIMNICHIDAE
13b Middle and hind coxae not as above.....14

14a Six or 7 abdominal sternites (fig.114) .....PSEPHENIDAE
14b Five abdominal sternites.....15

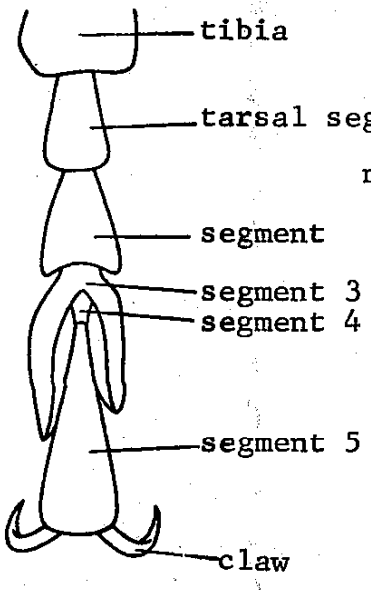


Fig. 110. Chrysomelidae. Tarsus of an adult. (Leech,1948).

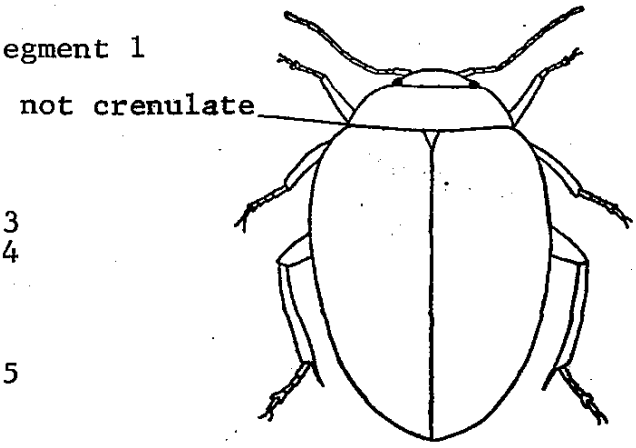


Fig. 111. Helodidae Dorsal view of an adult. (Leech,1948).

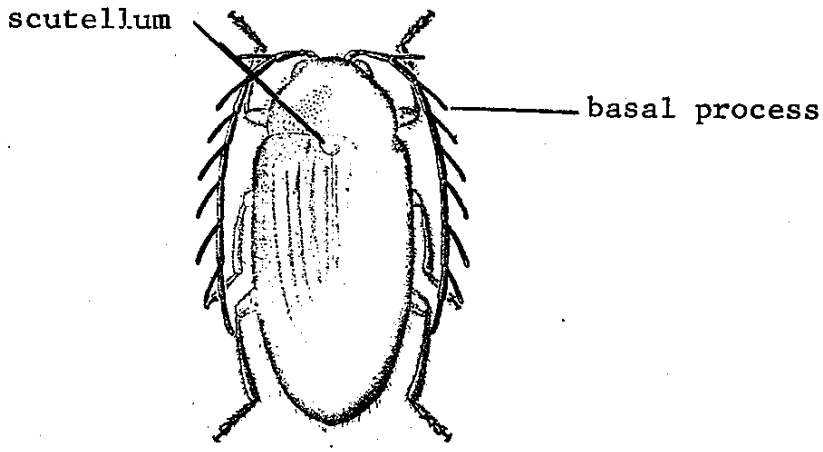


Fig.112. Ptilodactylidae.
Dorsal view of an adult.

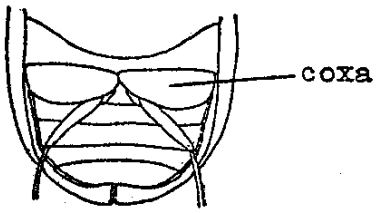


Fig. 113. Clambidae. Similar to members of the family Limnichidae. Ventral view of the abdomen of an adult. (Edmondson,1959).

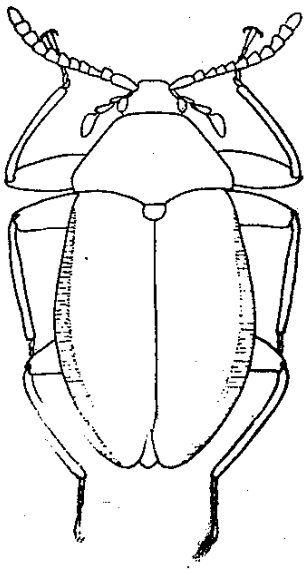


Fig. 114. Psephenidae.
Dorsal view of an adult.
(Edmondson,1959).

15a Antennae very short in length with apical segments serrate(figs.115,116) .....DRYOPIDAE

15b Antennae short to moderate in length and clubbed or threadlike, never with apical segments serrate (figs.117a-c,118) .....ELMIDAE

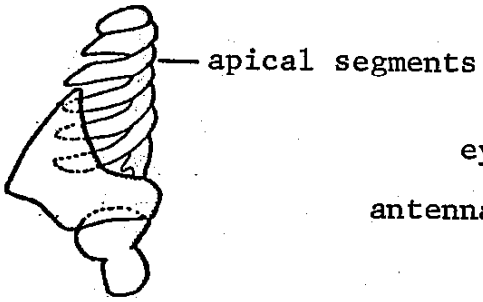


Fig. 115. Dryopidae. Antenna.(Hinton,1939).

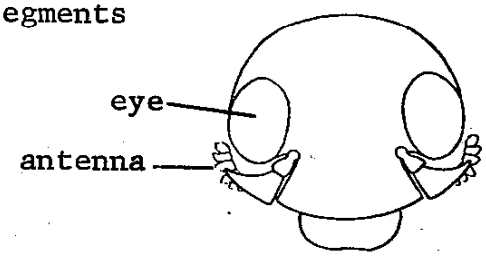


Fig. 116. Dryopidae. Frontal view of the head of an adult.(Edmondson,1959).

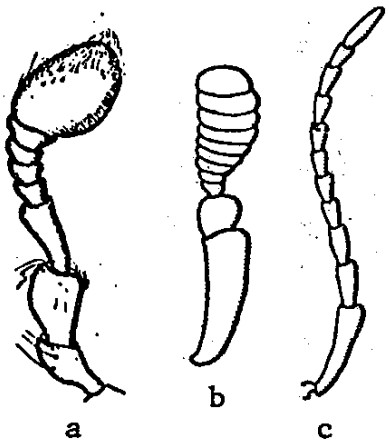


Fig. 117a-c. Elmidae. Types of antennae. (Hinton,1939).

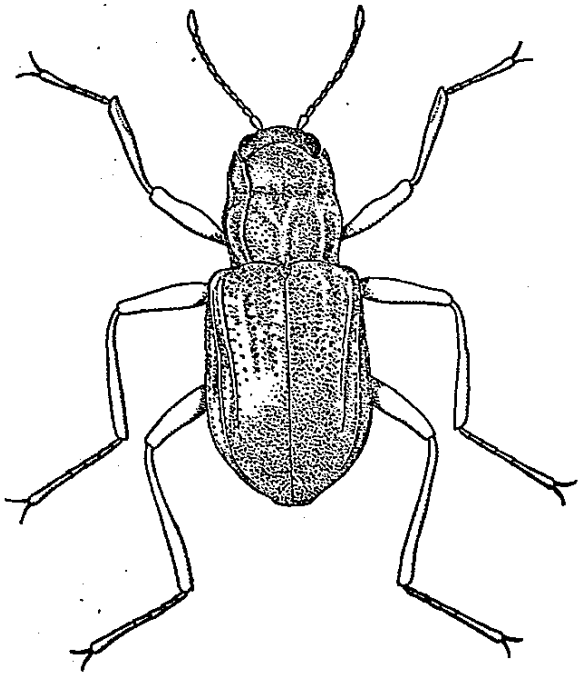


Fig. 118. Elmidae. Dorsal view of an adult. (Hinton,1940).

KEY TO THE FAMILIES OF CALIFORNIA

COLEOPTERA LARVAE (BEETLES)

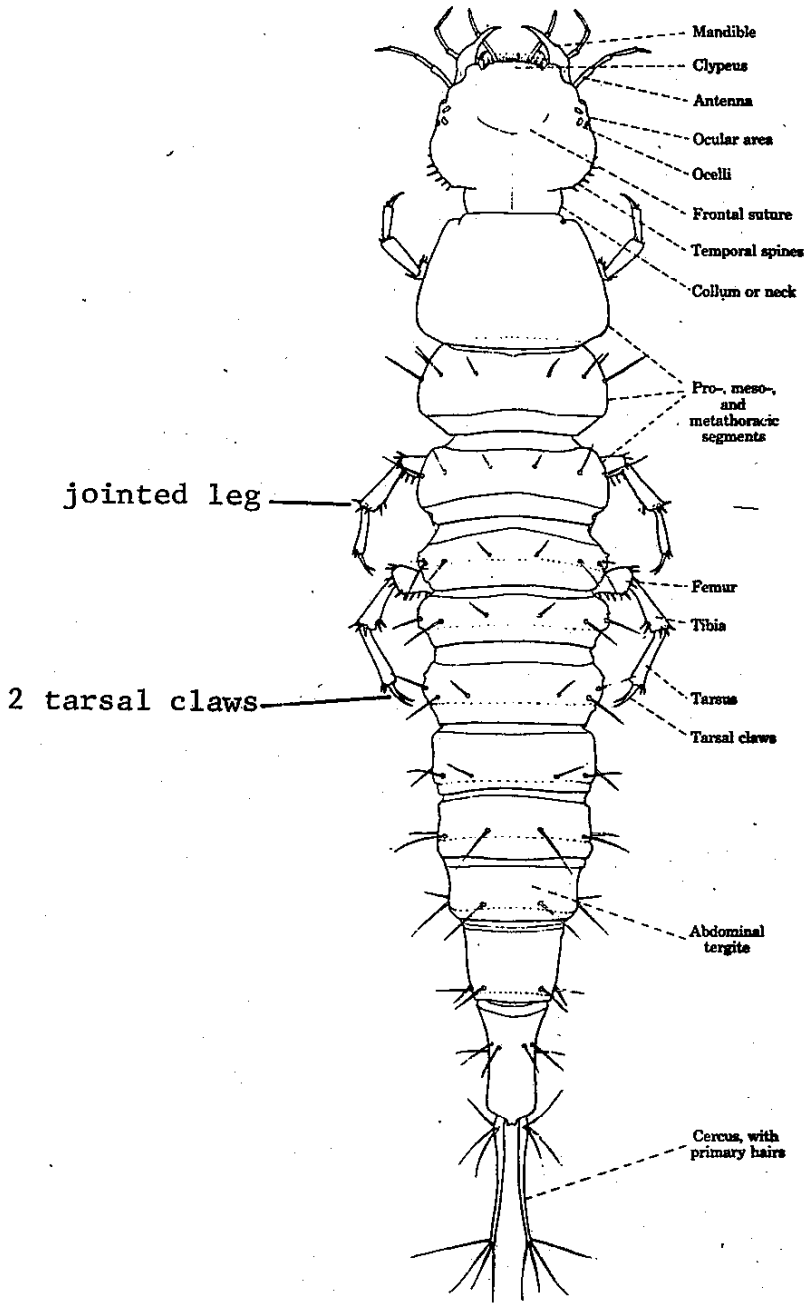


Fig. 119. Dytiscidae.
Dorsal view of a larva to show general features.
(Edmondson,1959).

1a With legs 2
1b Without legs (fig.120) .....CURCULIONIDAE

2a Tarsi with 1 claw (fig.122) 3
2b Tarsi with 2 claws (fig.119) 13

3a Legs 4 segmented (fig.122) 4
3b Legs 5 segmented (figs.121, 123a,b).....HALIPLIDAE

4a Cerci segmented and usually movable, often retracted into a breathing pocket on the 8th abdominal segment (figs.119, 132a-k, 133a,b; 134a,b; 135-137).....11
4b Cerci solidly fused at the base or absent (figs.124, 125, 127a-c,128,130,131)..... 5

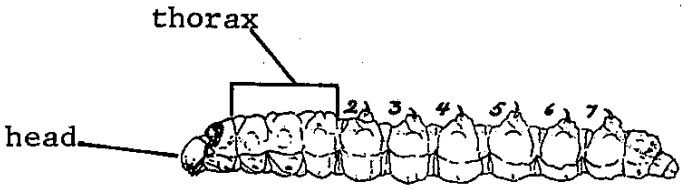


Fig.120. Curculionidae.
Lateral view of a larva.
(Böving and Craighead,1930).

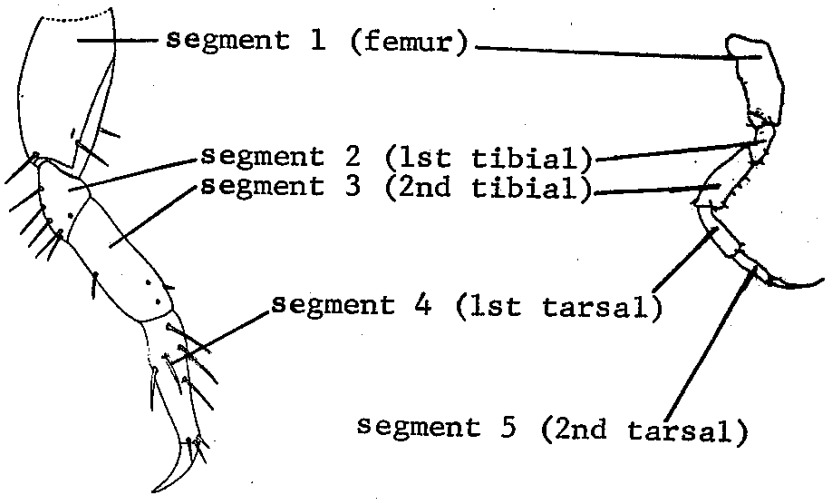


Fig. 122. General appearance of a 4-segmented leg.

Fig. 121. Haliplidae Leg.

5a Body rounded or oval and greatly depressed with the lateral margins of the body segments expanded to cover the head (figs.124a,b).....PSEPHENIDAE

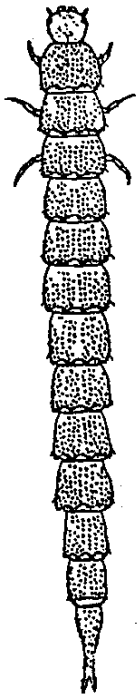
5b Body slender and round or triangular in form, the head exposed from above..... 6

6a Ninth abdominal segment with a ventral, moveable operculum closing a caudal chamber(figs.125,127a-c).... 7

6b Ninth abdominal segment without ventral operculum..... 9

7a Abdominal sternites 1 to 5 or 8 with a median fold (fig. 125).....DRYOPIDAE

7b Abdominal sternites without a median fold..... 8



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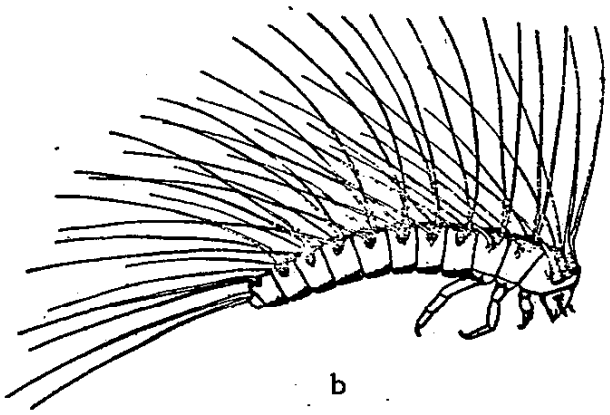


b

Fig. 123. Haliplidae.
Dorsal (a) and lateral (b) views of two different larvae.
(a, Wilson,1923; b, Bertrand,1928).

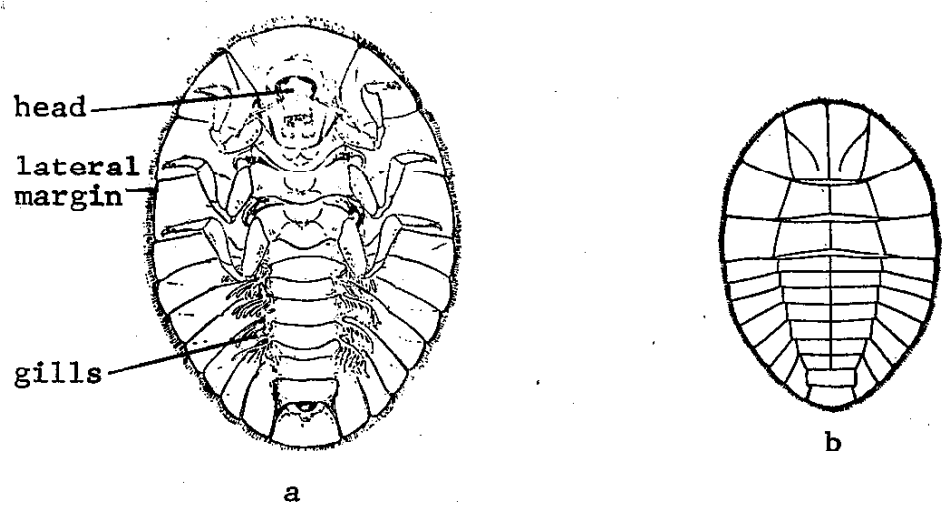


Fig. 124a,b. Psephenidae.
Ventral(a) and dorsal (b) views of a larva.
(a, Böving and Craighead,1930; b, Edmondson,1959).

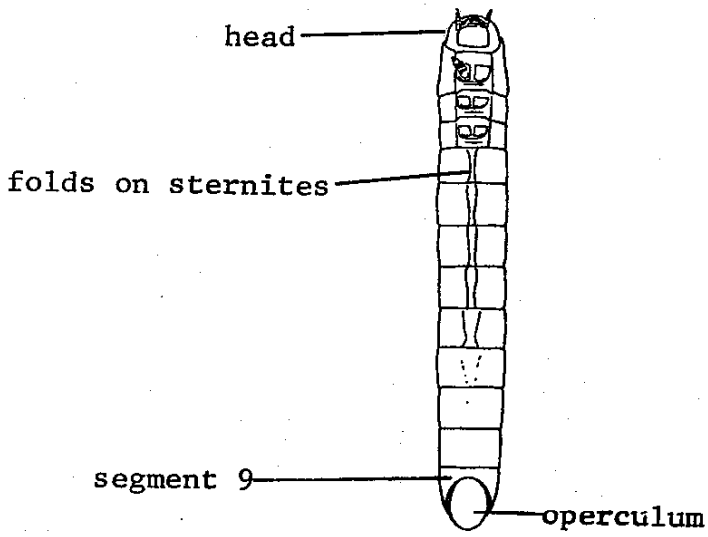


Fig. 125. Dryopidae.
Ventral view of a larva.
(Edmondson,1959).

8a End of the last abdominal segment evenly rounded (fig. 126) .....LIMNICHIDAE

8b End of the last abdominal segment emarginate (fig. 127a) .....ELMIDAE

9a Four or more of the first 7 abdominal segments with 2 ventral tufts of filamentous gills(fig.128); if gills are absent from the abdomen, then there are 5 to 21 mamillaeform gills in a caudal chamber on the 9th abdominal segment(figs.129a,b).....PTILODACTYLIDAE

9b Abdominal segments without gills as above; gills may be present in a caudal chamber on the 8th abdominal segment.....10

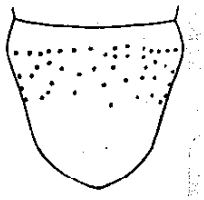
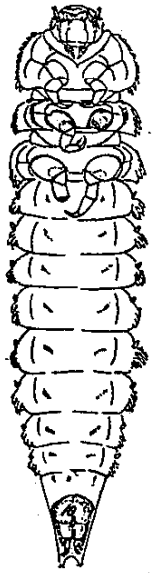


Fig. 126. Limnichidae.
Dorsal view of the last abdominal segment of a larva. (Edmondson,1959).



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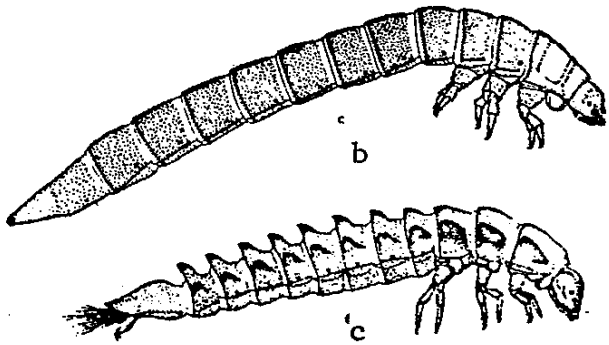


Fig. 127a-c. Elmidae
Ventral(a) and lateral(b,c) views of three different larvae.
(Usinger,1956).

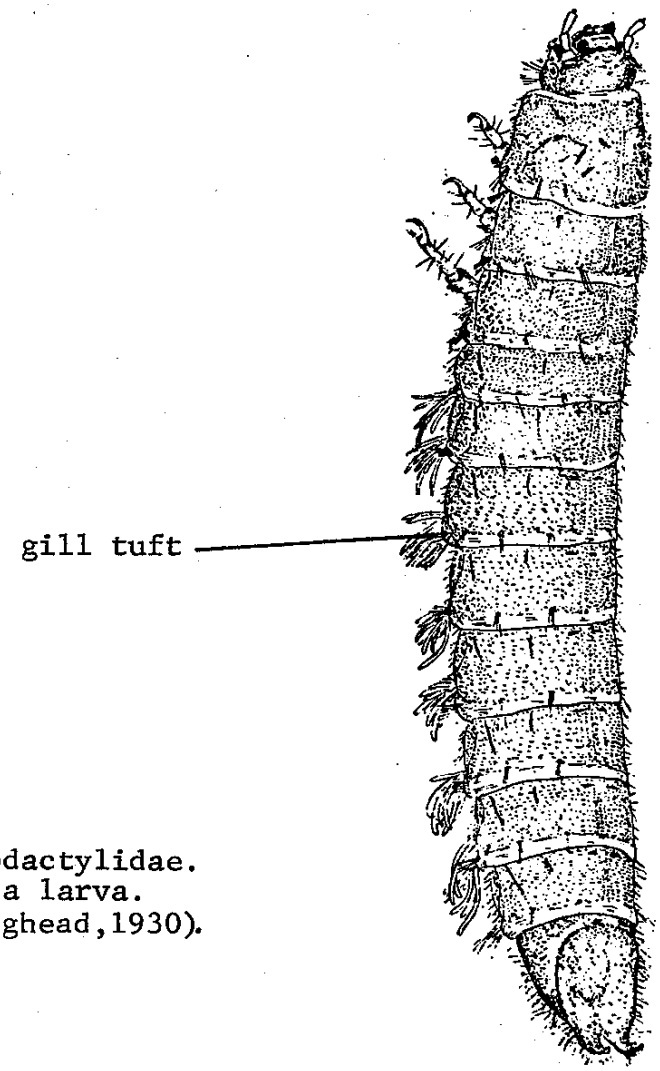


Fig. 128. Ptilodactylidae.
Lateral view of a larva.
(Böving and Craighead,1930).

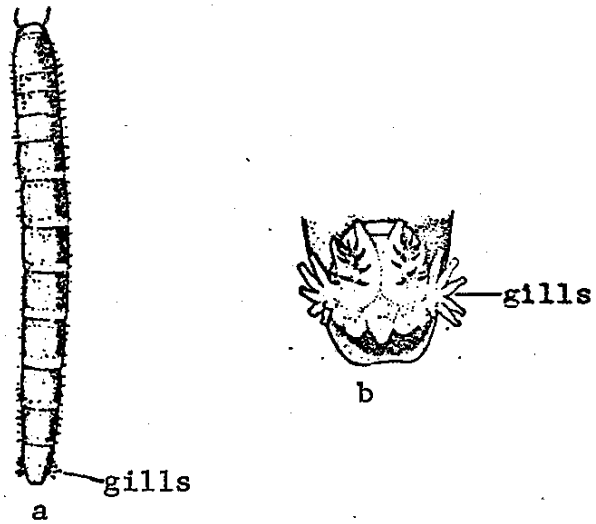
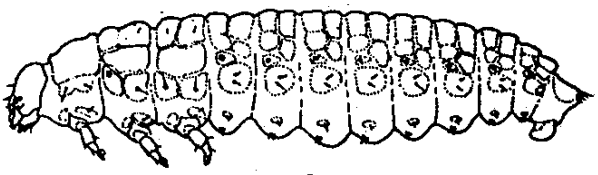


Fig. 129. Ptilodactylidae.
Dorsal view of a larva with mamillaeform gills(a) and a ventral view of the gills in the caudal chamber(b).(Böving and Craighead,1930).

10a No conspicuous gills on the abdomen; legs poorly developed; abdominal segments mostly membranous; antennae very short(figs. 130a,b) .....CHRYSOMELIDAE
10b Gills in a caudal chamber on the 8th abdominal segment; antennae long and tapering (fig.131)....HELODIDAE

11a Ocelli in groups of 5 (fig.133a) 12
11b Ocelli usually in groups of 6(figs.132a-k)...HYDROPHILIDAE



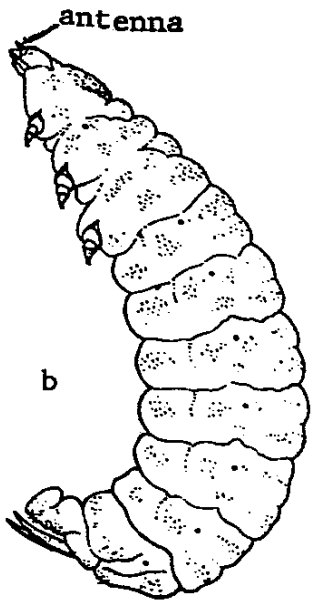


Fig. 130a,b. Chrysomelidae.
Lateral views of two different larvae
(Pennak,1953).

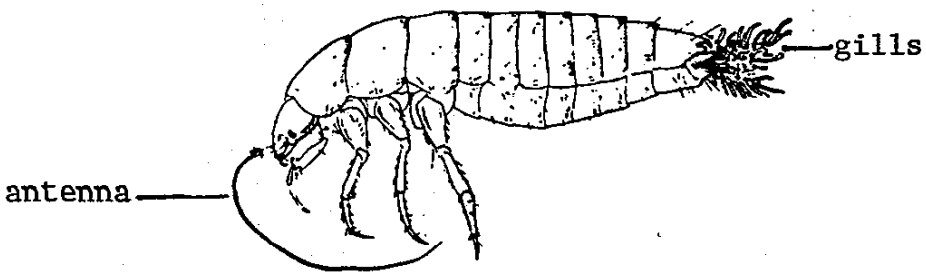


Fig.131. Helodidae.
Lateral view of a larva.
(Böving and Craighead,1930).

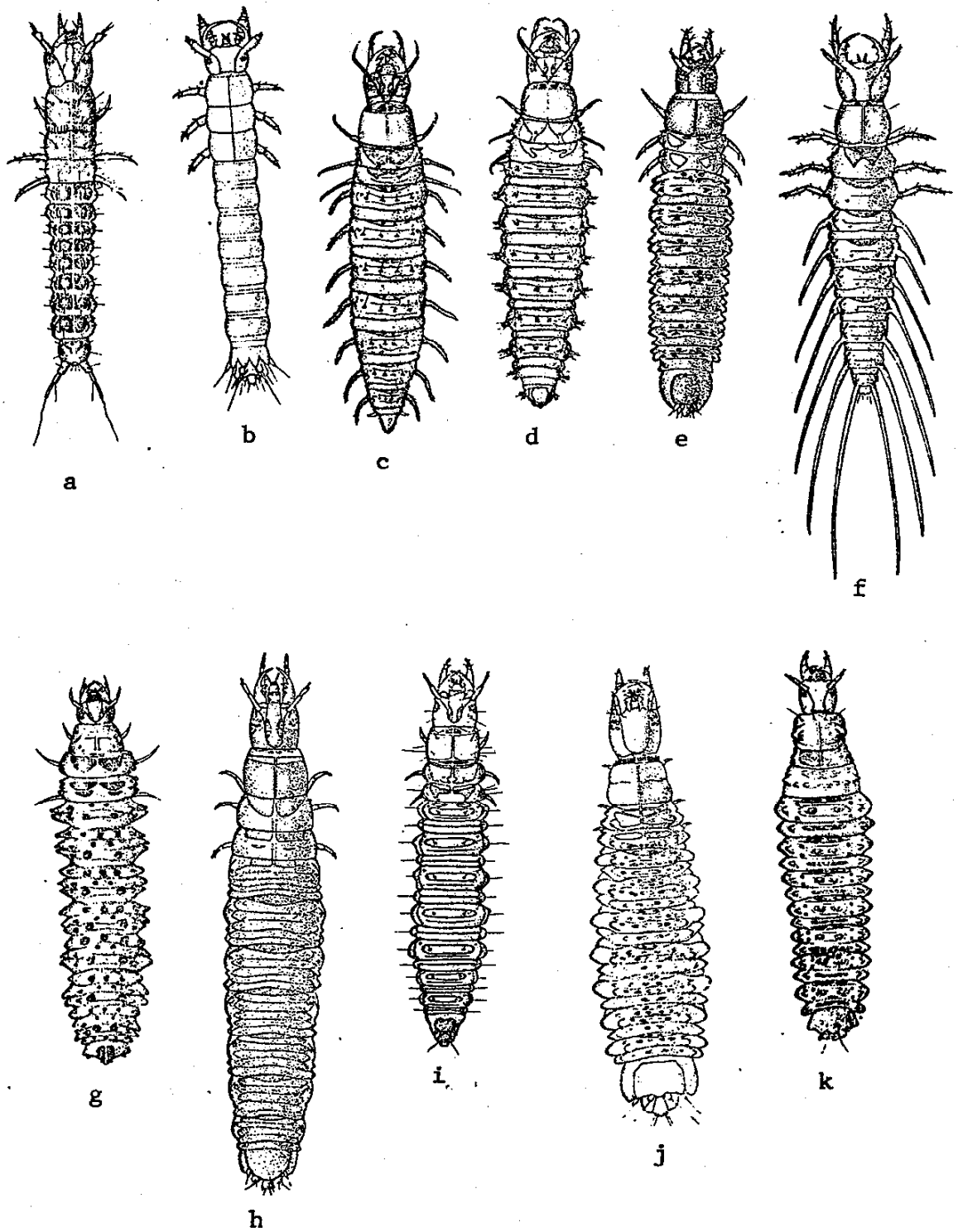


Fig. 132a-k. Hydrophilidae. Dorsal view of 11 different types of larvae.(Richmond,1920).

12a Tenth abdominal segment with a pair of curved hooks; no balloon-like structures on the prothorax or abdomen(figs.133a,b).....HYDRAENIDAE

12b Tenth abdominal segment without a pair of curved hooks; balloon-like structures on the prothorax and abdominal segments 1 and 8 (figs.134a,b).... .....HYDROSCAPHIDAE

13a Tenth abdominal segment with 4 hooks; lateral gills present on all the abdominal segments(fig.135)...GYRINIDAE

13b Tenth abdominal segment without hooks; lateral gills may or may not be present 14

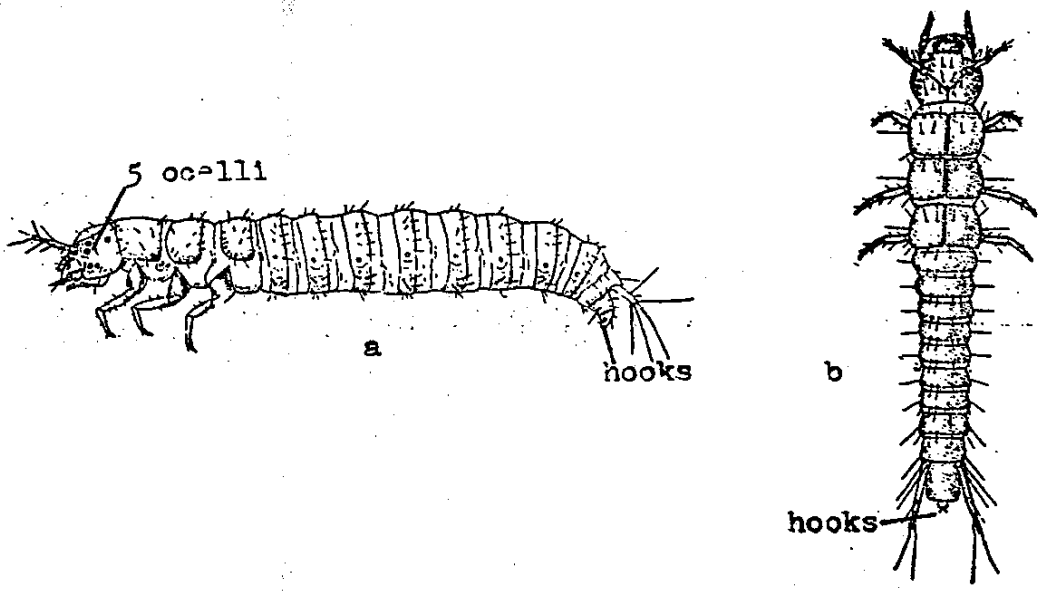


Fig. 133a,b. Hydraenidae.
Lateral(a) and dorsal(b) views of two different larvae.

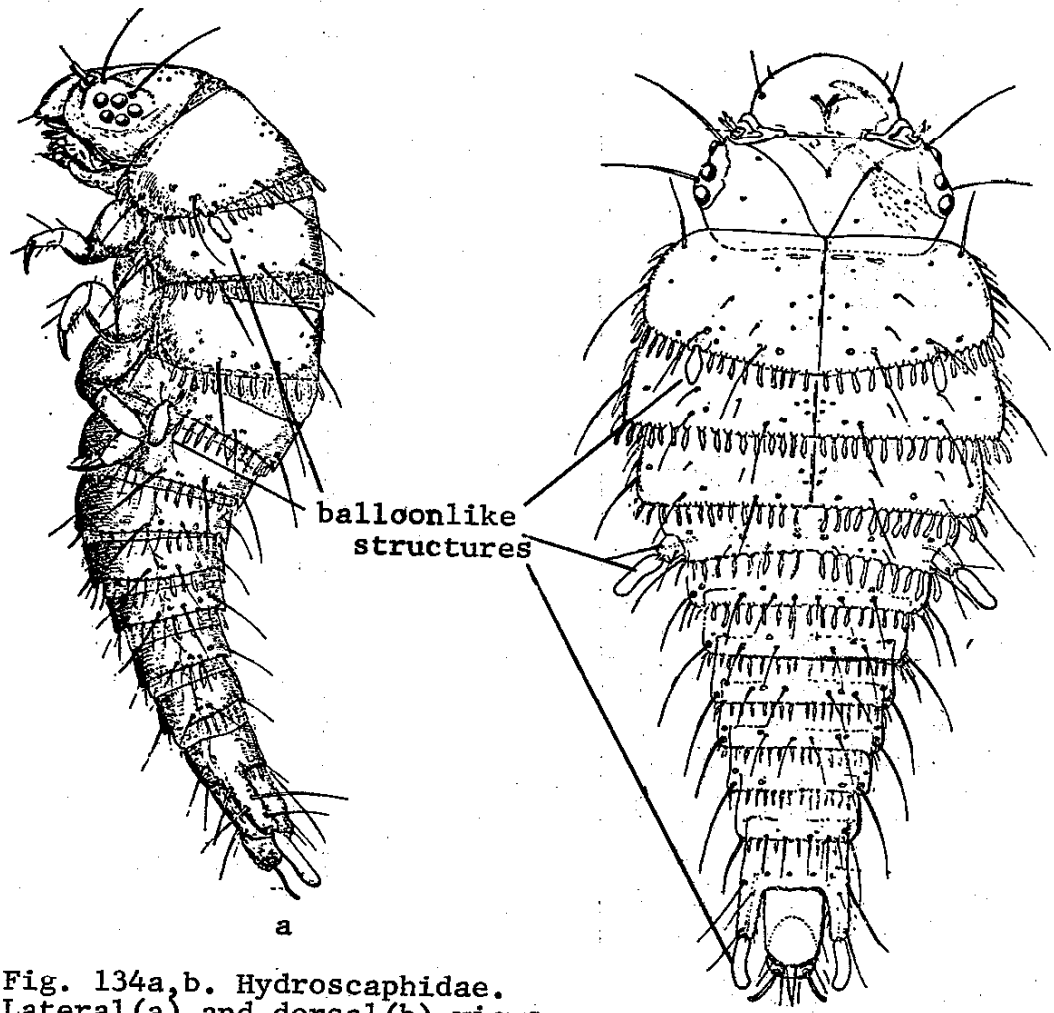


Fig. 134a,b. Hydroscaphidae.
Lateral(a) and dorsal(b) views
of a larva.(Böving and
Craighead,1930).

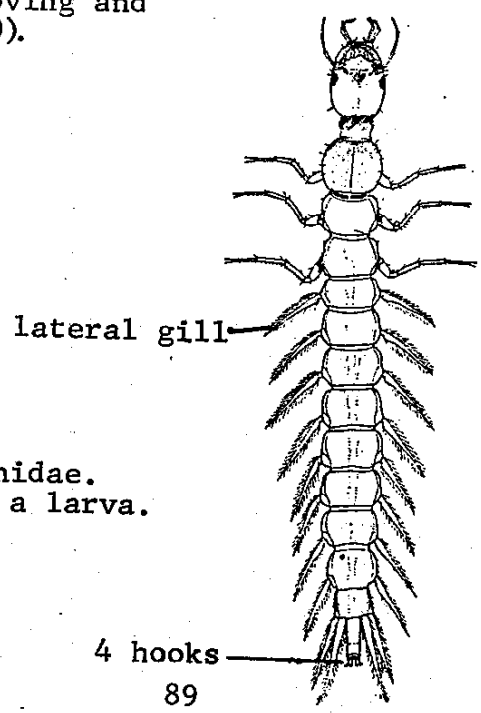


Fig. 135. Gyrinidae.
Dorsal view of a larva.

14a Legs stout, adapted for burrowing and body form like a wireworm(fig.136).....NOTERIDAE
14b Legs adapted for walking or swimming and body form not like a wireworm 15

15a Larvae flattened with the sides of the thorax and abdomen expanded into thin lateral plates (fig. 137).....AMPHIZOIDAE
15b Larvae without the above(fig.119).....DYTISCIDAE

Fig. 136. Noteridae. Dorsal view of a larva. (Usinger,1956)

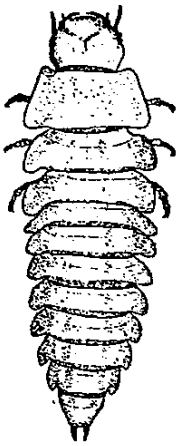


Fig. 137. Amphizoidae. Dorsal view of a larva.

KEY TO THE FAMILIES OF CALIFORNIA

DIPTERA (FLIES)

Order: DIPTERA (= two-winged)
Common Name: Flies, Mosquitoes, Gnats, Midges

The Diptera are a diverse group of insects. About 50% of the species in the order live in water during the immature stages of development. The adults are not aquatic. Many Diptera are known vectors of such diseases as malaria, filariasis, yellow fever, encephalitis. Beneficially, Diptera provide an important food source for many organisms, inc uding game birds and fish. Members of this order are found in an amazing variety of habitats including the intertidal zone of the coast, brine pools, hot springs and geysers, natural seeps of crude petroleum, streams, rivers, ponds, and lakes. Diptera fulfill the roles of scavengers, carnivores and herbivores.

The body form of these flies is highly variable. The larvae have no true legs, although they may have prolegs. The adults have 1 pair of wings with the hind pair being reduced to balancing structures call halteres.

The adults may deposit their eggs in masses or strings on objects above, below or on the surface of the water. Some species simply broadcast their eggs on the water. The larval stage last from 2 weeks to 2 years, and the pupal stage from less than 2 weeks to several months.

Order: DIPTERA

Synopsis of the California Families

Family: Tipulidae (crane flies)
Adult crane flies are often mistaken for very large mosquitoes. They do not bite and the family is composed of nearly 1500 species in North America alone. Larvae live in water or at the margins of streams and ponds in moist soils, moss and algae. Larvae usually feed on decaying plant material, however, some are carnivorous. Adults are common near water in vegetation.

Family: Blephariceridae (net-winged midges)
This family is worldwide in distribution with 16 species being known from California. The larvae are found attached to rocks in swift flowing mountain streams. The larvae feed on algae while the adults, which may be found on rocks or vegetation near streams, are carnivorous.

Family: Deuterophlebiidae (mountain midges)
These uncommon flies are found in cold mountain streams of western North America, Japan and Asia. Larvae feed on algae which they scrape from the rocks as they slowly move over the bottom of swift riffle areas.

Family: Tanyderidae (primitive crane flies)
Adults of this very rare family occur in thick vegetation near streams while the larvae can be found in wet sand along stream margins. Only two species are known from California although 33 species are known worldwide.

Family: Chironomidae (non-biting midges)
This large family of nearly 3000 known species is world wide in distribution. Adults are small, delicate flies often seem in swarms near ponds and lakes. Larvae are usually found in shallow water areas where aquatic plants are abundant. Adults and larvae are important food items of larger insects, birds and fish. Larvae of some species build tubes of debris. The immature stages are herbi orous.

Family: Thaumaleidae (solitary midges)
Adults of this uncommon family occur along the margins of clear water streams in vegetation. Larvae occur on the rocks in the stream with a thin film of water flowing over them. Larvae feed on detritus and algae.

Family: Ceratopogonidae (biting midges)
Adults of some species are bloodsuckers while others are predaceous on other small insects. They are also called punkies and no-see-ums, and some species do prey on man. The larval stages are predominately aquatic and range in habitat from fresh to salt water. The larvae are predators or herbivores. Some species breed in water contained in tree

holes or the cups of pitcher plants.

Family: Simuliidae (black flies, buffalo gnats)
Female black flies do bite man and can be very irritating. Adults are found swarming along the margins of streams and larvae are found attached to rocks and debris in the swiftest portions of streams. Larvae are attached by a posterior suck disc and the head trails downstream. The larvae have two large mouth brushes which strain the water for food particles. The biting nature of the female flies often is a serious problem to livestock, wild mammals and birds.

Family: Ptychopteridae (phantom crane flies)
Nine species are known from California with about 60 species worldwide. The immature stages are found in wet soil among decaying plants at the margins of ponds or swampy areas. The decomposing vegetation serves as the food for the larvae. The long breathing tubes of the larvae are pushed through the decaying material to the surface where oxygen is obtained.

Family: Dixidae
The larvae of these midges are found in streams and ponds attached to the downstream margins of rocks and debris. Food or the larvae consists fo detritus and microorganisms filtered from the water. The adult midges are non-biting and are usually found in small swarms near ponds or streams at dusk.

Family: Culicidae including Chaoboridae (mosquitoes and phantom midges)
This large group of worldwide distribution has gained fame for its transmission of disease and its biting members. Only the females of certain species have the biting habit. Larval forms in this family feed on algae, protozoa, organic detritus, crustaceans, and other small insect larvae. They, in turn, are an important component in the diets of fish, birds and larger insects. Some larvae lie near the surface of the water and when disturbed, swim downward in a wriggling fashion.

Family: Psychodidae (moth flies)
Larvae live in decaying materials in moist places near water, often on mats of floating moss and algae in slow flowing streams. A few species occur in drains and sewers. Some tropical species bite and transmit diseases. Food of the larvae consists of decaying vegetation and algae. The adult flies have bodies covered with hairs and the wings are hairy or scaly. The family is found worldwide.

Family: Stratiomyidae (soldier flies)
Adults of these brightly colored flies are often found on flowers. Eggs are layed on aquatic plants and other materials in ponds and streams. The larvae feed on algae, micro organisms, and organic debris.

Family: Tabanidae (horseflies and deerflies)
This large family is worldwide in distribution with over 300 species being known from North America. The adult females of some species do bite man as well as other large mammals. The males are often found feeding on flowers. The eggs are laid above water over streams and ponds. When they hatch, the larvae drop into the water to develop. Larvae feed on organic debris or are predators on other aquatic organisms.

Family: Rhagionidae (snipe flies)
Adults are found in vegetation along streams. Only one species is known to be aquatic in the United States. Adult females lay their eggs on vegetation over water and upon hatching the larvae drop into the water. The females die but remain attached to the egg mass, and other females deposit eggs on the same mass. The cycle is repeated so that often a large mass of eggs and dead females may develop.

Family: Dolichopodidae (long-legged flies)
These common, small flies are often seen in wet meadows and marshy areas. The adults perform a mating "dance" with specific movements and orientations. The larvae are predaceous, as are the adults, and can be found in a variety of habitats including mud, beach sands, and tree cavities.

Family: Empididae (dance flies)
This family gets its common name from the interesting mating "dance" of the adults. As in the Dolichopodidae, the dance involves specific movements and orientations and is performed in mating swarms. In some species the males offer food to the females or build shiny ballons to attract the females. The adults are predators or flower feeders but the larvae are predaceous.

Family: Syrphidae (flower flies)
The brightly colored adults of this family are important pollinators of flowers. The immature forms of the aquatic members of this family are often called rat-tailed maggots due to their resemblance to maggots and the long air tube developed from the body. The aquatic larvae are usually associated with highly polluted waters. Some of the non-aquatic adults in this family mimic bees amd wasps but they are not harmful to humans.

Family: Sciomyzidae (marsh flies)

The brightly colored adults of this family are found near ponds, streams and marshy areas. The aquatic larvae are thought to be strictly predaceous on aquatic snails. Some forms undergoing pupation have been shown to be adapted to fit the form of the snail shell.

Family: Ephydridae (shore and brine flies)

The small, dull adults of this group are found near fresh-water ponds and streams, the ocean, inland saline and alkaline lakes, and mineral springs. One unique member of this family breeds in pools of crude petroleum in California (Los Angles, Co.) and Cuba. The adults feed on algae and the larvae are also herbivorous, with some species boring in the stems and leaves of aquatic plants.

Family: Scopeumatidae (dung flies)

Most dung flies are found breeding in excrement or decaying vegetation. The only semi-aquatic species are borers in the stems of aquatic plants such as water lilies and bullrushes. The larvae undergo pupation in the stem of these plants and the adults float to the surface and fly off.

Family: Muscidae (house flies, stable flies)

These common flies are often vectors of human diseases. The adults are found in a variety of habits, the aquatic species occurring near the margins of streams and ponds on vegetation. The aquatic species are predaceous as adults and the larvae are herbivorous or scavengers on decaying plant and animal material. Over 500 aquatic species are known from the United States.

Order: Diptera

Key to the California Families of Diptera Larvae

1a Mandibles and other mouthparts opposed to each other and moving in a horizontal plane; head capsule complete or nearly so (figs.138,139,148,167)..... 2

1b Mandibles absent or, if present, parallel to each other and moving in a vertical plane; head capsule imcomplete (figs.152,153,160a,161a,166b).....14

2a Head capsule almost complete and not hardened posteriorly; head with lobes or rods extending backward from posterior end; head can be pulled back within the thorax (fig.138,139a-c).....TIPULIDAE

2b Head capsule complete and without lobes or rods extending from the posterior end; head cannot be pulled back within the thorax (figs.140,144,148)..... 3

3a Thorax fused with the head and the first abdominal segment; first 6 abdominal segments with a median row of suckers (fig. 140).....BLEPHARICERIDAE

3b Thorax distinct from the head and the first abdominal segment 4

4a Body flattened and the abdomen with 7 pairs of lateral prominences, each with several rows of small hairs (fig.141) .....DEUTEROPHLEBIIDAE

4b Body not flattened and lacking lateral prominences..... 5

5a Prolegs present (fig.144) 6

5b Prolegs absent (fig.151) 12

6a Prolegs present on the anal segment(may also be on the prothorax), not on the intermediate segments (figs.142,144,145,147b) 7

6b Prolegs present on the intermediate body segments or only on the prothorax (figs.148,149b,150 ,b) 12

7a Prolegs in pairs (figs.142,144) 8

7b Prolegs not in pairs (figs.145,147b) 9

8a Posterior end of the body with 6 long filaments and 2 prolegs; no prolegs on the prothorax (figs. 142,143) .....TANYDERIDAE

8b Posterior end of the body without any long filaments; prolegs on the prothorax (fig.144)..... .....CHIRONOMIDAE

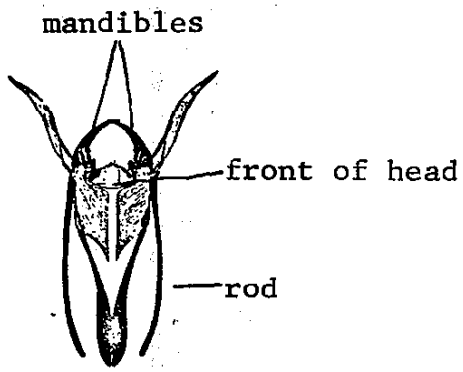


Fig. 138. Tipulidae
Dorsal view of the head capsule of a larva.(Alexander,1920).

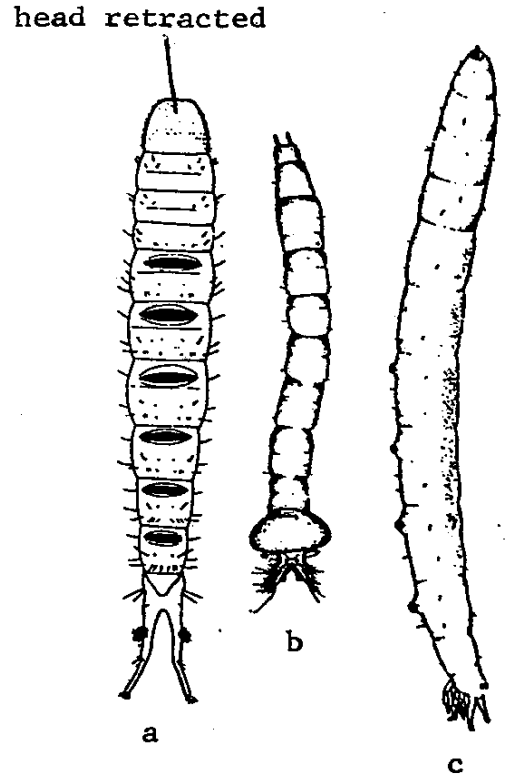


Fig. 139a-c. Tipulidae.
General appearance of larval types.(Alexander,1920).

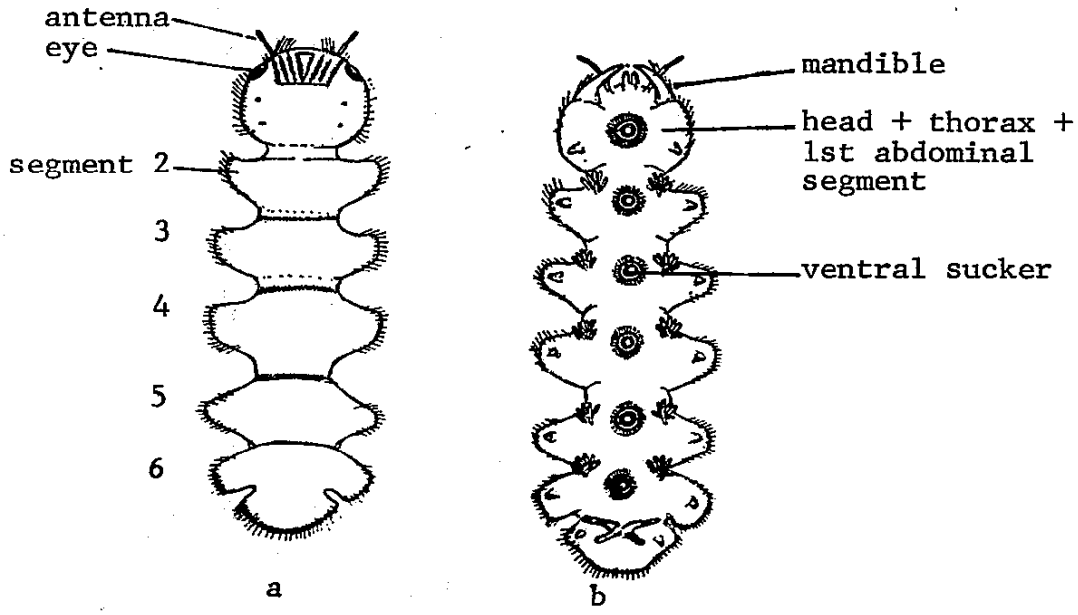


Fig. 140. Blephariceridae.
Dorsal(a) and ventral(b) view of a larva.

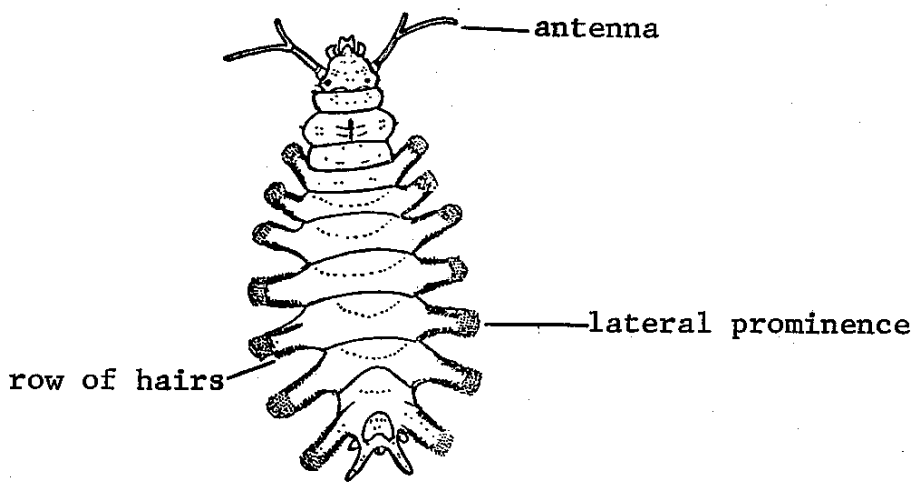


Fig. 141. Deuterophlebiidae. Dorsal view of a larva.(Alexander,1930).

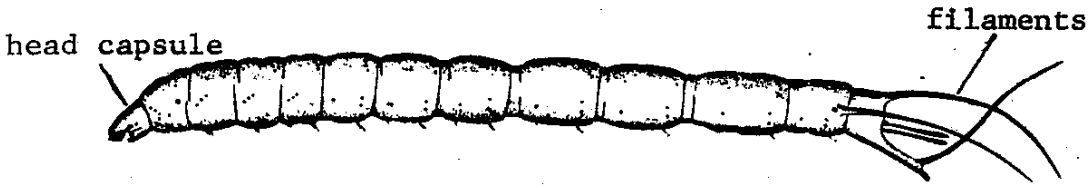


Fig. 142. Tanyderidae. Lateral view of a larva. (Alexander,1930).

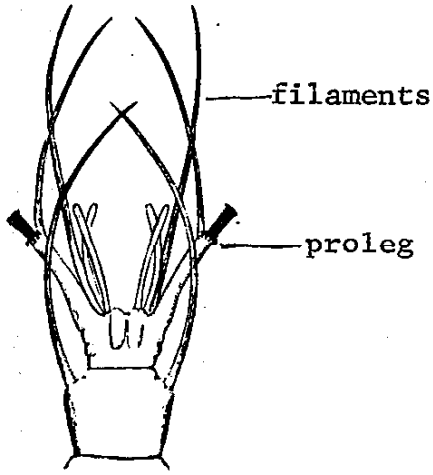


Fig. 143. Tanyderidae. Ventral view of the posterior end of a larva.(Alexander,1930).

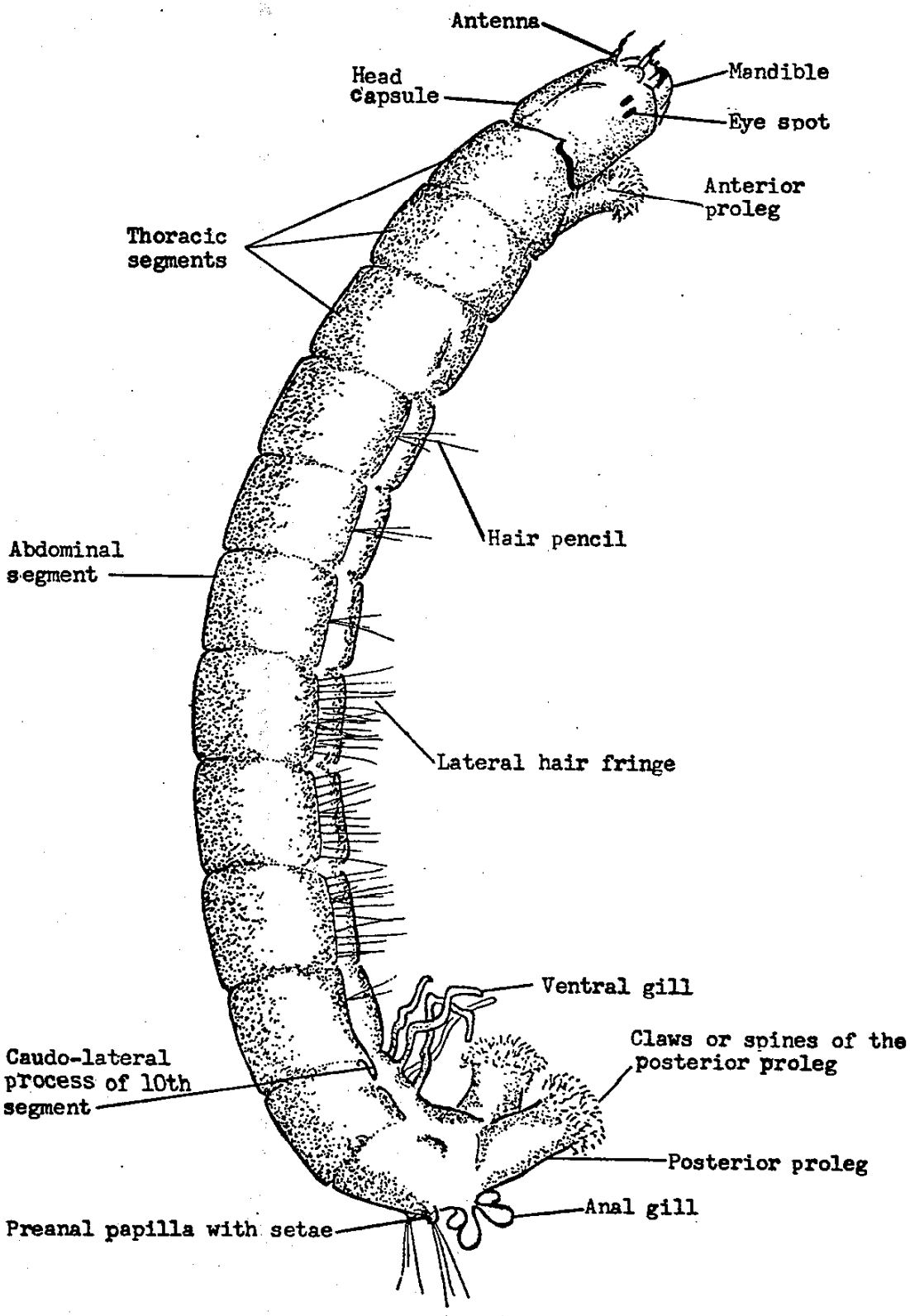


Fig. 144. Chironomidae
Lateral view of a larva.

9a Posterior end of the body with a spiracle between 2 short processes; prothorax with a pair of respiratory tubes (fig.145) .....THAUMALEIDAE

9b No posterior spiracle and no respiratory tubes on the prothorax (fig.147a,b) ...CERATOPOGONIDAE (in part)

10a Prolegs present only on the prothorax; adhesive disc at the end of the abdomen (fig.148) .....SIMULIIDAE

10b Prolegs present on the intermediate body segments; no adhesive disc at the end of the abdomen (figs.149b,150a) 11

Fig. 145. Thaumaleidae.
Lateral view of a larva.
(Johannsen,1934).

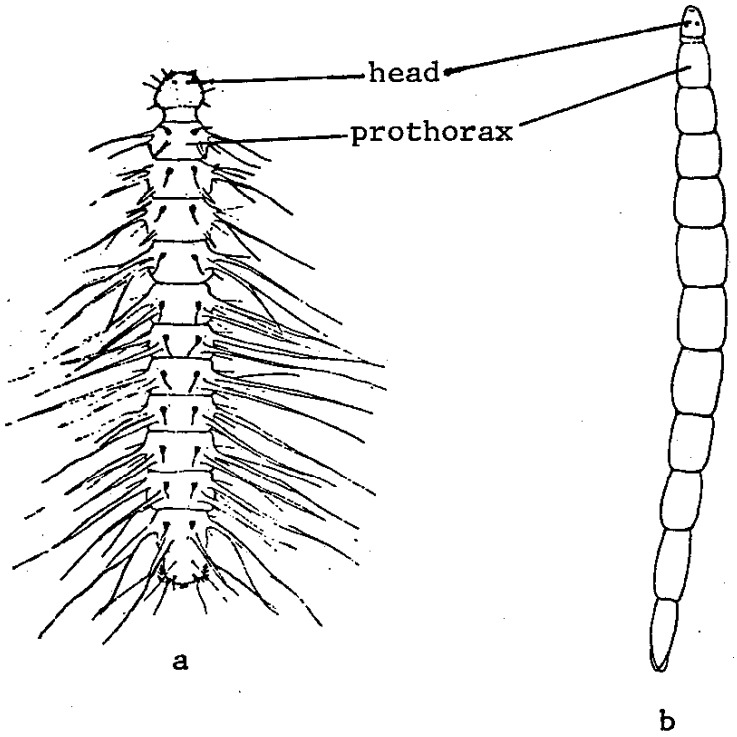


Fig. 146a,b. Ceratopononidae.
Dorsal views of two different larvae.
(a, Thomsen,1937; b, Edmondson,1959).

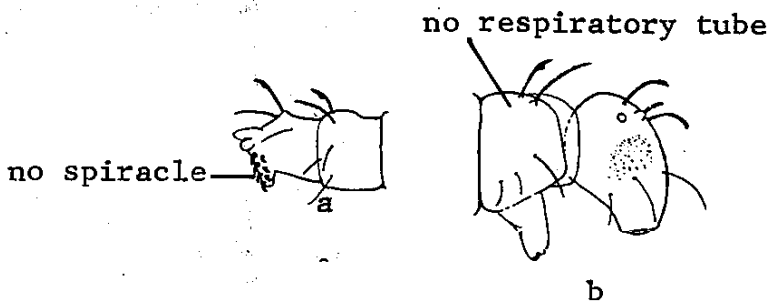


Fig. 147a,b. Ceratopogonidae.
a. Posterior end of a larva in lateral view.
b. Head and prothorax of a larva in lateral view

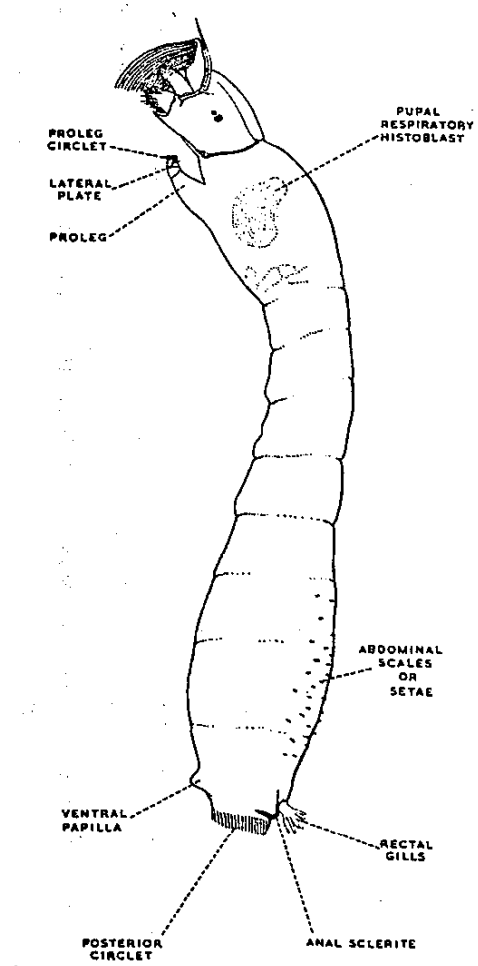


Fig. 148. Simuliidae.
Lateral view of a larva.

11a A pair of prolegs on abdominal segments 1 to 3: abdomen ending in a long, segmented tube (fig. 149a,b) .....PTYCHOPTERIDAE

11b A pair of prolegs on abdominal segment 1 only, or on segments 1 and 2 only; end of abdomen without a long tube (fig.150a,b) .....DIXIDAE

12a Thoracic segments combined into an enlarged section that is much broader than the abdomen (figs.167,168) 23

12b Thoracic segments distinct from one another and about as broad as the abdomen 13

13a Segments of the thorax and abdomen with secondary segmentation more or less; the posterior abdominal segments with conspicuous hardened dorsal plates (fig. 151) .....PSYCHODIDAE

13b Segments of the thorax and abdomen without secondary segmentation or hardened dorsal plates (figs.146a,b).....CERATOPOGONIDAE (in part)

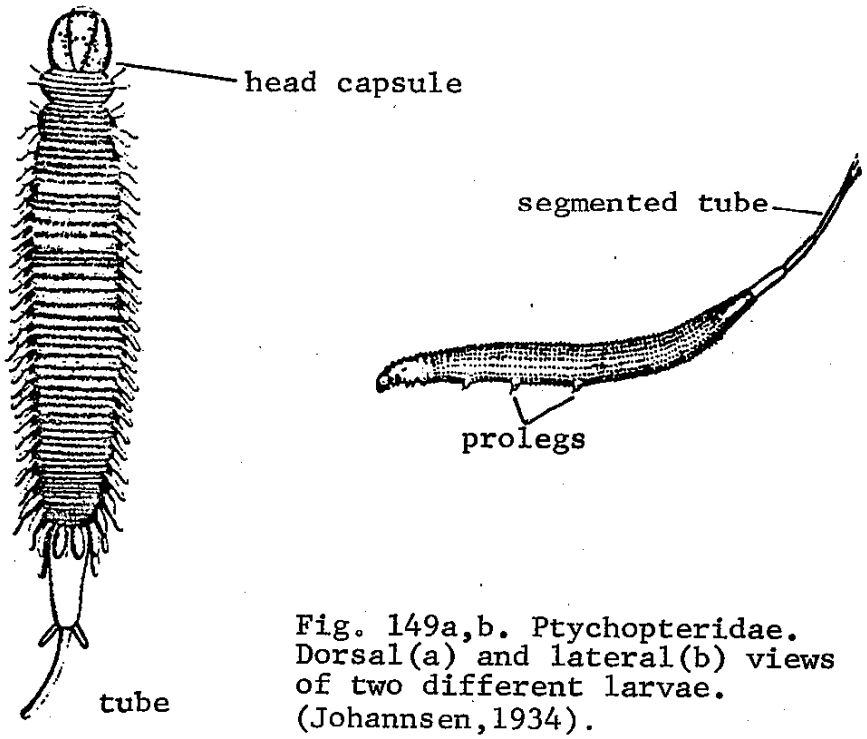


Fig. 149a,b. Ptychopteridae. Dorsal(a) and lateral(b) views of two different larvae. (Johannsen,1934).

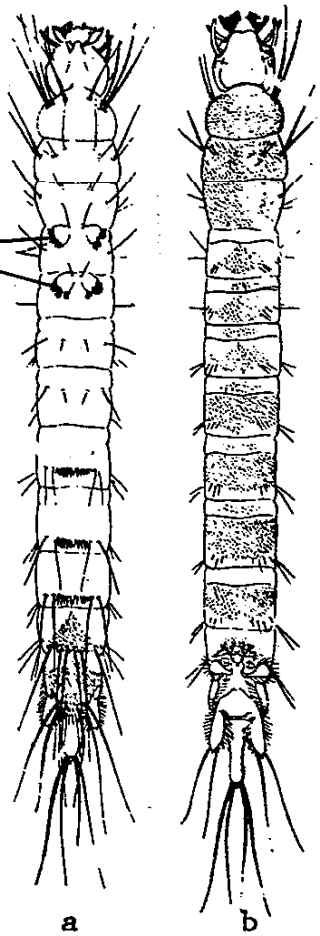


Fig. 150a,b. Dixidae.
Ventral(a) and dorsal(b)
(Nowell,1951).

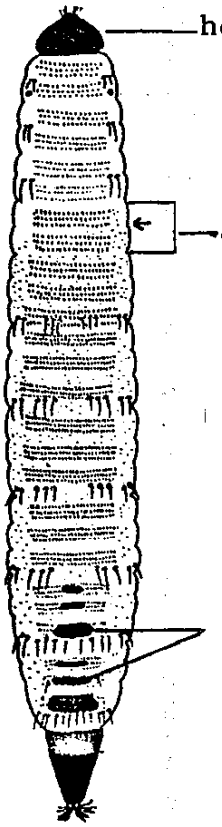


Fig. 151. Psychodidae.
Dorsal view of a larva.
(Quate,1955).

14a Head capsule usually hardened dorsally and may be pulled back into the prothorax; slender rods produced for posterior from the head capsule; mandibles sickle-shaped (figs.152a,b; 153,154,155a,156a,157) 15

14b Head not hardened, no real head capsule; head permanently pulled within the prothorax; mandibles usually short and hook like (figs.158,159a,161c, 162,163,164,166a,b) 19

15a Body more or less depressed; no prolegs (figs.152a,b) .....STRATIOMYIDAE

15b Prolegs present, or if absent, the body is cylindrical 16

16a Body cylindrical in form; a girdle of prolegs around each abdominal segment which may bear hooks; posterior respiratory organs in a vertical cleft (fig.153) .....TABANIDAE

16b Body form variable; each abdominal segment with never more than 1 pair of prolegs posterior respiratory organs not in a vertical cleft 17

17a End of the abdomen with a pair of caudal processes longer than the prolegs; each abdominal segment with a pair of ventral prolegs (figs. 154a,b) .....RHAGIONIDAE

17b End of the abdomen without caudal processes, or if present, then they are shorter than the prolegs, or the prolegs are absent 18

18a Caudal end of the abdomen ending in a spiracular pit surrounded by several pointed lobes (figs. 156a,b) .....DOLICHOPODIDAE

18b Caudal end of the abdomen not ending in several pointed lobes, but sometimes ending with 2 pairs of distinct raised processes (figs.155a,b;157).....EMPIDIDAE

19a Mandibles absent or minute; spiracles at the end of a long tube which, when extended is ½ the length of the body or more (fig.158).....SYRPHIDAE

19b Mandibles present; spiracles in well separated discs close to the abdomen or at the end of a tube.....20

20a Spiracular disc distinctly lobed (figs.159a,b).SCIOMYZIDAE

20b Spiracular disc without lobes 21

21a Mandibles serrate, palmate or fingerlike; if the mandibles are simple(curved without teeth) then the posterior spiracular disc end in needlelike spines(figs.160a,b;161a-c,162,163).....EPHYDRIDAE

21b Mandibles simple.....22

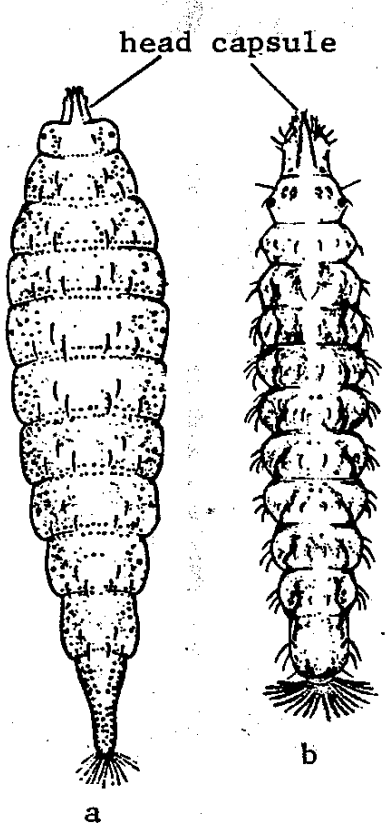


Fig. 152a,b. Stratiomyidae
Dorsal view of two larvae.
(Johannsen,1935).

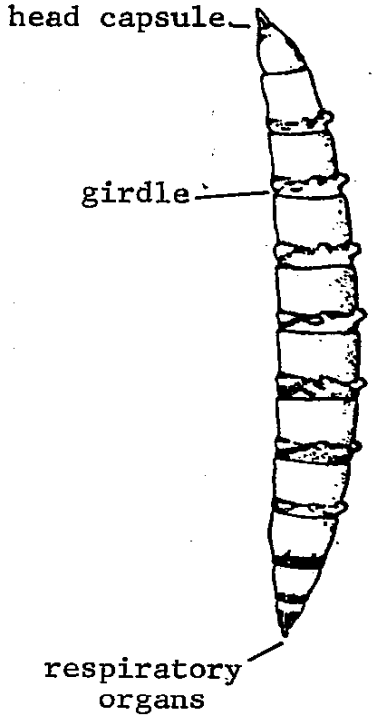


Fig. 153. Tabanidae
Lateral view of a larva.
(Cameron,1926).

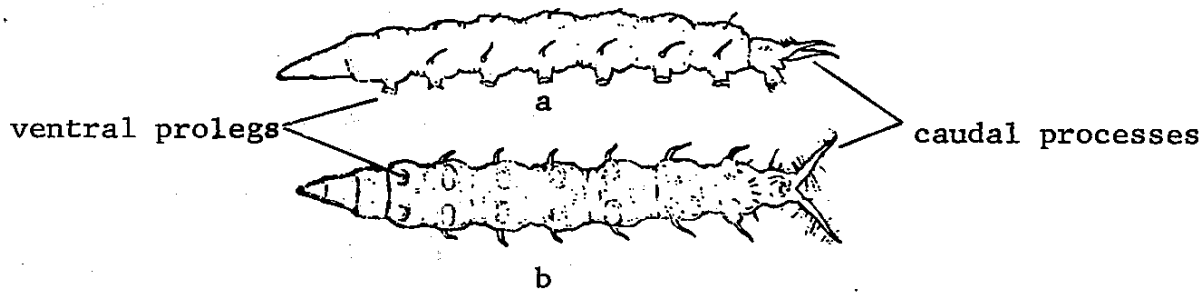


Fig. 154a,b. Rhagionidae.
Lateral(a) and ventral(b) views
of a larva.(Johannsen,1935).

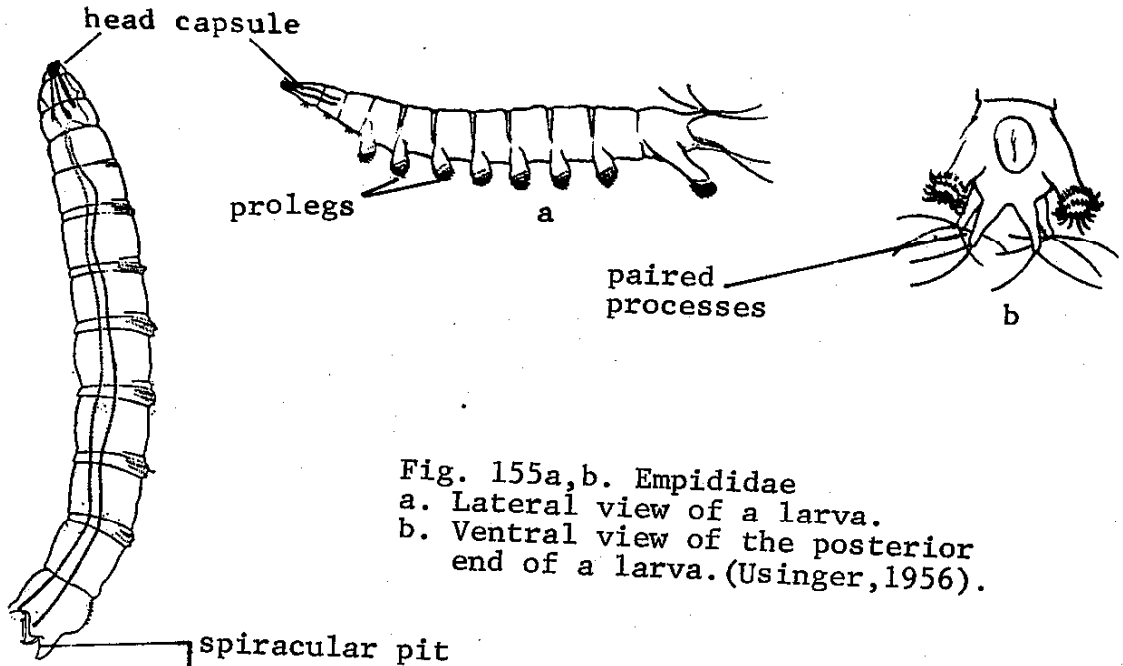


Fig. 155a,b. Empididae
a. Lateral view of a larva.
b. Ventral view of the posterior end of a larva. (Usinger, 1956).

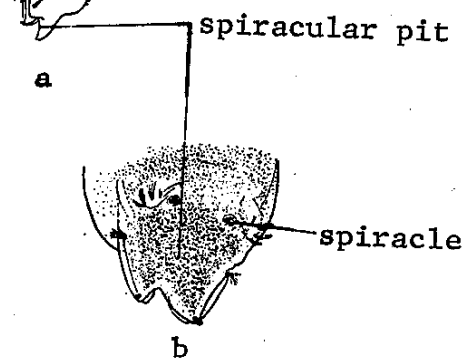


Fig. 156a,b. Dolichopodidae.
a. Lateral view of a larva.
b. View of the spiracular pit.

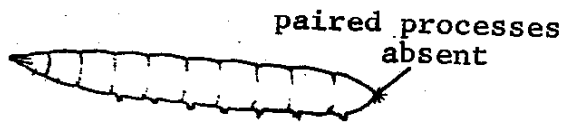


Fig. 157. Empididae.
Lateral view of a larva.
(Johannsen, 1935).

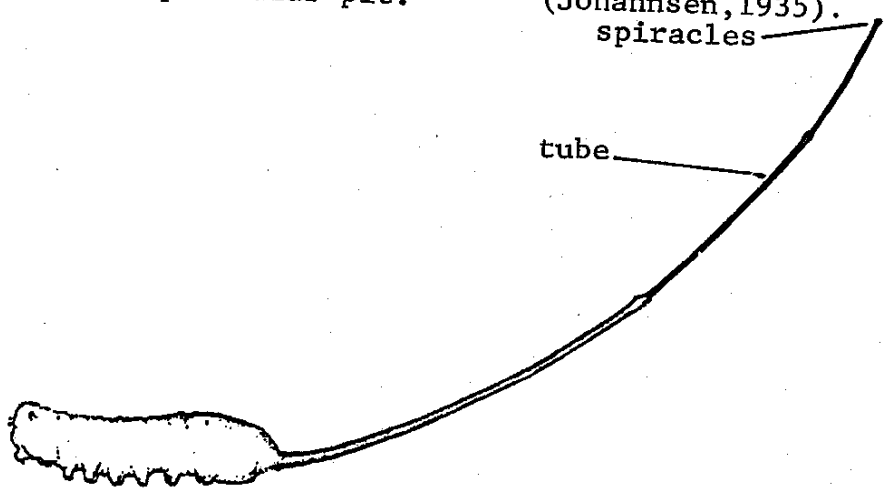


Fig. 158. Syrphidae.
Lateral view of a larva.
(Johannsen, 1935).

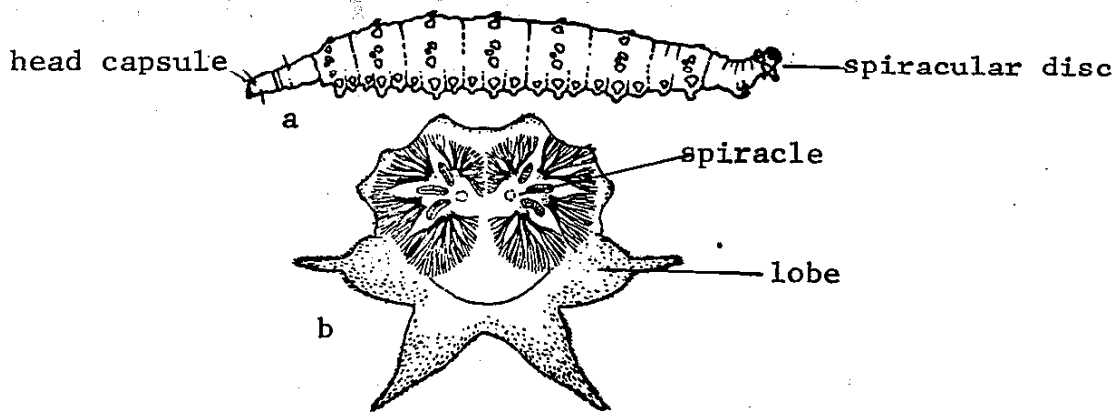


Fig. 159a,b. Sciomyzidae.
a. Lateral view of a larva.
b. End view of the spiracular disc of a larva.
(Peterson,1951).

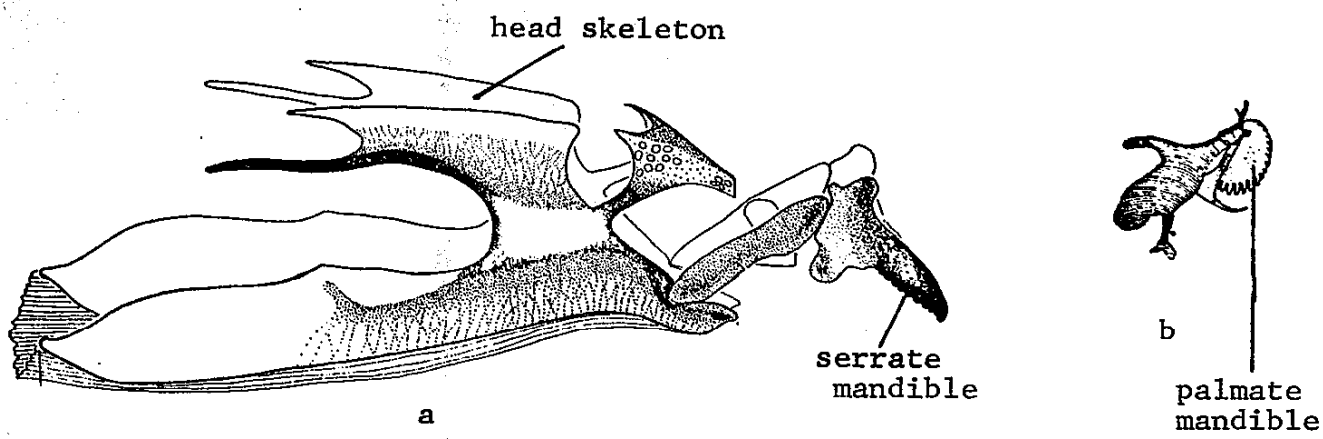


Fig. 160a,b. Ephydridae.
Types of larval mandibles.
(Berg,1950).

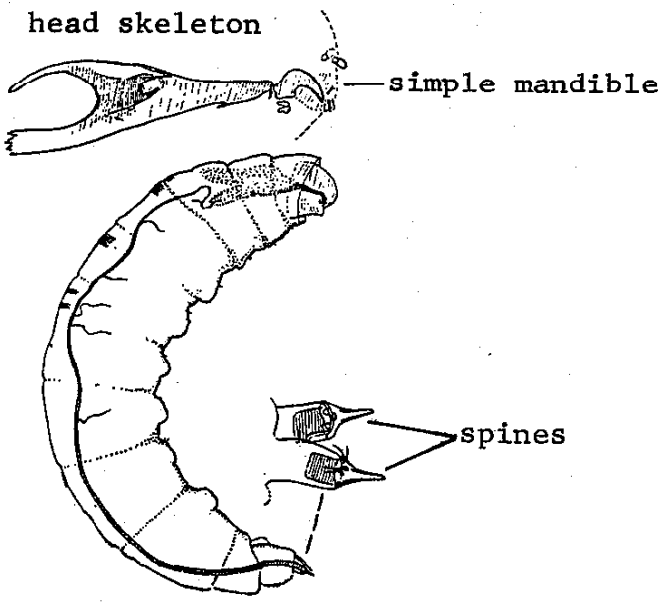


Fig.. 161a-c. Ephydridae.
a. Lateral view of larval head structures.
b. Lateral view of a larva.
c. Spiracular disc ending in spines.
(Williams,1939)

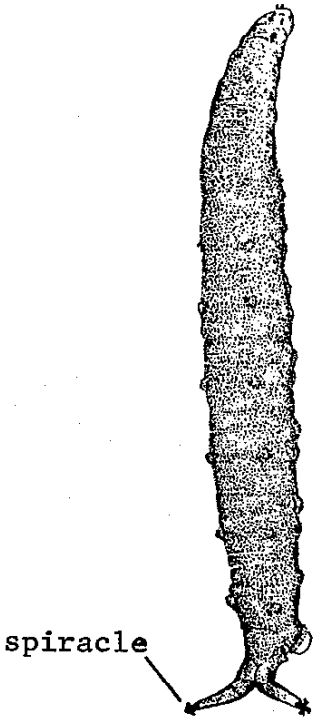


Fig. 162. Ephydridae.
Dorsal view of a larva.
(Williams,1939).

Fig. 163. Ephydridae.
Lateral view of a larva.
(Johannsen,1935).

22a Posterior spiracle with a spinelike slit-bearing process (figs.164,165) .....SCOPEUMATIDAE
22b Posterior spiracle not as above (figs.166a,b).....MUSCIDAE

23a Antennae prehensile, with long and strong apical spines (fig 168) .....CHAOBORIDAE
23b Antennae not prehensile and lacking the strong apical spines (fig.167) .....CULICIDAE

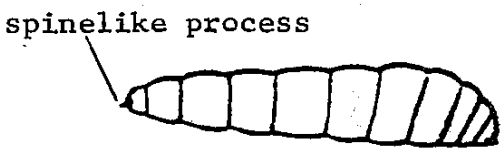


Fig. 164. Scopeumatidae. Lateral view of a larva. (Needham,1907).

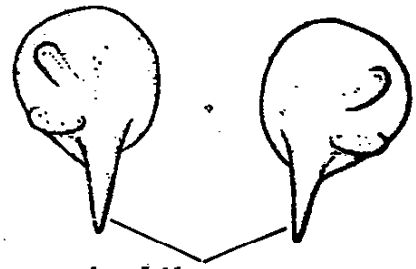


Fig. 165 Scopeumatidae. End view of the spiracular plates. (Johannsen,1935).

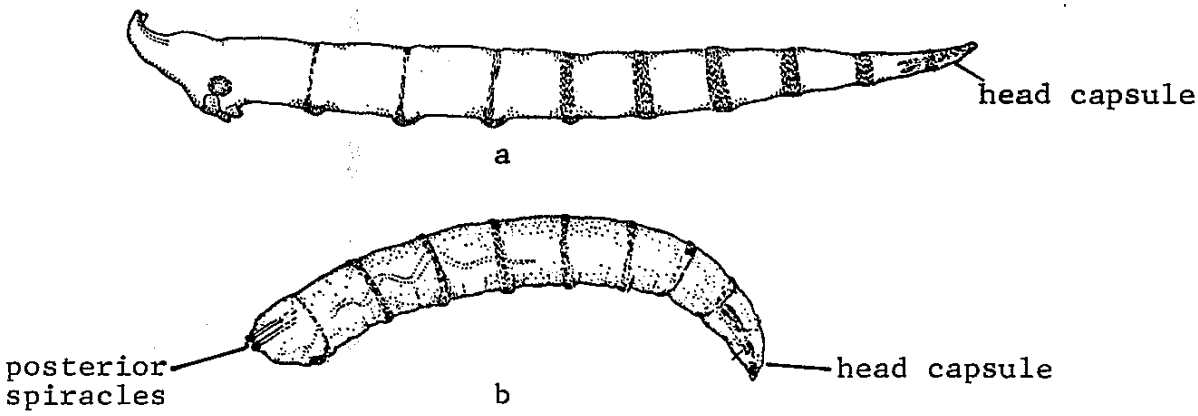


Fig. 166a,b. Muscidae. Two different larvae in lateral view. (Williams,1939).

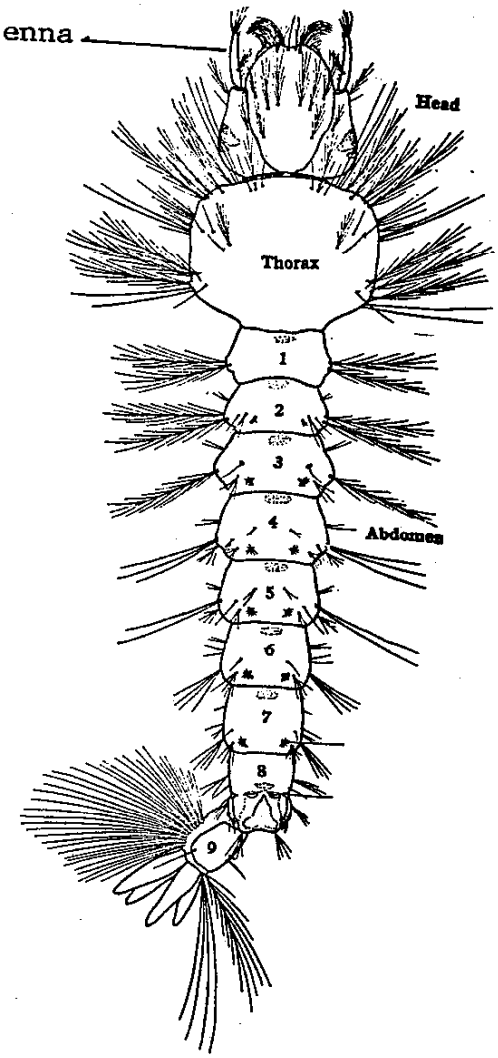


Fig. 167. Culicidae.
Dorsal view of a larva.
(Matheson,1944).

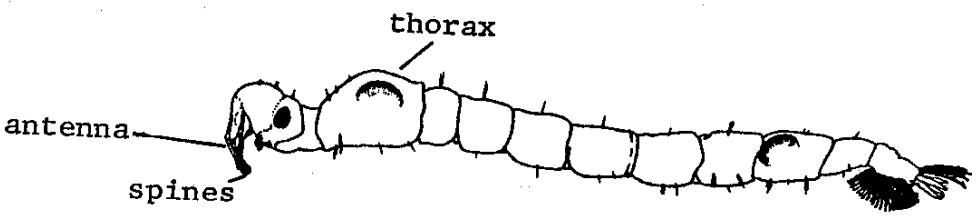


Fig. 168. Chaoboridae.
Lateral view of a larva.
(Peterson,1951).

GLOSSARY

Abdomen- The third division of the insect body, normally consisting of 9 or 10 segments. (fig.15).

Abdominal- Belonging to or pertaining to the abdomen.

Adult- The full-grown, sexually mature insect.

Anal- In the direction of, pertaining or attached to the anus or to the last segment of the abdomen.

Antecoxal sclerite- An inner sclerite between the trochantin and the episternum. (fig.103).

Antenna- The paired segmented sensory organs, found one on each side of the head, often near the eyes. (figs.107,117).

Antennal club- The enlarged terminal segments of an antenna. (figs.107,108).

Anterior- In front.

Apex- The part of any joint or segment opposite the base where it is attached.

Apical- At, near or pertaining to the apex of any structure.

Appendage- Any part, piece or organ attached by a joint to the body or to any other body structure.

Beak- The jointed structure covering the maxillae of the mouth in the order Hemiptera, and usually long and pointed. (fig.56b).

Bristles- Stiff hairs, usually short and blunt.

Carnivorous- Subsisting or feeding on animal tissues.

Caudal- Situated in or directed toward the hind part of the body.

Cercus (pl., cerci)- An appendage (usually paired) of the tenth abdominal segment, usually slender, filamentous and segmented. (figs.27,44).

Claw- A hollow, sharp organ at the end of an insect leg. (figs.57,58,110).

Conically projecting- Projecting in the general form of a cone.

Coxa (pl., coxae)- The basal (bottom) segment of the leg, which attaches to the body. (fig.106).

Coxal cavity- The opening or space in which the coxa articulates.

Crenulate- With small scallops, evenly rounded and rather deeply curved. (figs. 42a-c).

Depressed- Having the central part lower than the margin.

Distal- Far from the point of attachment or origin.

Diurnal- Recurring everyday; relating to, or occuring in the daylight.

Divergent- Spreading out from a common base.

Dorsal- Belonging to the upper surface.

Elytra- The anterior leathery wings of beetles, serving as coverings to the hind wings.(fig. 104).

Emarginate- Having the margin notched or deprived of a margin.

Encased- Enclosed.

Episternum- The anterior and larger lateral thoracic sclerite between the metathorax.(figs.99,102).

Extensible- Capable of being extended; outstretched.

Family- The taxonomic category below order consisting of genera (see Taxonomy).

Femur (pl., femora)- The thigh; usually the stoutest segment of the leg, articulated to the body through the trochanter and coxa and bearing the tibia at its distal end. (figs. 44,56,61).

Filamentous- A single thread or a thin flexible threadlike object process, or appendage.

Fringe- An edging of hair, scales or other processes extending well beyond the margin.

Frontal- Referring to the front of the head or to the anterior aspect of any part.

Fused- Run together; combined.

Genus- The taxonomic category below the family, consisting of species; the first part of an organisms scientific name.

Gill- A special, variously formed respiratory organ in the aquatic immature stages of many insects, by means of which they get dissolved oxygen from the water. (figs. 15,17,23).

Glossa (pl., glossae)- The two inner lobes of the labium; loosely used as a synonym for the tongue.(figs.45a,b;46a,b).

Gula- The throat. (figs.72a-c).

Hair- A slender flexible filament of equal diameter throughout.

Head- The first region of the insect body, connected at its base to the thorax, bearing the mouth structures and antennae.(fig.44).

Head capsule- The welded together sclerites of the head which form a hard compact case. (figs.149,153).

Instar- A stage in the life of an arthropod(as in insects) between two successive molts.

Labium- The lower lip; a compound sturcture which forms the floor of the mouth. (figs.33b,37,38).

Labrum- The upper lip which forms the roof of the mouth (figs. 15,29a,b).

Larva- The immature form of an insect that undergoes metamorphosis.

Lateral- Relating, pertaining, or attached to the side.

Lobe- Any prominent rounded process on a margin or structure.

Macroinvertebrate- Animals that are large enough to be seen with the unaided eye and can be retained by a U.S. Standard No.30 sieve (28 meshes per inch, 0.595 mm openings), and live at least part of their life cycle within or upon available substrates in water transport systems.

Maxillae- One of the first or second pair of mouthparts posterior to the mandibles in insects.

Mandibles- The first pair of jaws in insects, stout and tooth-like in chewing insects, needle or sword-shaped in piercing-mouthed sucking insects. (fig.11).

Median- In or at the middle.

Membranous- Thin and semi-transparent; of a thin pliable texture.

Mentum- The anterior sclerite of the insect labrum bearing the moveable parts. (fig.36).

Mesothorax- The second or middle segment of the thorax which bears the middle legs and the anterior wings. (fig.44).

metasternum- The upper surface of the third or posterior thora ic segment. (fig.84).

Metamorphsis- A marked and more or less abrupt change in the form or structure of an animal(as in insects or amphibians), occurring subsequent to birth or hatching.

Metathorax- The posterior segment of the thorax of an insect.

Mouth- The anterior opening into the alimentary canal, where the feeding structures are situated and in which the food is readied for digestion.

Mouth parts- A collective name including labrum, mandibles, maxillae, labrium and appendages.

Naiad- An aquatic nymph, usually referring to the immature stages of dragonflies and damselflies (Odonata).

Notched- Indented, cut or nicked.

Nymph- A young insect which hatches from the egg in an advanced stage of development, differing from the adult in having wings and reproductive organs incompletely developed; an immature aquatic insect.

Occiput- The back part of the head. (fig.44).

Ocellus (pl., ocelli)- The simple eye in adult insects, occuring singly or in small groups. (figs.66,119,133).

Omnivorous- Feeding on both animal and plant substances.

Order- The taxonomic category below class consisting of families. (see Taxonomy).

Palpus- A segmented usually tactile or gustatory process on the insect mouth. (fig.45b).

Paraglossae- The lateral terminal lobes of the labium. (fig.45a,b).

Plate- Any broad, flattened piece of the body, often hardened and darker in color than the surrounding skin.

Posterior- Hindmost; opposed to anterior.

Predaceous- Adapted to predation.

Prementum- The part of the insect labium lying in front of the mentum and bearing a part of the lobes. (fig.36).

Proleg- Any unjointed appendage that serves the purpose of a leg, found on the thorax and/or abdomen of some immature aquatic insects. (figs.143,144,148,149,150).

Pronotum- The upper or dorsal surface of the prothorax. (fig. 84).

Prosternum- The fore-breast; the sclerite between the first pair of legs.

Prothorax- The first segment of the thorax bearing the front pair of legs but no wings.(fig.44).

Pubescent- Downy; clothed with soft short, fine, closely set hair.

Pupa (pl., pupae)- The intermediate resting stage of some insects between the larva and adult.

Quadrangular- Four angled; square or nearly so. (figs.20a,21).

Quadrate- Something more or less resembling a square. (figs. 20a,21).

Rectangular- In the form of a rectangle.

Retractile- Capable of being extended and pulled back or retracted.

Ringlet- A small circle.

Scale- A flat plate-like structure of the body wall of insects.

Sclerite- Any piece of the insect body wall bounded by sutures. (figs.102,103).

Sclerotized plate- A hardened area of the insect skin forming a yellow or black plate.(fig.71).

Scutellum- In Coleoptera, the triangular piece between the elytra. (figs.104,105,112).

Segment- A ring or subdivision of the body or of an appendage between areas of flexibility.

Serrate- Saw-like; with notched edges like the teeth of a saw.

Setae (sing., seta)- Commonly known as hairs; slender hair-like appendages. (fig.42).

Sheath- A structure enclosing others.

Simple- Unmodified by any condition; not complex.

Species- The basic unit of the taxonomic classification of organisms; the taxonomic category below genus and the latter portion of the scientific name of an organism. The current biological concept of a species is defined as, "a group of actually or potentially inter-

breeding organisms reproductively isolated from other such groups of interbreeding organsims.

Spine- A thorn-like process or outgrowth of the skin not segarated from it by a joint.

Spiracle- A breathing pore through which air enters the body. (fig.156).

Spiracular disc- An oval to round cup-shaped area at the posterior end of some insect larvae that contain one or more spiracles. (fig. 159b).

Spur- A spine-like appendage, usually on the tibia.

Sternite- The ventral(underside) piece of a segment.

Sternum (pl., sterna)- The underside of an insect thorax between the leg articulations.

Sucking tube- A long, slender tube that is used to siphon juices from plants in the order Neuroptera. (fig.69).

Suture- A seam or impressed line indicating the division of the distinct parts of the body wall.

Tail- An elongate segment at the end of the abdomen.

Tarsal claw- The claw or claws at the end of the tarsus(foot). (fig. 63).

Tarsus (pl., tarsi)- The foot; the last section of an insect leg attached to the tibia consisting of from one to five segments or joints. (fig. 63).

Taxon (pl., taxa)- Any classification category such as phylum, class, order, family, genus or species.

Taxonomy- The curriculum within biology which deals with the classification and naming of organisms. The classification of organisms follows a hierarchial scheme built on the basic species unit.

Terminal- Situated at the tip.

Thoracic- Belonging or attached to the thorax.

Thorax- The second or mid-region of the insect body bearing the true legs and wings and made up of three smaller sections called the pro-, meso-, and metathorax. When the thoracic sections are all combined as in Coleoptera, Orthoptera and Hemiptera the term thorax is used. (fig. 44).

Tibia (pl., tibiae)- The fourth division of an insect leg between the femur and the tarsi. (figs. 110,122).

Transverse- Running across; cutting the longitudinal axis at right angles.

Trochanter- The second segment counting from the base of the leg of an insect. (fig.15).

Trochantin- In Coleoptera, a structure often present on the outer side of the coxa and sometimes moveable on this structure; also the small sclerite connecting the coxa with the sternum in Dytiscidae. (figs. 73a,b).

Tubercle- Rounded lobes or raised bump on the dorsal and/or lateral margins of some aquatic insect larvae.(fig.92).

Veins- The rod-like structures supporting and stiffening the wings in insects.

Venation- The complete system of veins of a wing.

Ventral- Pertaining to the under surface of the abdomen.

Ventral cleft- A vertical split in a structure.

Wings, wing- The paired membranous organs of flight in insects.

Forewings- The first pair (front pair) of wings attached to the mesothorax. (figs. 4,13).

Hindwings- The second pair (hind pair) of wings attached to the metathorax. (figs. 4,13).

Wing buds- The undeveloped wings of some aquatic insect larvae from which the wings develop.

Wing pads- The undeveloped wings of the nymphs of some aquatic insects which show behind the thorax as two lateral flat structures. (figs. 9a,b).

Wing sheaths- Wing pads.

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APPENDIX

AQUATIC FIELD SHEET

Dist._____ Co._____ Rte._____ PM_____

Station_____ Field No._____

Date_____ Time_____ Collected by_____

Stream/Lake_____ USGS Quad._____

Location_____ Elevation_____

County_____ Rte_____ PM_____ Nearest Town_____

Weather_____ Wind Direction_____ Est. mph_____

Lake_____ Pond_____ Stream: Riffle_____ Pool_____

Other_____ Avg. Width_____ Avg. Depth_____

Ft/Sec. Est. Flow_____ Method_____ cfs_____

Bottom Type_____ Bottom Materials_____

_____ Deposits_____ Shade_____

Biota Sampled_____

Sampler Type/Method_____

Exposure Period_____ Sample Depth_____

Air Temperature_____ Water Temperature_____ D.O._____

pH_____ Turbidity_____ Transparency:_____

Misc. Water Chemistry_____

_____ Source_____

Vegetation: Streamside_____ Emergent:_____

Submergent:_____ Floating:_____

Periphyton_____ Algae: Benthic_____

Periphytic_____ Mats_____

Fish:_____

Method of Preservation:_____

Pollution: Sources_____

Purpose:_____

Other Data Available:_____

Photographs:_____

Remarks and Notes:_____

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ORGANISMS IDENTIFIED:

NOTES:

NO. _____

DATE _____

MACROINVERTEBRATE TAXONOMIC DATA SHEET

NAME OF WATER BODY _____ STATION NO. _____ SAMPLE TYPE _____

STATION LOCATION _____ COLLECTED BY _____

SORTED BY _____ DATE COLLECTED _____

PURPOSE _____

* INSECTA	Total #	Stage	Dry Wt.
DIPTERA			
PLECOPTERA			
TRICHOPTERA			
EPHEMEROPTERA			
COLEOPTERA			
NEUROPTERA			

* ODONATA			
HEMIPTERA			

CRUSTACEA	Total #	Dry Wt.
ANNELIDA		
MOLLUSCA		
OTHER INVERTEBRATES:		

TOTAL NUMBER OF ORGANISMS _____ TOTAL DIVERSITY _____

TOTAL NUMBER OF TAXA _____

STAGE: L = LARVAE, N = NYMPH, P = PUPAE

FIELD AND LABORATORY BENCH SHEET

Dist.____ Co.____ Rte.____ PM____

Station____ Field No____

Date____ Time____ Collected By____

Stream/Lake____ USGS Quad.____

Location____ Elevation____

County____ Rte____ PM____ Nearest Town____

Weather____ Wind Direction____ Est. mph____

Lake____ Pond____ Stream: Riffle____ Pool____

Other____ Avg. Width____ Avg. Depth____

Ft/Sec. Est. Flow____ Method____ cfs____

Bottom Type____ Bottom Materials____

____ Deposits____ Shade____

Biota Sampled____

Sampler Type/Method____

Exposure Period____ Sample Depth____

Air Temperature____ Water Temperature____ D.O.____

pH____ Turbidity____ Transparency:____

Misc. Water Chemistry____

____ Source:____

Vegetation: Streamside____ Emergent:____

Submergent:____ Floating:____

Periphyton:____ Algae: Benthic____

Periphytic:____ Mats:____

Fish:____

Method of Preservation:____

Pollution Sources____

Purpose:____

Other Data Available:____

Photographs:____

Remarks and Notes:____

Date____ Location____ Water Body____ Other Data Available____

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FIELD SAMPLE LABEL

DEPARTMENT OF TRANSPORTATION

DIST. ____ CO. ____ RTE ____ PM ____ STATION ____

SAMPLER TYPE _____

COLLECTED BY _____

DATE _____ FIELD NO. REF. _____

DH-TL-717 (Orig. 4-74)