

Chapter 4

Biological Monitoring

- Introduction to Volunteer Water Quality Monitoring Training Notebook -

The quality of a stream's health can be determined in several ways. Physical monitoring gives information about a stream's watershed and can help to identify possible sources of water quality problems. Chemical analysis provides information about selected parameters at one moment in time. In order to get an indication of stream conditions over a longer period of time, we need to look at the biological community that the stream supports. A more complete assessment of water quality can be accomplished by evaluating the physical, chemical and biological aspects of a stream.

Biological monitoring, also called biomonitoring, involves sampling the biological community to determine the stream's health. After collection, the biological organisms are identified. The results are scored and the stream is given a water quality rating. In this program, benthic macroinvertebrates are used as biological indicators of stream health. The term *benthic* refers to the bottom of a stream.

Advantages of Macroinvertebrates as Biological Indicators

- Non-Mobile
- Species with Different Tolerances
- Continuous Monitoring
- Easy to Collect
- Inexpensive Equipment
- Easy to Identify
- No Chemicals Needed

Macroinvertebrates are good indicators of water quality because they are permanent residents of the stream, and they can move only short distances. This makes them susceptible to any pollutants that may be in the water. Some pollutants "pulse" through the water. This could be due to discharges of pollutants from a source at intermittent times or variations in flow

(e.g., after rain events) or other factors. Chemical sampling will not always reveal this type of impact, but the macroinvertebrate community will reflect impairment.

Macroinvertebrates fall into three categories of pollution tolerance:

- Pollution Sensitive
- Somewhat Pollution Tolerant
- Pollution Tolerant

The various pollution tolerances of the invertebrates make them very good water quality indicators. If water quality is degraded due to pollutants or degraded stream habitat, the invertebrate community will reflect the degradation.

Classification

The taxonomic classification scheme used to identify living organisms is as follows:

Kingdom → Phylum → Class → **Order** → Family → Genus → Species

Use one of the crutches for remembering levels, such as, “King Phillip Came Over For Good Salmon.” Within this program, macroinvertebrates will be identified to the level of Order. This can be accomplished without the aid of a microscope. The following is an example of the first four classifications of a mayfly:

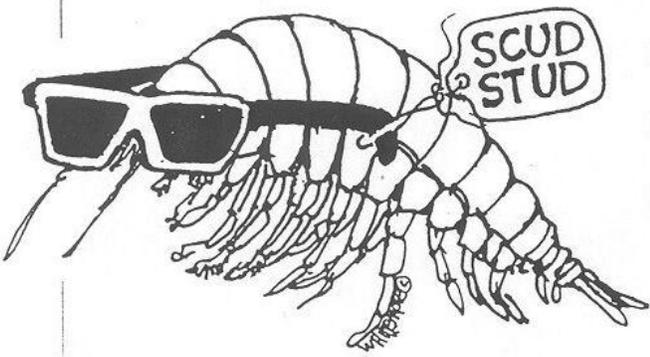
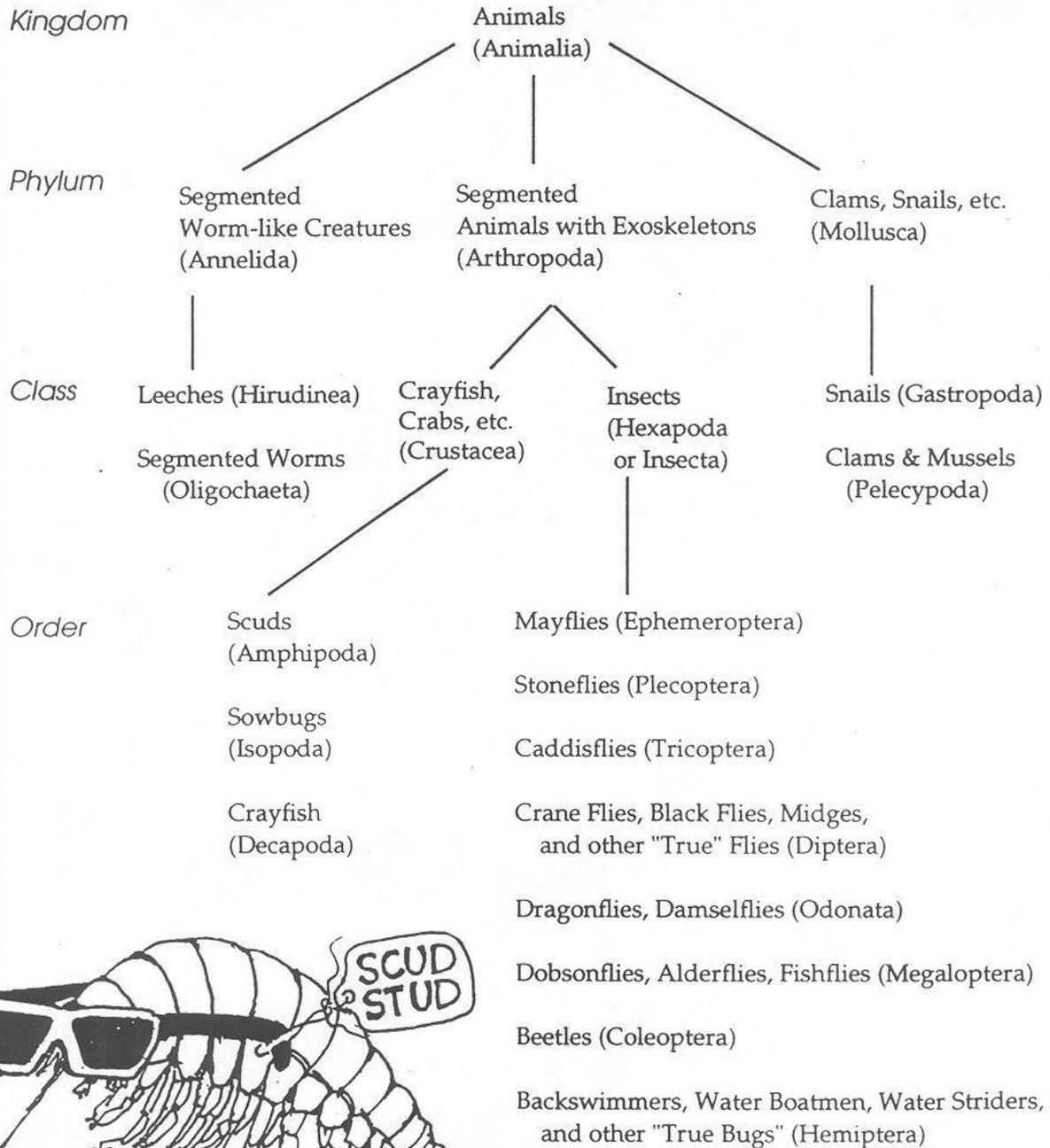
Kingdom: Animals (Animalia)
Phylum: Segmented animals with exoskeletons (Arthropoda)
Class: Insects (Insecta)
Order: Mayflies (Ephemeroptera)

Morphology

Morphology is the study of the form and structure of living organisms. As used in this program, it is defining the terms applied to those parts of the invertebrate that will be looked at to identify the organism. The terms most frequently used are:

- Head
- Thorax
- Abdomen
- Gills
- Legs and prolegs
- Tails
- Filaments
- Wingpads

BENTHIC MACROINVERTEBRATE (BUG) CLASSIFICATION



Note: This is not a complete chart of all invertebrates; it contains only common phyla, classes, and orders of stream benthic macroinvertebrates.

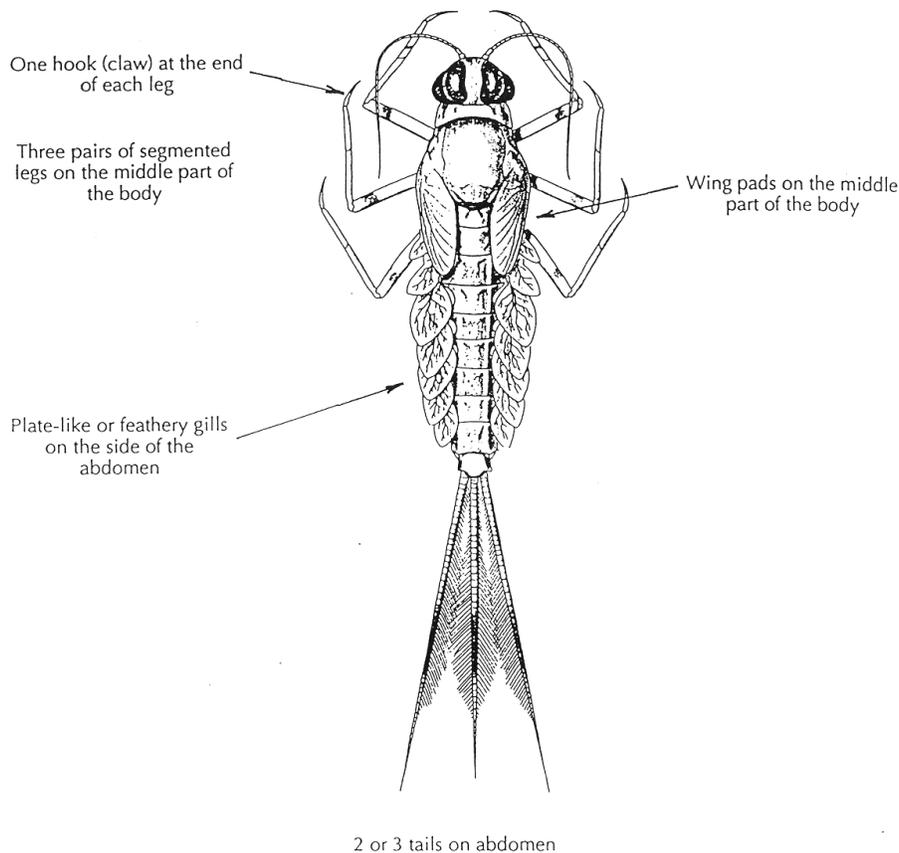
Reprinted from *The Streamkeeper's Field Guide*.

The best characteristic for identification of mayflies are the feather-shaped gills located on the abdomen. Most mayflies have three filamentlike tails, although some have only two. Unlike mayflies, all stoneflies have two tails. Stoneflies may have gills that look like hairs that are located under the legs on the thorax (they look like hairy armpits). Caddisflies have no tail, but instead have what looks like brushy hooks. They have one to three chitinous plates on the thorax behind the head, but the abdomen is soft (without plates). Unlike mayflies or stoneflies, caddisflies have no wing pads. They are the only organism that builds a case.

Identification

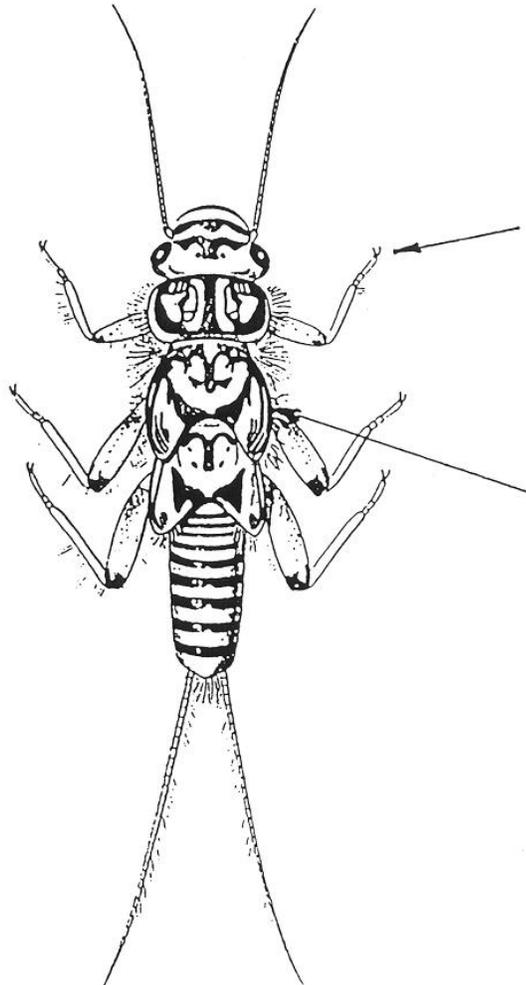
Using a Macroinvertebrate Key will help you identify the bugs you find in your stream.

Characteristics of: **MAYFLIES** (Order EPHEMEROPTERA)



Characteristics of: **STONEFLIES** (Order PLECOPTERA)

Three pairs of segmented legs on the middle part of the body



2 hooks (claws) at the end of each leg

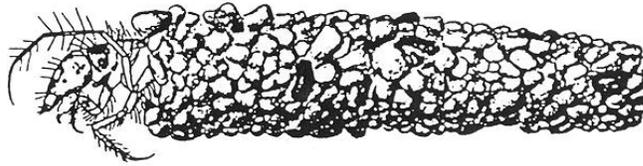
Wing pads often on the middle part of the body

No gills on the side of the abdomen or, if present, are filament-like

2 tails on abdomen

Characteristics of: **CADDISFLIES** (Order TRICHOPTERA)

The insect may be in a case made of sand grains, or bits of leaf or twigs



Three pairs of segmented legs on the middle part of the body



No wing pads on the middle part of the body

Filament-like gills may be present on the underside of the abdomen

Short or long prolegs at the end of the abdomen that end in a single hook

DICHOTOMOUS KEY TO STREAM MACROINVERTEBRATES

(Page 1)

Drawings in this key are from: Merritt-Cummins: *An Introduction to the Aquatic Insects of North America*, Copyright 1977 by Kendall/Hunt Publishing Company; Izaak Walton League of America (IWL); or McCafferty: *Aquatic Entomology*, © 1981 Boston: Jones and Bartlett Publishers. Reprinted with permission.

1. A. Segmented legs.....go to 2
- B. No segmented legs.....go to 14

2. A. 6 legs.....go to 3
- B. More than 6 legs.....go to 23

3. A. No wings, or wings not fully developed and do not cover entire body.....go to 4

- B. Wings cover entire body (but not legs), may appear beetle-like.....go to 26

4. A. Body not oval & flat; head & legs not concealed beneath body.....go to 5

- B. Body oval & flat; head & legs concealed beneath body.....**WATER PENNY**
(a type of beetle larva)

Order Coleoptera, Family Psephenidae
Feeding Group: SCRAPER

5. A. 2 or 3 distinct *hairlike* tails; tails not fleshy or hooked, but may be fringed with hairs.....go to 6

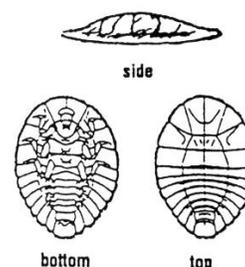
- B. Not as above.....go to 7

6. A. 2-3 tails; platelike or hairlike gills along sides of abdomen.....**MAYFLY LARVA**

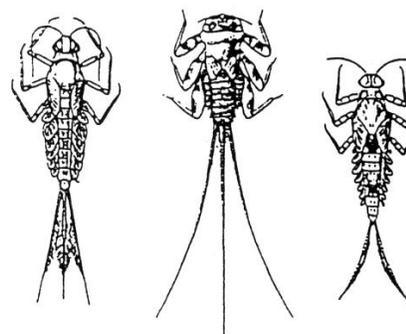
Order Ephemeroptera
Feeding Group: VARIES*

- B. 2 tails; may have hairy gills under thorax.....**STONEFLY LARVA**

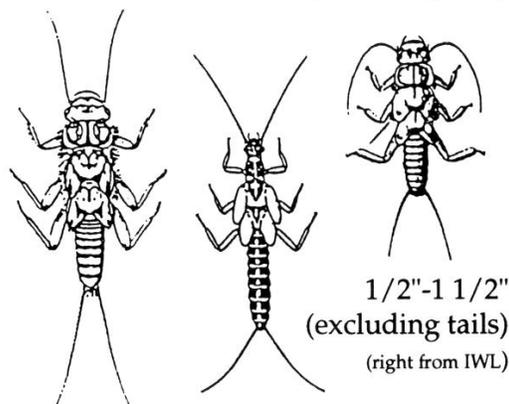
Order Plecoptera
Feeding Group: VARIES*



1/4"
(excluding tails)
(all from IWL)



(center from IWL) 1/4"-1"
(excluding tails)



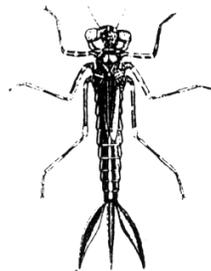
1/2"-1 1/2"
(excluding tails)
(right from IWL)

* If feeding group varies, see picture key on pages 155-157 for more information.
(All drawings on this page are from McCafferty: *Aquatic Entomology*, except as noted)

DICHOTOMOUS KEY TO STREAM MACROINVERTEBRATES

(Page 2)

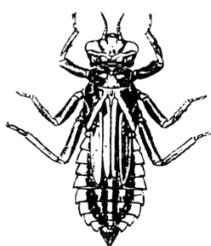
7. A. 3 oar-shaped tails (gills) at *end* of abdomen; no gills along *sides* of abdomen
.....**DAMSEFLY LARVA**
Order Odonata, Suborder Zygoptera
Feeding Group: PREDATOR



1/2"-1"
(left from IWL)

- B. Not as above.....go to 8

8. A. Fat abdomen; large eyes; mask-like lower lip.....**DRAGONFLY LARVA**
Order Odonata, Suborder Anisoptera
Feeding Group: PREDATOR



1/2"-2"

- B. Not as above.....go to 9

9. A. May be hiding in case made of gravel or plant parts; abdomen ends in pair of prolegs which may be hidden by hairs; each proleg has single hook on end, sometimes fused together and has no lateral filaments on abdomen.
.....**CADDISFLY LARVA**



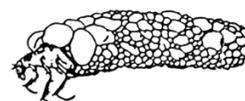
(IWL)

up to 1"

-**CADDISFLY LARVA**
Order Trichoptera
Feeding Group: VARIES*

- B. Not as above.....go to 10

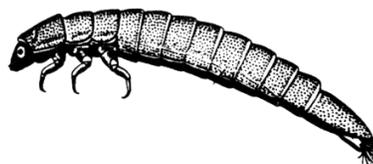
10. A. Well developed lateral filaments extend from abdominal segments.....go to 11



1/4"-1/2"

- B. No lateral filaments along abdomen; body is hardened & stiff; tip of abdomen has small plate-like opening with hooks and filaments.

-**RIFFLE BEETLE LARVA**
Order Coleoptera, Family Elmidae
Feeding Group: GATHERER COLLECTOR

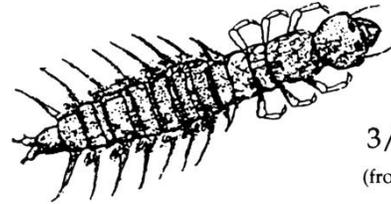


*If feeding group varies, see picture key on page 158-161 for more information
(all drawings on this page from McCafferty: *Aquatic Entomology*, except as noted)

DICHOTOMOUS KEY TO STREAM MACROINVERTEBRATES

(Page 3)

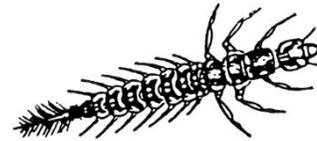
11. A. Fluffy or branched gill tufts under abdomen.....**DOBSONFLY LARVA**
("Hellgrammite")
Order Megaloptera, Family Corydalidae
Feeding Group: PREDATOR



3/4"-4"
(from IWL)

- B. Not as above.....go to 12

12. A. Abdomen ends in single, unforked, long, hairlike tail....**ALDERFLY LARVA**
Order Megaloptera, Family Sialidae
Feeding Group: PREDATOR



no gills under lateral
filaments on abdomen up to 1"

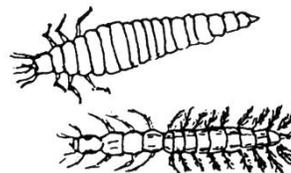
- B. Not as above.....go to 13

13. A. Abdomen ends in a pair of prolegs, each with 2 hooks.....**FISHFLY LARVA**
Order Megaloptera, Family Corydalidae
Feeding Group: PREDATOR



up to 1 1/2"
no gills under lateral
filaments on abdomen

- B. Not as above; large, obvious mouthparts
.....**AQUATIC BEETLE LARVA**
Order Coleoptera
Feeding Group: PREDATOR

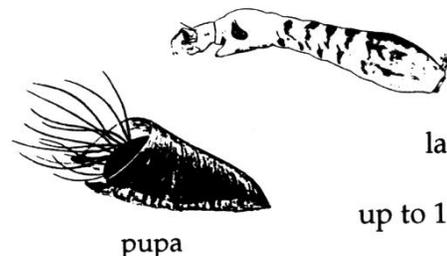


1/4"-1"
(from IWL)

14. A. Has small but distinct head; body less than 1/2" long.....go to 15

- B. Appears not to have a head, although it may be retracted into body.....go to 16

15. A. Body widens at bottom end (bowling pin shaped); may be attached to substrate; dark head....**BLACK FLY LARVA**
Order Diptera, Family Simuliidae
Feeding Group: FILTERER COLLECTOR

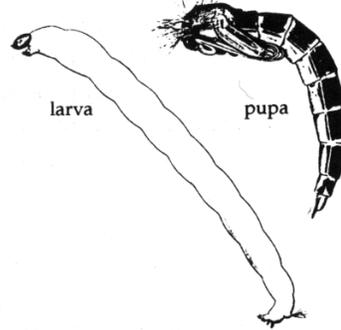


larva
up to 1/2"

(all drawings on this page from McCafferty: *Aquatic Entomology*, unless otherwise noted)

DICHOTOMOUS KEY
TO STREAM MACROINVERTEBRATES

15. B. Both ends of body about the same width; tiny pair of prolegs under head & at tip of abdomen.....MIDGE LARVA
Order Diptera, Family Chironomidae
Feeding Group: GATHERER COLLECTOR



up to 1/2"

16. A. Fleshy Caterpillar-like body.....go to 17
B. Body not caterpillar-like.....go to 18

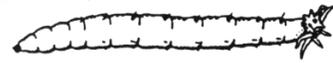
17. A. Two feathered "horns" at back end; caterpillar-like legs
.....WATERSNIPE FLY LARVA
Order Diptera, Family Athericidae
Feeding Group: PREDATOR



1/4"-1"

last segment not swollen - SHREDDER

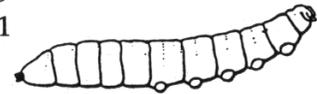
B. Can be up to 4" long; head not apparent because it is retracted into body; may have fleshy, finger-like extensions at one end
.....CRANEFLY LARVA
Order Diptera, Family Tipulidae
Feeding Group: SHREDDER OR PREDATOR



1/3"-4"

last segment swollen or no fingerlike extensions - PREDATOR (all from Cummins)

18. A. Body without hard shell.....go to 19
B. Body with hard shell.....go to 21



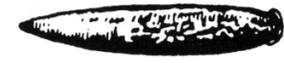
19. A. Flattened, unsegmented, worm-like body; distinct eye spots; gliding movement.....PLANARIAN (Flatworm)
Class Turbellaria
Feeding Group: PREDATOR or PARASITE



up to 3/4" (from IWL)

B. Segmented body.....go to 20

20. A. Flattened body with suckers at each end
.....LEECH
Class Hirudinea
Feeding Group: PREDATOR or PARASITE



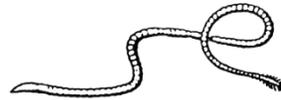
1/4"-2" (bottom figure from IWL)

(all drawings on this page are from McCafferty: *Aquatic Entomology*, unless otherwise noted)

DICHOTOMOUS KEY TO STREAM MACROINVERTEBRATES

(Page 5)

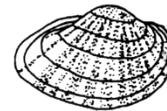
20. B. Segmented, earthworm-like body
.....**AQUATIC EARTHWORM**
 Class Oligochaeta
Feeding Group: GATHERER COLLECTOR



1/4"-2"

21. A. Snail-like.....go to 22

- B. Body enclosed within two hinged shells
.....**FRESHWATER CLAM or MUSSEL**
 Class Pelecypoda
Feeding Group: FILTERER COLLECTOR



(both from IWL)

22. A. Has operculum (hard covering used to close the opening).....**GILLED SNAIL**
 Class Gastropoda, Order Prosobranchia
Feeding Group: SCRAPER



(Right-handed)



(right from IWL)

- B. No operculum; may be spiral-shaped, limpet-like, or coiled in one plane
.....**LUNG-BREATHING SNAIL**
 Class Gastropoda, Order Pulmonata
Feeding Group: SCRAPER

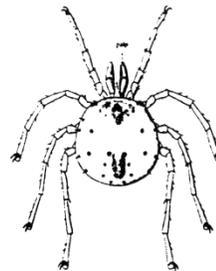


(Left-handed)



(both from IWL)

23. A. Looks like spider; may be very tiny; has 8 legs.....**AQUATIC MITE**
 Class Arachnida, Order Hydracarina
Feeding Group: PREDATOR

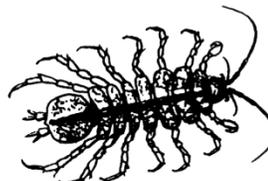


up to 1/8"

- B. Not as above.....go to 24

24. A. Lobster or shrimp-like.....go to 25

- B. Armadillo shaped body, wider than high; crawls slowly on bottom
.....**AQUATIC SOWBUG**
 Subphylum Crustacea, Order Isopoda
Feeding Group: SHREDDER



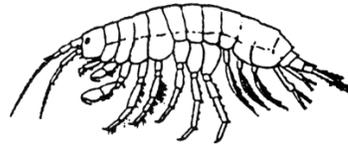
1/4"-3/4"

(all drawings on this page are from McCafferty: *Aquatic Entomology*, unless otherwise noted)

DICHOTOMOUS KEY TO STREAM MACROINVERTEBRATES

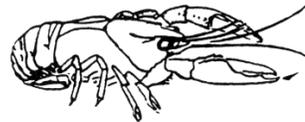
(Page 6)

25. A. Looks like tiny shrimp; swims quickly on its side.....**SCUD**
Subphylum Crustacea, Order Amphipoda
Feeding Group: SHREDDER



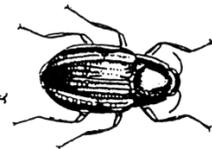
1/4"-1/2"

- B. Looks like small lobster; has 2 large front claws (10 legs total).....**CRAYFISH**
Subphylum Crustacea, Order Decapoda
Feeding Group: GATHERER COLLECTOR



up to 6"

26. A. Beetle-like, crawls slowly on bottom
.....**RIFFLE BEETLE ADULT**
Order Coleoptera, Family Elmidae
Feeding Group.: SCRAPER or
GATHERER COLLECTOR



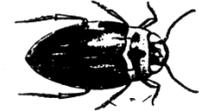
1/4"

- B. Beetle-like, swims quickly.....go to 27

27. A. Wings meet along the midline of back side of body, they do not overlap
.....**BEETLE ADULT**
Order Coleoptera
Feeding Group: MOST ARE PREDATORS



Predaceous Diving Beetle

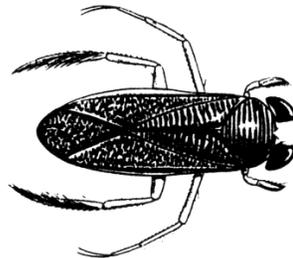


Whirligig Beetle
(swims in circular motion on water surface)

up to 1"

27. B. Wings overlap on backside, usually form a visible triangular pattern just below head.....go to 28

28. A. Front legs are shorter than mid and hind legs; propels itself with oar-like strokes,
.....**WATER BOATMAN**
Order Hemiptera, Family Corixidae
Feeding Group: VARIES



up to 3/4"

- B. Similar to WATER BOATMAN but swims upside down, on its back
.....**BACKSWIMMER**
Order Hemiptera, Family Notonectidae



up to 3/4"

Feeding Group: PREDATOR

(all drawings on this page are from McCafferty: *Aquatic Entomology*, unless otherwise noted)

Key Identification Characteristics

Pollution Sensitive Organisms – Group One Taxa

- Stonefly nymph - (Order Plecoptera) $\frac{1}{2}$ " – $1\frac{1}{2}$ "; Sometimes have hairlike gills under the legs on the thorax (hairy armpits); two tails. Two sets of wing pads on thorax. There are no gills on the abdomen.
- Caddisfly larva - (Order Trichoptera) Up to 1"; Body longer than it is wide; distinct head; one to three hard plates on thorax; six legs; abdomen ends in two terminal hooks and, unlike thorax, has no hardened outer plates.
- Water Penny larva - (Order Coleoptera) $\frac{1}{4}$ "; An immature Water Penny beetle; flat, saucer-shaped body like a tiny penny; segmented with six tiny legs underneath.
- Riffle Beetle - (Order Coleoptera) Adult: a tiny beetle, no longer than $\frac{1}{4}$ "; dark in color; six legs; crawls slowly on the bottom. Larva: also no longer than $\frac{1}{4}$ "; entire length of body covered with hard plates; six legs on thorax; uniform brown color. *Combine numbers of adults and larvae when reporting numbers on data sheets.*
- Mayfly nymph - (Order Ephemeroptera) $\frac{1}{4}$ "- 1"; Moving feathery, or platelike gills along sides of abdomen; 6 large legs each ending in one hook; 2 to 3 hairlike tails (*usually* 3); tails may be webbed together. One set of wingpads on thorax.
- Gilled Snail - (Class Gastropoda) When holding the snail in your hand with the shell point up towards your fingers and the opening facing you, **the shell opens to the right, so is called "right-handed."** DO NOT COUNT EMPTY SHELLS.
- Dobsonfly larva - (Hellgrammite – Family Corydalidae) $\frac{3}{4}$ " to 4"; dark in color; short antennae; large, pinching jaws; 6 legs; 8 pairs of feelers on lower half of the body; lateral filaments on abdomen with paired, cottonlike gill tufts along underside of the filaments; 2 tails and 2 pairs of hooks at back end.

Somewhat Pollution Tolerant Organisms – Group Two Taxa

- Crayfish - (Order Decapoda) Up to 6"; 10 legs, 2 large claws; 8 walking legs; resembles a tiny lobster.
- Sowbug - (Order Isopoda) ¼"- ¾"; Gray, oblong body wider than it is high; long antennae; more than 6 legs; looks like a "roly poly."
- Scud - (Order Amphipoda) ¼"; white to gray body higher than it is wide; body flattened side-to-side; more than 6 legs; resembles small shrimp; swims sideways.
- Alderfly larva - (Family Sialidae) 1"; Resembles small hellgrammite but has one long, thin, branched tail at back end (no hooks); tail may resemble the capital letter "A" at the base; **no gills tufts underneath the lateral filaments on abdomen.**
- Fishfly larva - (Family Corydalidae) Up to 1 ½"; Also may resemble a small hellgrammite, but **no gills under lateral filaments on abdomen** and the body is often reddish-tan in color or with yellowish streaks.
- Damselfly nymph - (Suborder Zygoptera) ½" – 1"; Large eyes; six thin, hooked legs; three broad **oar-shaped** tails; body positioned like a tripod when in water; sides of lower body are smooth (without gills); usually found in habitats with slower current.
- Watersnipe Fly larva - (Family Athericidae (Atherix)) ¼" – 1"; Pale to green in color; conical head; tapered body; many caterpillarlike legs; two feathery "horns" on end of abdomen.
- Crane Fly larva - (Suborder Nematocera) 1/3" - 4"; Milky, green, or light brown in color; plump caterpillarlike, segmented body; may have enlarged lobe or fleshy, fingerlike extensions at the end of abdomen.
- Other (aquatic) beetle larvae - (Larvae of aquatic beetles other than the Riffle Beetle) (Order Coleoptera) ¼" – 1"; A diverse group - six legs on upper half of body; feelers; antennae; obvious mouthparts.
- Dragonfly nymph - (Suborder Anisoptera) ½" – 2"; Abdomen shape may vary from wide oval (may be flattened and look like a leaf) to torpedolike; large eyes; masklike lower lip; 6 hooked legs.
- Clam/Mussel - (Class Bivalvia) Combine numbers of both clams and mussels under this category; **DO NOT COUNT EMPTY SHELLS.**

Pollution Tolerant Organisms – Group Three Taxa

Aquatic Worms/Horsehair Worm – (Include all wormlike organisms) **Class Oligochaeta**,

¼”-2””: aquatic earthworms with segmented bodies; may look thin or gray. **Phylum Nematomorpha** (horsehair worms), 4”-27””: body not segmented; may look like a coiled horsehair and appear tangled.

Midge Fly larva - (Suborder Nematocera) In Missouri streams, usually less than ¼””; Wormlike, segmented body; has distinct head; two tiny legs (prolegs) on first segment and also at tip of abdomen.

Black Fly larva - (Family Simuliidae) Up to ¼””; One end of body wider than the other; black head; sometimes have fanlike projections on head for filtering; suction pad on tip of abdomen.

Leech - (Order Hirudinea) ¼”-2””; Flattened; has sucker mouth; more “muscular” than aquatic worms.

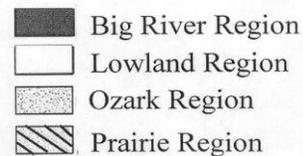
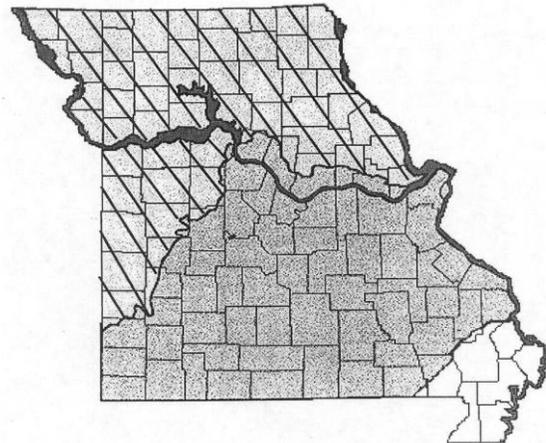
Pouch Snail and Pond Snails – (Class Gastropoda) No operculum; breath air; when holding the snail in your hand with the shell point up towards your fingers and the opening facing you, **the shell opens to the left, so they are called “left-handed.”** DO NOT COUNT EMPTY SHELLS.

Other Snails - (Class Gastropoda) Snail shell is flat, coils in one plane and does not have a point. DO NOT COUNT EMPTY SHELLS.

The difference between “nymph” and “larva” concerns the life-cycle of the organism. Organisms that undergo complete metamorphosis are called larvae and have a pupa stage in their life cycle. Organisms that undergo incomplete metamorphosis are called nymphs and lack the pupa stage in their life cycle. Note, however, there is some inconsistency in the literature regarding this policy.

Aquatic Faunal Regions

Although Missouri has five aquatic faunal regions, we've combined the two prairie regions both in the discussion below and on the map. Each region is characterized by different habitats and fauna. The types of aquatic habitat you will find in the stream you sample will generally be determined by the aquatic faunal region in which the stream is located. Most volunteers sample in the Ozark Region, the Prairie Region or the Lowland Region.



Ozark Region:

Ozark streams comprise most of the streams in the southern portion of the state, with the exception of the Bootheel and a few western counties. This region is characterized by older bedrock and higher elevation than the surrounding regions. The bedrock is usually limestone or dolomite. Streams in the Ozark Region are often bordered by high bluffs and gradients, usually exceeding three feet per mile, causing Ozark streams to have abundant riffles. Streams in the Ozarks are characterized by a riffle-run-pool sequence. The water of these streams is usually clear and often cool due to the numerous springs in the Ozarks. The predominant substrates are coarse gravel, cobble, boulders and bedrock. Many of the invertebrates sampled in this habitat are adapted to live in the spaces between pieces of gravel or cobble (called “interstitial” spaces) and often attach to the substrate itself.

Sampling: When sampling Ozark streams, three different types of micro-habitat can usually be found within a riffle, like at the upstream end (head) of the riffle versus the middle or lower end (tail) of the riffle. The change from one micro-habitat type to another may be subtle such as a change in flow or rock size.

Glaciated and Osage Prairie Regions:

Glaciated prairie region streams comprise most of the streams in north Missouri. Osage prairie region streams comprise parts of west and southwest Missouri. The water of these

streams tends to be more turbid due to the surrounding soil type. Many of the prairie streams in northern Missouri have been channelized (straightened) by man. The banks are generally steep and vegetated. Historically, streams in this region have always been slow moving due to the lower gradient, so they rarely have riffles and are characterized by a sequence of pool-run-pool. The substrates are generally silt, sand, shelf bedrock and/or shale. These types of substrate do not generally provide the interstitial spaces in which invertebrates can hide.

***Sampling:* Sampling in prairie streams may require you to look for different types of habitat such as root mats, snags and non-flow areas.**

Lowland Region:

Before human settlement, the Bootheel had extensive wetlands, but a network of man-made ditches now drain the area. Along with the few remaining natural streams and wetlands, these ditches are the principal aquatic habitat in the Lowland Region. Gradients are usually less than one foot per mile. The substrate in the faster moving waters is mostly sand or gravel, while slower waters are silt-bottomed.

***Sampling:* In most cases, sample ditches for invertebrates as you would prairie streams.**

Big River Region:

These big rivers in Missouri are the Missouri, Mississippi and lower Grand Rivers. They are characterized by continuous strong flow and may experience prolonged flooding. Sand and silt are the predominant substrates.

***Sampling:* Our protocol is not designed for sampling big rivers. However, a Big River Protocol is available. Ask your instructor.**

Field Sampling Procedure

HOW: Demonstrated in the field during training workshop.

WHEN: Conduct biological monitoring at least two, but no more than four, times per year at a site (you can negatively impact the site if you sample more than four times per year). At least one sample (three net sets per sample) should be collected in late winter/early spring (February, March or April) and another in late summer/early autumn (before leaves fall).

WHERE: Stable riffle, if at all possible, or other appropriate, alternative habitat.

Site Selection:

Review Chapter 2, *Site Identification & Selection* for more detailed guidance on selecting a monitoring site.

Equipment:

- 1.) 3' x 3' kick net (500-micron mesh) for sampling riffles, root mats and snags
- 2.) Sorting pan and/or white ice cube trays
- 3.) Forceps
- 4.) Squirt bottle – can use a small, well-rinsed soda or dishwashing liquid bottle
- 5.) Hand magnifying lens
- 6.) Long-handled D-frame net for sampling non-riffle habitats when kick nets don't work

Habitat

Macroinvertebrates are good indicators of water quality conditions due to their varying tolerances to pollution. The water quality rating that you determine from your *Macroinvertebrate Data Sheet* will be a general indication of the water quality of your watershed. To ensure you have a complete picture of what lives in your stream, three net sets of invertebrates should be collected from three different habitats. Collecting invertebrate samples from three different habitats is more representative of stream health than sampling one or two habitats. Many invertebrates require a specific type of habitat. Sampling three different types of habitats will raise the water quality rating and provide the most complete picture of stream health.

Riffles:

If possible, every monitoring site should contain a stable riffle. Riffles provide a variety of microhabitats such as rock size, flow and leaf packs, which house different organisms. Sensitive organisms generally prefer a habitat with high oxygen levels. Since a riffle aerates the water, sensitive organisms should be found there. Flowing water also brings food to many invertebrates.

Always work in an upstream direction so that sampling activities do not disturb portions of the riffle to be sampled later so start with the riffle farthest downstream in your sampling area and work upstream to the next riffle from there. Select three areas within the riffle that are

slightly different (e.g., different substrate size, current velocity, depths, presence of rooted aquatic plants, woody debris, leaf packs, etc.).

On large streams, either start at the downstream end of the riffle and move upstream, or begin close to the bank and move across the stream, taking your second sample in the middle of the stream and your third sample near the far bank.

If the riffle is too small to get three net sets out of it, you may also want to sample root mat or other habitat, if present, to ensure you get a total of three net sets (e.g., two sets in the riffle and one in the root mat). Regardless of which three microhabitats you sample at a particular site, be sure you say so in the box provided on the data sheet, and always sample those same microhabitats at that site in the future. This will ensure that the data you collect remains consistent over time. **This is extremely important.**

Sample Collection in Riffles Adequate sampling requires two people; one to hold the net and the other to dislodge invertebrates from the substrate.

- 1.) Place the net in the riffle. The net should face upstream and it should be tilted enough to provide a “pocket”.
- 2.) Ensure the bottom of the net is on the stream bottom leaving no room between the net and substrate (prevents organisms from washing under the net).
- 3.) Pick up and rub all large stones in the 3-foot by 3-foot (3' x 3') area immediately upstream of the net to dislodge invertebrates and wash them into the net. As you do so, remove the washed off stones from sampling area.
- 4.) Dance and kick with your feet in the 3' x 3' area until you have disturbed all of the substrate 3 - 6 inches deep to dislodge the invertebrates.

In Ozark streams, finding riffles to sample is easy. However, in the northern and western Missouri prairie streams, and in the Bootheel, there are very few riffles to sample. The lack of riffles in Missouri’s prairie streams is a result of the naturally flatter topography, so alternative habitats must be sampled for invertebrates.

Root Mats:

Root mats are the matted roots of vegetation growing from the bank which hang in the water or grow out of the bank. They can include anything from grass or shrubs roots to tree root

balls growing on the banks. Root mats are usually found in slower areas of the stream such as runs or pools. This is excellent habitat and home to many species of dragonflies, damselflies, mayflies and caddisflies.

Sample Collection from Root Mats Adequate sampling requires two people; one to hold the net and the other to dislodge invertebrates from the root mat.

- 1.) One person places the kick net against the bank on the downstream side of the root mat.
- 2.) Make sure that the net is anchored to the streambed.
- 3.) The other person then kicks the root mat in a swirling motion with one foot to create a circular current in order to dislodge the invertebrates from the root mat. The circular motion of the sampler's foot will drive the invertebrates into the net, even if there is no current.

Snags:

Snags are a special habitat that can be home to many of the larval stages of mayflies, caddisflies and "true flies" (Dipterians), such as crane flies, midge flies, and black flies with wormlike larva. Snags are pieces of wood such as tree limbs, logs and sticks that have fallen into the water. Be sure to sample snags that have been in the water for some time. The best snags to sample have been described as "worm wood." These are pieces of wood that have been in the water long enough it is half-rotten and will provide many places for invertebrates to live.

Sample Collection from Snags Adequate sampling requires two people; one to hold the net and the other to dislodge invertebrates from the snag.

- 1.) One person holds the net in a horizontal position about 6 inches to 12 inches under the water.
- 2.) The second volunteer removes the snag from the water. When removing snags from the water, pull the snag out of the water quickly. Invertebrates may swim off if the snag is removed too slowly.
- 3.) Brush the snag down with a brush while holding the net underneath to catch dislodged invertebrates.
- 4.) **Sample approximately 3 to 5 snags for one net set.**

Non-flow:

Non-flow areas of the stream are not in the main channel and do not have flow. They may be pooled areas in pockets behind logs or in pockets on the downstream end of a riffle, or in a bend in the stream. Because the water slows in these areas, previously suspended material is often deposited. As a result, they often have high amounts of organic matter such as leaves and woody debris present in them.

Sample Collection from Non-flow Areas Adequate sampling can be achieved by one person with a D-frame net, but you may need two if you use a kick net. Although this habitat *can* be sampled using a kick net, it is easier with a D-frame net.

- 1.) Hold the D-frame net out in front of you holding the frame in the substrate pointed upstream (your body should be upstream from the net).
- 2.) Then walk backwards upstream while shuffling your feet to stir up detrital material to be caught in the net.
- 3.) Sample 3 net sets like this.

Sample Analysis

- 1.) Pick the macroinvertebrates from the net. Look for all sizes, not just the BIG ones.
- 2.) Record on the *Macroinvertebrate Data Sheet* the time spent removing the macroinvertebrates from the sorting tray or net. To correctly derive the time spent, multiply the number of people picking by the amount of time each spent [e.g., 4 people spent 20 minutes each picking. So 4 (people) x 20 (minutes each) = 80 minutes total]. **DO NOT include any time spent identifying the macroinvertebrates in your time spent picking.**
- 3.) Identify the macroinvertebrates. Use the *Dichotomous Key to Stream Macroinvertebrates* and Key Identification Characteristics provided in this chapter, as well as the “Blue Bug Card” and the “Key to Macro Life” sheets provided.
- 4.) Count the invertebrates and record results on the *Macroinvertebrate Data Sheet*.

Repeat the process outlined above three times. Fill out the *Macroinvertebrate Data Sheet* for each net set collected. Be sure to record the numbers of invertebrates present in each net set on the data sheet. It is important that you include the actual number rather than a check mark. Calculate the “*water quality rating*” based on three net sets as directed on the *Macroinvertebrate Data Sheet*. It is very important to have three net sets. Three net sets from three different habitats usually improve the water quality rating and give a more representative rating. Again, always work in an upstream direction each time you go out so that sampling activities do not disturb portions of the stream to be sampled for your second and third net set at that site. Start sampling the habitat farthest downstream in your sampling site and work upstream to the next riffle (or other habitat) from there.

Factors That Will Affect the Water Quality Rating

All of the following factors affect the water quality rating:

- **Substrate** – The type of habitat the stream provides will affect the rating. Silt and sand bottom streams will generally have lower ratings than cobble-bottomed Ozark streams.
- **Depth and Velocity** – Sensitive organisms prefer water with some velocity because it helps to keep oxygen levels high via atmospheric mixing. However, too much velocity can be a problem. Urban streams are examples of this when rain events generate deep, fast flows that cause organisms to be swept away by the force of the water.
- **Season** – Many invertebrates are insect larva and emerge at varying times of the year. If you monitor when they are in the adult stage, your rating will be lowered.
- **Water Temperature** – Very warm streams, like those with no riparian corridor or those in urban areas that are partially paved, will not hold much oxygen and will not support aquatic life. Chemicals are not the only pollutants. Heat can be a pollutant.

- **Flow** – Invertebrates must have a fairly consistent quantity of water to survive.
- **Water Chemistry** – A balance of chemical constituents must be maintained to support a diversity of aquatic life. Imbalances will result in changes in the stream that will alter what can live there. Certain chemicals are toxic to organisms, and if they are present in large enough quantities, all the life in a stream may be killed.
- **Physical Factors** – Habitat, flow, temperature and erosion rates are all physical factors that affect aquatic life. Poor ratings can often be attributed to physical problems in the stream rather than a point source discharge or a single chemical pollutant.
- **General Identification to Order** – When professional biologists evaluate macroinvertebrates, they identify them to genus and species. This is a difficult and time-consuming process but allows for analysis of the data that can provide very fine discriminations as to the level of stream impairment. It is estimated that there are over 700 species of mayflies in North America. Some require the highest quality stream conditions to thrive. Others are somewhat tolerant of degradation. Because we generally only identify insects to the level of Order, we do not make these types of discriminations, so our ratings can be misleading.

Considerations

There are some drawbacks to biological monitoring. It is difficult to determine if a stream is healthy, moderately impacted or seriously polluted based on only one sampling trip, even if you have a background in stream ecology. As you can imagine, patterns or “trends” in water quality become more apparent after a series of samples are collected over time. Also, the methods taught here are simplified enough to be usable by most people, but some accuracy is lost because the identification of the organisms is very general.

The cause of a low water quality rating based on biological monitoring may not be easy to determine. It could be due to one cause or a variety of causes including such things as wastes from sewage treatment plants, poor land-use practices, seasonal changes, confined animal

feeding operations, etc. Some streams' origins include cold water from springs that naturally have a limited biological community. A low rating could also be due to degraded physical habitat. The list goes on and on. Perfecting identification will take practice and maybe some assistance from a biologist.

ANALYZING INVERTEBRATE DATA

OBSERVATION	ANALYSIS
<ul style="list-style-type: none"> • high diversity, high density, many sensitive species such as stoneflies, caddisflies and mayflies → 	<ul style="list-style-type: none"> • no problems; good water quality
<ul style="list-style-type: none"> • high diversity, low density of species present → 	<ul style="list-style-type: none"> • possibly due to poor habitat conditions
<ul style="list-style-type: none"> • low diversity, high density of species present → 	<ul style="list-style-type: none"> • organic pollution (nutrient enrichment) or sedimentation; excessive algal growth resulting from nutrient enrichment
<ul style="list-style-type: none"> • low diversity, low density or no macroinvertebrates but the stream <i>appears</i> clean → 	<ul style="list-style-type: none"> • toxic pollution (e.g., chlorine, acids, heavy metals, oil, herbicides, insecticides); unproductive

Note that you can download data sheets OR submit data online by visiting the Stream Team website: <http://www.mostreamteam.org>

MACROINVERTEBRATE DATA SHEET

Please check the box next to "Site #" if this is a new site and please be sure to attach a map.

Site # 1 Stream Turkey Creek County Boone
 Site Description 100 yds upstream from Hwy 163 Time 1300
 Date 4/5/07 Trained Data Submitter (person assuming responsibility for these data) Shelley Banks
 Trained Data Submitter's Stream Team Number 1439 Rainfall (inches in last 7 days) 1.0
 Trained Participants Chris Langdon, Tim Rielly

Invertebrate Type	Net Set #1	Net Set #2	Net Set #3	Score
Habitat type →	<u>Riffle</u> →	<u>Riffle</u> →	<u>Riffle</u>	After entering the number (#) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the total as your Water Quality Rating.
Time Spent Picking (Minutes picking x number of people picking)	min. picking <u>15</u> x # people <u>3</u> = total min. <u>45</u>	min. picking <u>10</u> x # people <u>3</u> = total min. <u>30</u>	min. picking <u>12</u> x # people <u>3</u> = total min. <u>36</u>	
Sensitive	# of Organisms	# of Organisms	# of Organisms	
Caddisfly Larvae				3
Hellgrammites	10	7	9	③
Mayfly Nymphs		45	30	③
Gilled Snails (right)				3
Riffle Beetles	20			③
Stonefly Nymphs				3
Water Penny Larvae	25	12	22	③
Somewhat Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Other Beetle Larvae		2		②
Clams/Mussels				2
Crane Fly Larvae	1		2	②
Crayfish				2
Dragonfly Nymphs				2
Damselfly Nymphs				2
Scuds	1	10	3	②
Sowbugs				2
Fishfly Larvae	5			②
Alderfly Larvae				2
Watersnipe Fly				2
Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Aquatic Worms	3	1	2	①
Black Fly Larvae	2	1	1	①
Leeches			3	①
Midge Larvae	4	4	1	①
Pouch Snails (left)	1			①
Other Snails (flat)				1
< 12 = Poor 12 - 17 = Fair 18 - 23 = Good > 23 = Excellent				Water Quality Rating <u>25</u>

Comments (mention any changes from your usual readings) _____

Fish Present (Please Mark) Yes or No

PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO:

Priscilla Stotts/Water Protection Program
 Department of Natural Resources
 P.O. Box 176
 Jefferson City, MO 65102-0176

Volunteer Monitoring - 1/07



Instructions for Biological Monitoring

- Collect three net sets of invertebrates from three different microhabitats. This ensures a more complete picture of what lives in your stream and more accurately reflects stream health. Adequate sampling can be achieved by one person with a D-frame net, but you may need two people if you use a kick net.
- If possible, take all three net sets from different areas within a stable riffle. Microhabitats to sample include differences in: rock size, flow, leaf packs and emergent vegetation.
- Always work in an upstream direction so that sampling activities do not disturb portions of the riffle to be sampled later.
- If, and only if, you do not have enough riffle habitat within your 300 ft. sampling site to collect three net sets, you may also want to sample alternative microhabitats.
 - Prioritize sampling of habitat types as follows:
 - Riffle
 - Root mat
 - Snags
 - Non-flow
 - Whatever you decide to sample at your site (e.g., two riffle net sets and one root mat), always sample those same three microhabitats at the site every time you sample there, and list the habitat type for each sample. This will ensure that the data you collect remains consistent over time.

Sampling Streams With Riffles

Sampling may require two people, one to hold the net and the other to dislodge invertebrates from the substrate.

1. **Place** the net in the riffle facing upstream, and tilt it enough to provide a “pocket.”
2. **Ensure the bottom of the net** is on the stream bottom leaving no room between the net and substrate (prevents organisms from washing under the net).
3. **Rub all large stones** in the 3-foot by 3-foot (3' x 3') area immediately upstream of the net to dislodge invertebrates and wash them into the net.
4. **Dance and kick** with your feet in the 3' x 3' area until you have disturbed all of the substrate 3 inches to 6 inches deep to dislodge the invertebrates into the net.

Streams Without Riffles (or without riffles not large enough for 3 net sets)

Sample Collection from Root Mats – Adequate sampling requires two people.

1. Have one person place the side of the kick net against the bank on the downstream side of the root mat.
2. Make sure that the net is anchored to the stream bed.
3. The other person will then kick the root mat **in a swirling motion** with one foot to create a circular current in order to dislodge the invertebrates from the root mat. The circular motion of the sampler's foot will drive the invertebrates into the net, even if there is no current.

Sample Collection from Snags – Adequate sampling requires two people.

1. Have one person hold the net in a horizontal position about 6-12 inches under the water.
2. The 2nd volunteer will remove the snag from the water. When removing snags from the water, pull the snag out of the water quickly. If the snag is removed too slowly, the invertebrates may swim off.
3. Brush the snag down with a brush above the net to dislodge invertebrates.
4. Sample approximately 3 to 5 snags for one net set.

Sample non-flow areas in the same manner as a riffle, collecting three separate samples. However, the sampler will need to use a swirling motion with the foot to create a current to move debris into the net. Although this habitat can be sampled using a kick net, it is easier with a D-frame net.

MACROINVERTEBRATE DATA SHEET

Please check the box next to "Site #" if this is a new site and please be sure to attach a map.

Site # 1 Stream Turkey Creek County Boone
 Site Description 100 yds upstream from Hwy 163 Time 1320
 Date 4/5/08 Trained Data Submitter (person assuming responsibility for these data) Shelley Banks
 Trained Data Submitter's Stream Team Number 1639 Rainfall (inches in last 7 days) 1.0
 Trained Participants Chris Langdon, Tim Rielly

Invertebrate Type	Net Set #1	Net Set #2	Net Set #3	Score
Habitat type →	Riffle →	Riffle →	Riffle	After entering the number (#) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the total as your Water Quality Rating.
Time Spent Picking (Minutes picking x number of people picking)	min. picking <u>15</u> x # people <u>3</u> = total min. <u>45</u>	min. picking <u>10</u> x # people <u>3</u> = total min. <u>30</u>	min. picking <u>12</u> x # people <u>3</u> = total min. <u>36</u>	
Sensitive	# of Organisms	# of Organisms	# of Organisms	
Caddisfly Larvae				3
Hellgrammites	3	1	1	③
Mayfly Nymphs		4	6	③
Gilled Snails (right)				3
Riffle Beetles	1			③
Stonefly Nymphs				3
Water Penny Larvae		5	1	③
Somewhat Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Other Beetle Larvae		1		②
Clams/Mussels				2
Crane Fly Larvae	5		1	②
Crayfish				2
Dragonfly Nymphs				2
Damselfly Nymphs				2
Scuds				2
Sowbugs	4	4	10	②
Fishfly Larvae	5			②
Alderfly Larvae				2
Watersnipe Fly				2
Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Aquatic Worms	25	15	22	①
Black Fly Larvae	100+	100+	15	①
Leeches			20	①
Midge Larvae	20	35	38	①
Pouch Snails (left)	42			①
Other Snails (flat)				1
< 12 = Poor 12 - 17 = Fair 18 - 23 = Good > 23 = Excellent				Water Quality Rating <u>25</u>
Comments (mention any changes from your usual readings) <u>The water quality rating hasn't changed, but there are so many more tolerant critters this year! This is a big change.</u>				
Fish Present (Please Mark) <input checked="" type="checkbox"/> Yes or <input type="checkbox"/> No <u>What does it mean?</u>				
PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO: Priscilla Stotts/Water Protection Program Department of Natural Resources P.O. Box 176 Jefferson City, MO 65102-0176				
Volunteer Monitoring - 1/07				



Instructions for Biological Monitoring

- Collect three net sets of invertebrates from three different microhabitats. This ensures a more complete picture of what lives in your stream and more accurately reflects stream health. Adequate sampling can be achieved by one person with a D-frame net, but you may need two people if you use a kick net.
- If possible, take all three net sets from different areas within a stable riffle. Microhabitats to sample include differences in: rock size, flow, leaf packs and emergent vegetation.
- Always work in an upstream direction so that sampling activities do not disturb portions of the riffle to be sampled later.
- If, and only if, you do not have enough riffle habitat within your 300 ft. sampling site to collect three net sets, you may also want to sample alternative microhabitats.
 - Prioritize sampling of habitat types as follows:
 - Riffle
 - Root mat
 - Snags
 - Non-flow
 - Whatever you decide to sample at your site (e.g., two riffle net sets and one root mat), always sample those same three microhabitats at the site every time you sample there, and list the habitat type for each sample. This will ensure that the data you collect remains consistent over time.

Sampling Streams With Riffles

Sampling may require two people, one to hold the net and the other to dislodge invertebrates from the substrate.

1. **Place** the net in the riffle facing upstream, and tilt it enough to provide a “pocket.”
2. **Ensure the bottom of the net** is on the stream bottom leaving no room between the net and substrate (prevents organisms from washing under the net).
3. **Rub all large stones** in the 3-foot by 3-foot (3' x 3') area immediately upstream of the net to dislodge invertebrates and wash them into the net.
4. **Dance and kick** with your feet in the 3' x 3' area until you have disturbed all of the substrate 3 inches to 6 inches deep to dislodge the invertebrates into the net.

Streams Without Riffles (or without riffles not large enough for 3 net sets)

Sample Collection from Root Mats – Adequate sampling requires two people.

1. Have one person place the side of the kick net against the bank on the downstream side of the root mat.
2. Make sure that the net is anchored to the stream bed.
3. The other person will then kick the root mat **in a swirling motion** with one foot to create a circular current in order to dislodge the invertebrates from the root mat. The circular motion of the sampler's foot will drive the invertebrates into the net, even if there is no current.

Sample Collection from Snags – Adequate sampling requires two people.

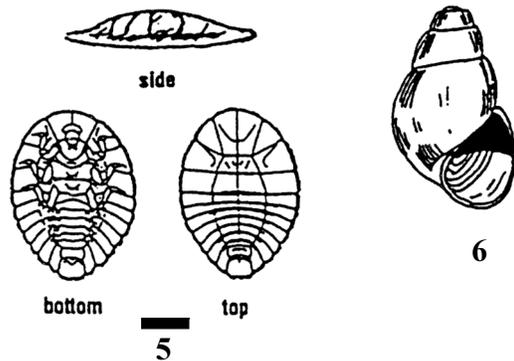
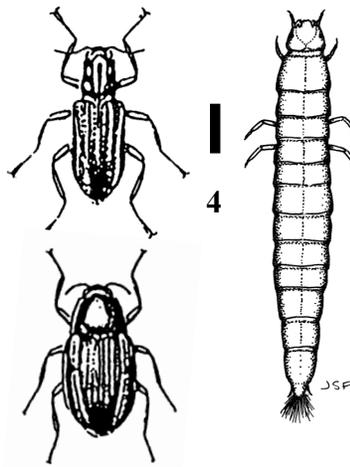
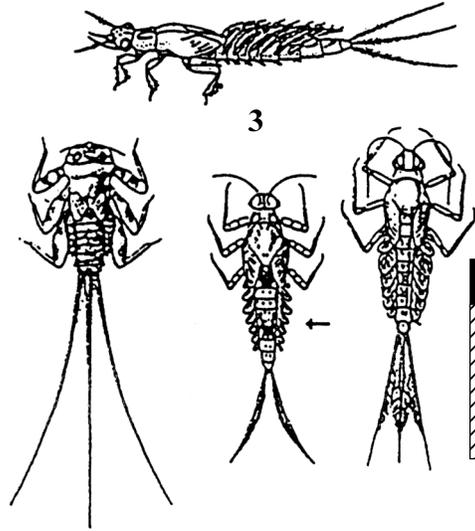
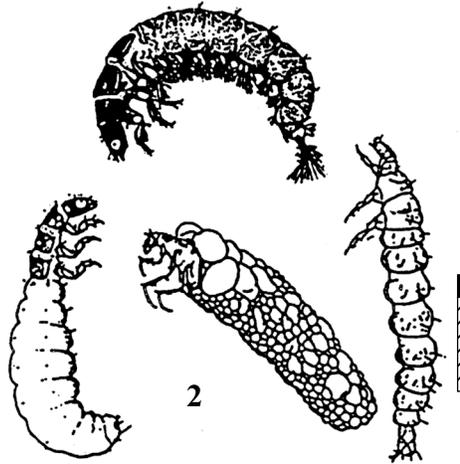
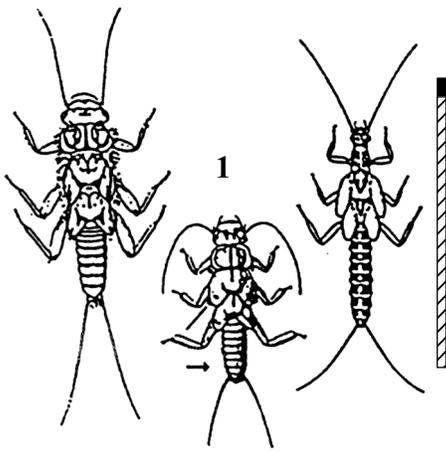
1. Have one person hold the net in a horizontal position about 6-12 inches under the water.
2. The 2nd volunteer will remove the snag from the water. When removing snags from the water, pull the snag out of the water quickly. If the snag is removed too slowly, the invertebrates may swim off.
3. Brush the snag down with a brush above the net to dislodge invertebrates.
4. Sample approximately 3 to 5 snags for one net set.

Sample non-flow areas in the same manner as a riffle, collecting three separate samples. However, the sampler will need to use a swirling motion with the foot to create a current to move debris into the net. Although this habitat can be sampled using a kick net, it is easier with a D-frame net.

Stream Insects & Crustaceans

GROUP ONE TAXA

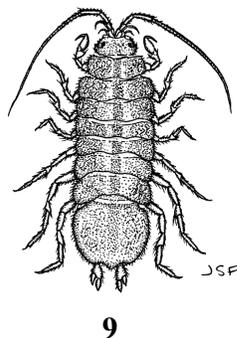
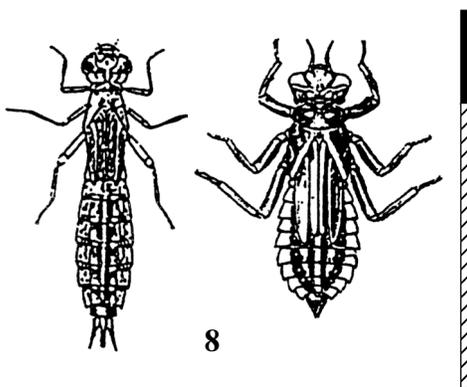
Pollution sensitive organisms found in good quality water.



- 1 Stonefly nymph: *Order Plecoptera*. 1/8" - 1 1/2"; 6 legs with hooked tips; 2 hairlike tails. Smooth (no gills) on abdomen (see arrow). May have gills on thorax under the legs.
- 2 Caddisfly larva: *Order Trichoptera*. Up to 1"; 6 legs on thorax; 2 hooks at end of abdomen. May be in a stick, rock, or leaf case with its head sticking out. May have fluffy gill tufts on lower half.
- 3 Mayfly nymph: *Order Ephemeroptera*. 1/4" - 1"; brown, moving, platelike, or feathery gills on abdomen (see arrow); 6 large hooked legs; antennae; 2 or 3 long, hairlike tails. Tails may be webbed together.
- 4 Riffle Beetle: *Order Coleoptera*. Adult: Tiny, 6-legged beetle; crawls slowly on the bottom. Larva: Entire length of body covered with hard plates; 6 legs on thorax; uniform brown color. Combine number of adults & larva when reporting total counts.
- 5 Water Penny larva: *Order Coleoptera*. 1/4"; flat saucer-shaped body, like a penny; segmented with 6 tiny legs underneath. Immature beetle.
- 6 Gilled Snail: *Class Gastropoda*. Shell opening covered by thin plate called operculum. When pointed up and opening facing you, the shell opens to right. Do not count empty shells.
- 7 Dobsonfly larva (hellgrammite): *Family Corydalidae*. 3/4" - 4"; dark-colored; 6 legs, large pinching jaws; eight pairs feelers on lower half of body with paired cottonlike gill tufts along underside of lateral filaments; short antennae; 2 tails and 2 pairs of hooks at back end.

GROUP TWO TAXA

Somewhat pollution tolerant organisms can be in good or fair quality water.

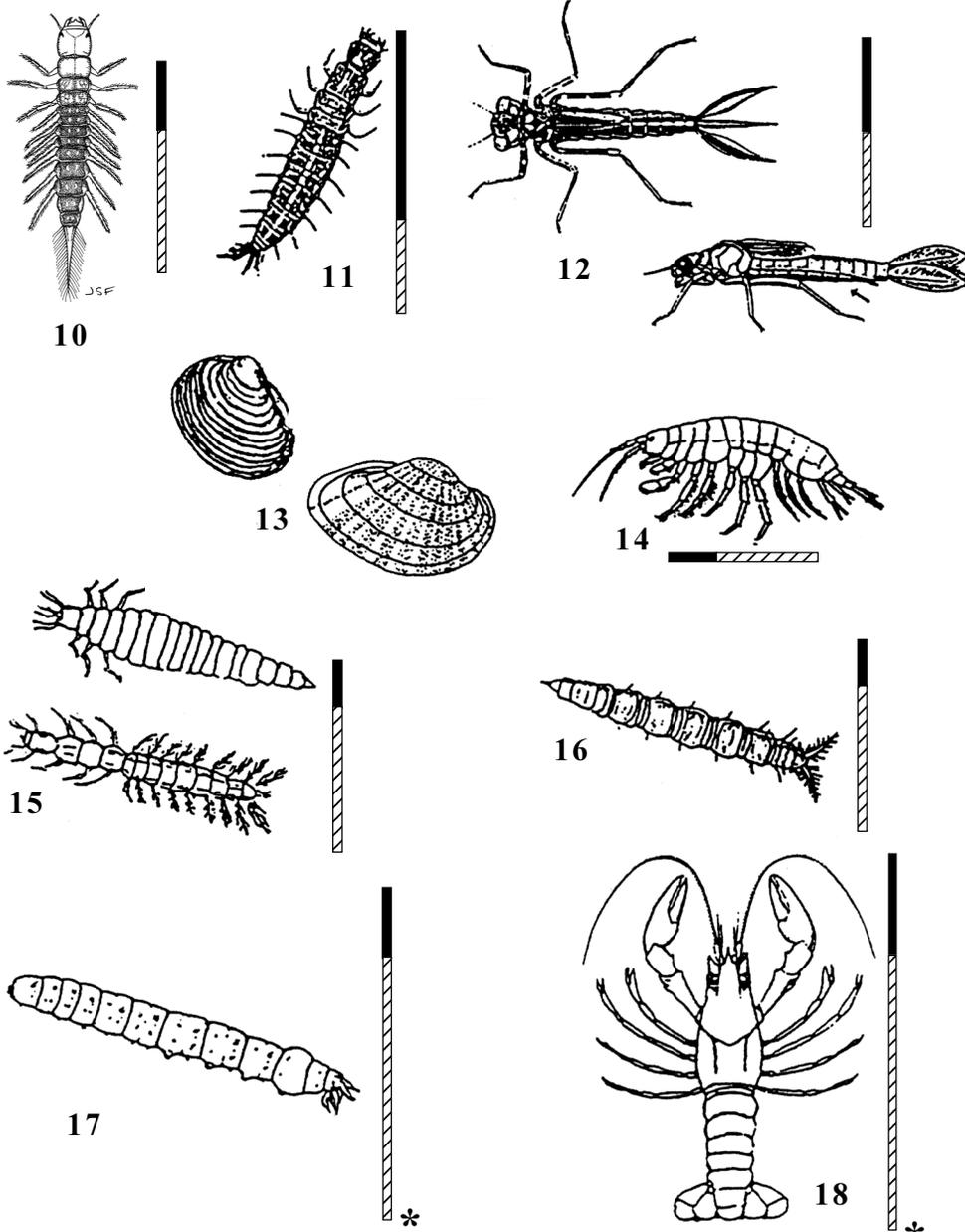


- 8 Dragonfly nymph: *Suborder Anisoptera*. 1/2" - 2"; large eyes, 6 hooked legs. Wide oval to round abdomen, masklike lower lip.
- 9 Sowbug: *Order Isopoda*. 1/4" - 3/4"; gray oblong body wider than it is high, more than 6 legs, long antennae, looks like a 'rolly poly.'

* May be larger.

~Solid bar indicates approx. minimum size. Combined solid and striped bar is approx. maximum size.~

Save Our Streams



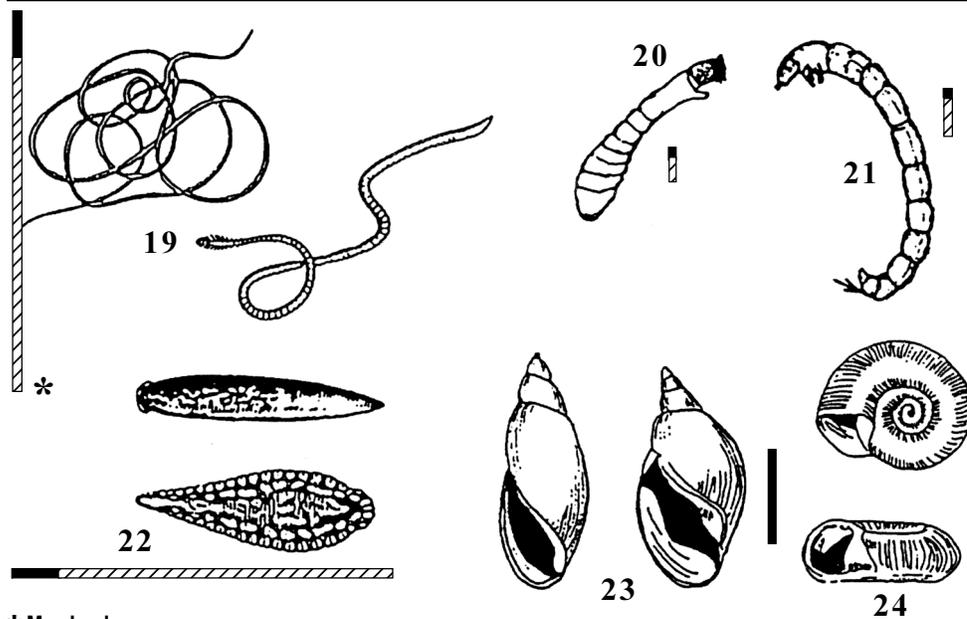
GROUP TWO TAXA continued

- 10 Alderfly larva: *Family Sialidae*. 3/8" - 1"; looks like small hellgrammite but has 1 long, thin, branched tail at end of abdomen (no hooks). No gill tuft underneath the lateral filaments on abdomen.
- 11 Fishfly larva: *Family Corydalidae*. Up to 1 1/2"; lateral filaments on abdomen. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.
- 12 Damselfly nymph: *Suborder Zygoptera*. 1/2" - 1"; large eyes; 6 thin hooked legs; 3 broad oar-shaped tails; body positioned like a tripod. Smooth (no gills) on sides of lower half of body (see arrow).
- 13 Clam/Mussel: *Class Bivalvia*. Do not count empty shells.
- 14 Scud: *Order Amphipoda*. 1/4" - 3/4"; white to gray, body higher than it is wide; swims sideways; more than 6 legs; resembles small shrimp.
- 15 Other Beetle larva: *Order Coleoptera*. 1/4" - 1"; light-colored; 6 legs on upper half of body; feelers; antennae; obvious mouthparts. Diverse group.
- 16 Watersnipe Fly larva: *Family Athericidae (Atherix)*. 1/4" - 1"; pale to green; tapered body; many caterpillarlike legs; conical head; two feathery 'horns' at back end.
- 17 Crane Fly larva: *Suborder Nematocera*. 1/3" - 4"; milky, green, or light brown; plump caterpillarlike segmented body. May have enlarged lobe or fleshy fingerlike extensions at the end of the abdomen.
- 18 Crayfish: *Order Decapoda*. Up to 6"; 2 large claws, 8 legs, resembles small lobster.

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

- 19 Aquatic Worm/Horsehair Worm: *Class Oligochaeta/ Phylum Nematomorpha*. Aquatic worm: 1/4" - 2"; can be very tiny, thin wormlike body. Horsehair Worm: 4"-27"; slender, can be tangled.
- 20 Black Fly larva: *Family Simuliidae*. 1/8" - 3/8"; one end of body wider. Black head, suction pad on end.
- 21 Midge Fly larva: *Suborder Nematocera*. Less than 1/4"; distinct head; wormlike segmented body; pair of tiny pro-legs under head and tip of abdomen.
- 22 Leech: *Order Hirudinea*. 1/4" - 2"; flattened muscular body, ends with suction pads.
- 23 Pouch Snail and Pond Snails: *Class Gastropoda*. No operculum. Breathe air. Shell usually opens on left. Do not count empty shells.
- 24 Other snails: *Class Gastropoda*. No operculum. Breathe air. Snail shell coils in one plane. Do not count empty shells.



* May be larger.

~Solid bar indicates approx. minimum size. Combined solid and stripped bar is approx. maximum size.~

