

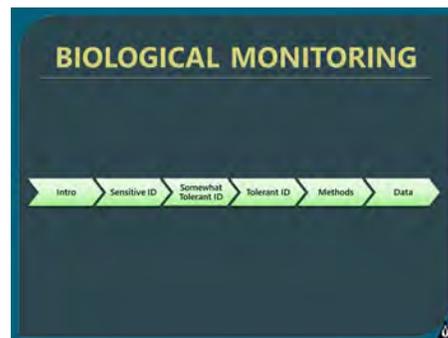
Chapter 5

Biological Monitoring



A good way to monitor the water quality of a stream is to closely examine the biological diversity of its habitat. This chapter will introduce you to benthic macroinvertebrates and the important role they play in helping us understand the water quality of Missouri's rivers and streams. Specifically, you will:

- Understand the importance of biological monitoring
- Identify pollution sensitive, somewhat tolerant, and tolerant macroinvertebrates
- Identify the methods and processes to monitor the biological diversity of your stream
- Analyze the data of benthic macroinvertebrates in your stream



BENTHIC MACROINVERTEBRATES

Benthic	Stream Bottom
Macro	Large
Invertebrate	Organism without backbone

Intro
Sensitive ID
Somewhat Tolerant ID
Tolerant ID
Methods
Data

VITAL IN STREAM ECOSYSTEMS



A MAYFLY PANIC ATTACK

Intro
Sensitive ID
Somewhat Tolerant ID
Tolerant ID
Methods
Data

ADVANTAGES

Non-mobile
Easy to collect
Different pollution tolerances
Continuous monitoring
Inexpensive equipment
Easy to identify
No chemicals needed



Intro
Sensitive ID
Somewhat Tolerant ID
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Methods
Data

Benthic Macroinvertebrates

What are benthic macroinvertebrates? By definition, macroinvertebrates are organisms without backbones which are visible to the human eye without the aid of a microscope. Aquatic macroinvertebrates are often regarded as benthic, which means they live on, under, and around rocks and sediment at the bottoms of lakes, rivers, and streams. Freshwater benthic communities may consist of fly and beetle larvae, mayflies, caddisflies, stoneflies, dragonflies, aquatic worms, snails, leeches, and numerous other organisms.

Since these macroinvertebrates are important to the food chain in our rivers and streams, they play a vital role in a stream’s ecosystem. Their presence in a stream, or lack there of, is a good indicator of water quality and health of these ecosystems. There are many advantages to using macroinvertebrates as an indicator of water quality:

- **Non-Mobile:** While fish will move if their habitats start to deteriorate, invertebrates are much more limited in their mobility.
- **Taxa with Different Pollution Tolerances:** Invertebrates have different levels of sensitivity to pollution. They can be assigned to three categories: pollution sensitive, somewhat tolerant, and tolerant. This allows us to determine the condition of a stream based on their presence or absence.
- **Continuous Monitoring:** Invertebrates are permanent residents of a stream. This makes them susceptible to pollutants present in the water and can reveal the impact pollutants have on the health of a stream over time.
- **Easy to Collect:** Invertebrates are easy to collect.
- **Inexpensive Equipment:** Chemical monitoring requires expensive and sometimes highly sophisticated equipment to analyze water samples. Biological monitoring only requires a kick net, forceps, and a small tray.
- **Easy to Identify:** Although it seems difficult at first, with a little practice, people become very adept at identifying these organisms.
- **No Chemicals Needed:** No chemicals are needed to conduct this type of monitoring.

Taxonomic Classification

Taxonomic classification is a hierarchical system for classifying organisms. The broadest classifications are by kingdom; the most specific classification is by genus and species.

Taxonomic Classification

Kingdom
Phylum
Class
Order
Family
Genus
Species

How to Remember the Taxonomy

King
Phillip
Came
Over
For
Great
Salmon

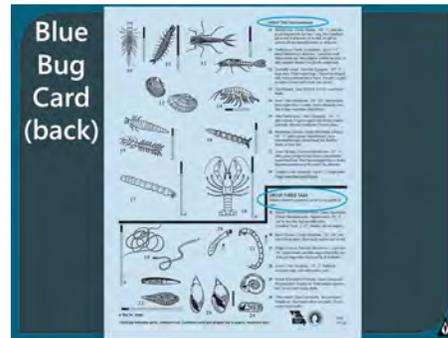
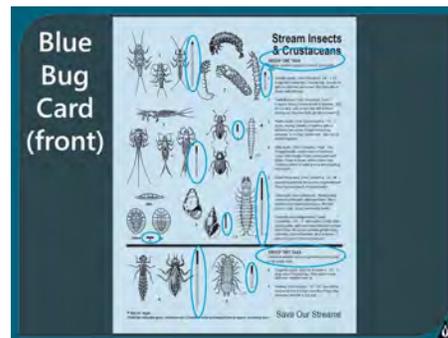
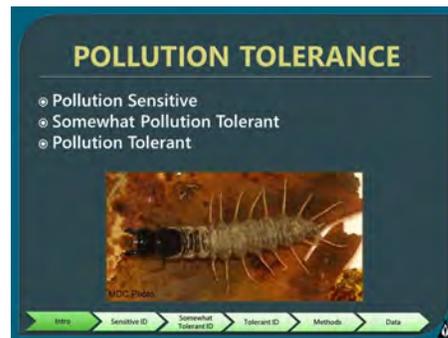
With the exception of a few taxa, volunteers will generally identify organisms to the level of Order when conducting their biological monitoring. This is the typical taxa level that can be identified easily in the field without magnification.

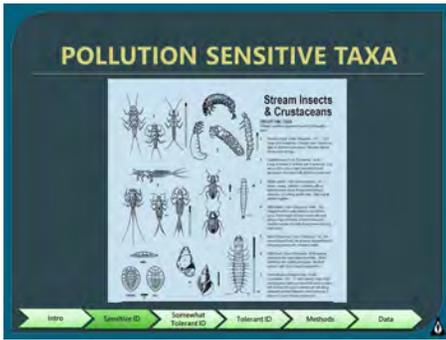
Pollution Tolerance

The invertebrates you will be looking for can be categorized into three main groups:

- **Pollution Sensitive:** These organisms are very sensitive to pollutants and will only be present in streams that have excellent water quality.
- **Somewhat Pollution Tolerant:** These invertebrates can survive in streams with moderate impairment.
- **Pollution Tolerant:** Organisms in this category are very tolerant of pollution and are the only organisms you will find in streams with severe impairment. Pollution tolerant organisms can be present in all streams, including those with excellent water quality.

A useful resource for aiding in macroinvertebrate identification is *Stream Insects & Crustaceans*, or Blue Bug Card, adapted from the Izaak Walton League. Taxa are placed in three groups: Group One is pollution sensitive, Group Two is somewhat pollution tolerant, and Group Three is pollution tolerant. The Blue Bug card is located at the end of this chapter.

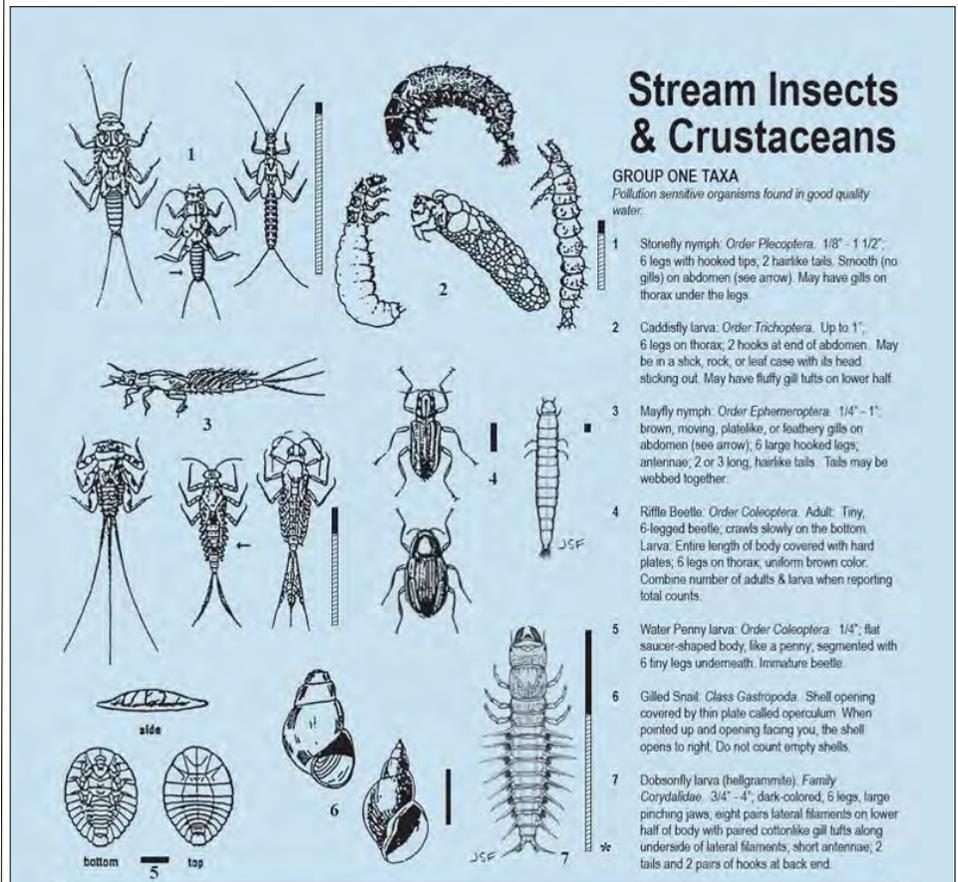




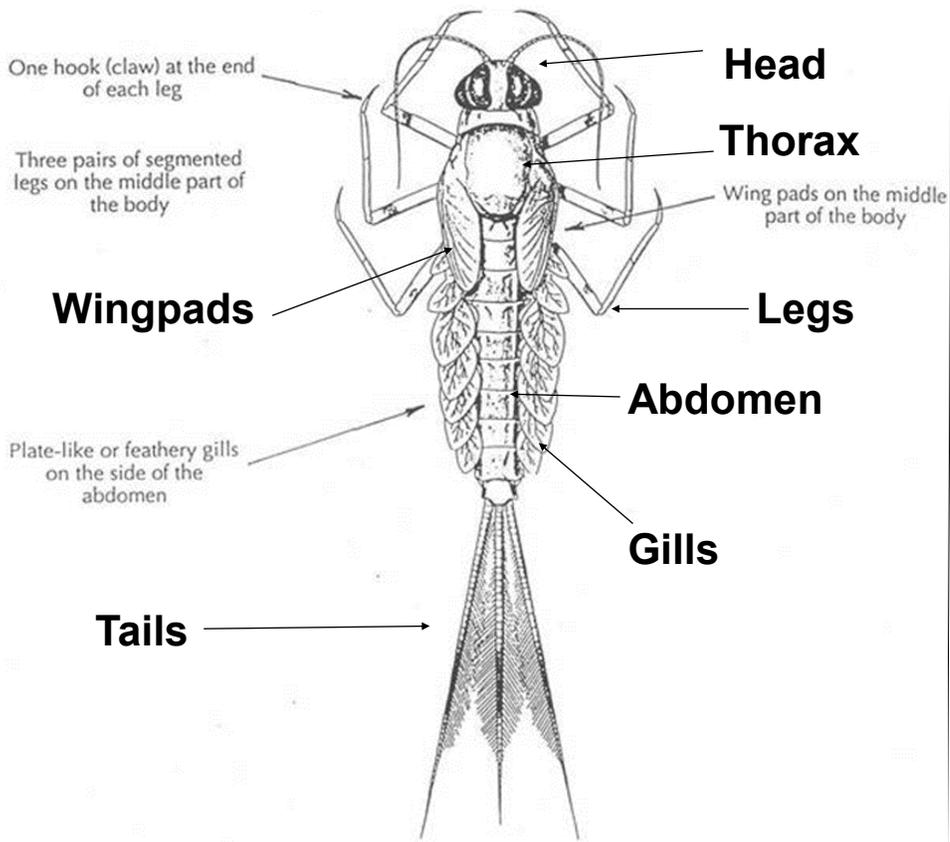
Pollution Sensitive Taxa

Pollution sensitive invertebrates are organisms that are very sensitive to pollutants and will only be present in streams with excellent water quality. Invertebrates that belong to this group include:

- Mayfly Nymph
- Stonefly Nymph
- Caddisfly Larva
- Riffle Beetle Larva and Adult
- Water Penny Larva
- Gilled Snail
- Dobsonfly Larva (Hellgrammite)

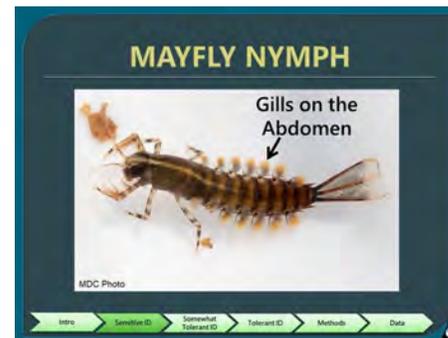
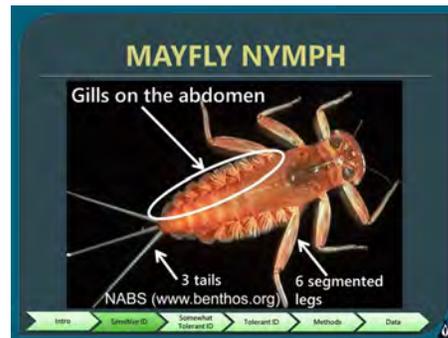
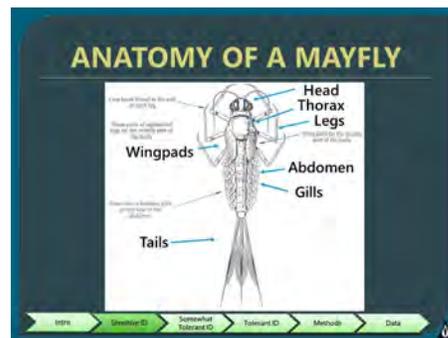


Pollution Sensitive: Mayfly Nymph

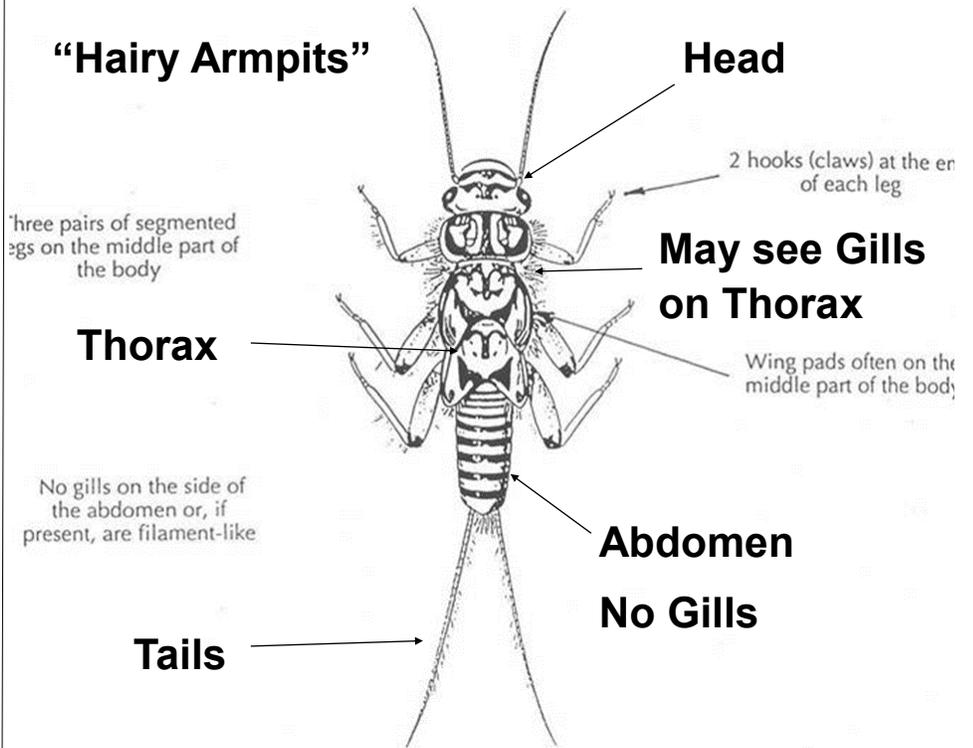
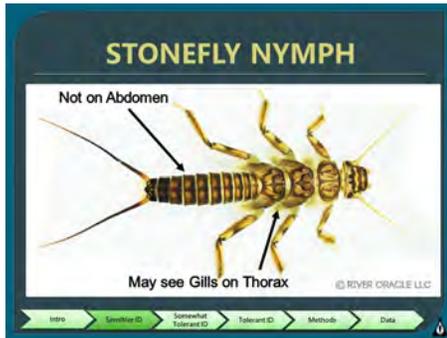
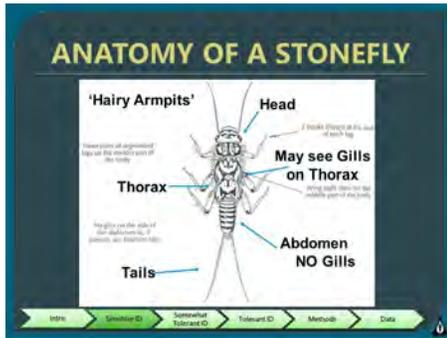


Distinguishing Features:

- Plate-like, elongate, or feather-shaped gills located on the sides of the abdomen.
- One hook (claw) at the end of each leg.
- Most mayflies have three filament-like tails; some may have only two.



Pollution Sensitive: Stonefly Nymph

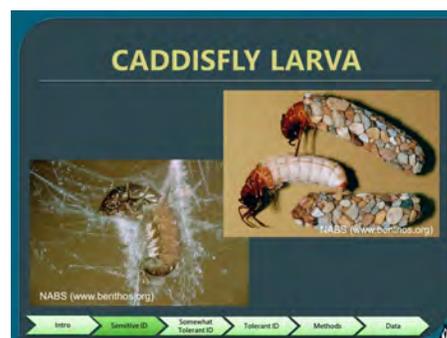
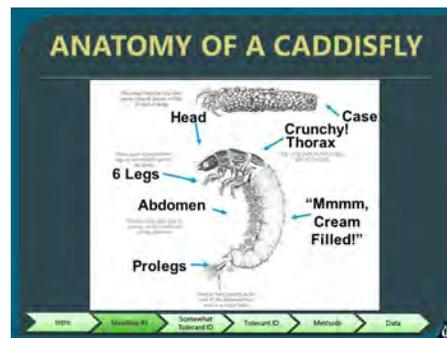
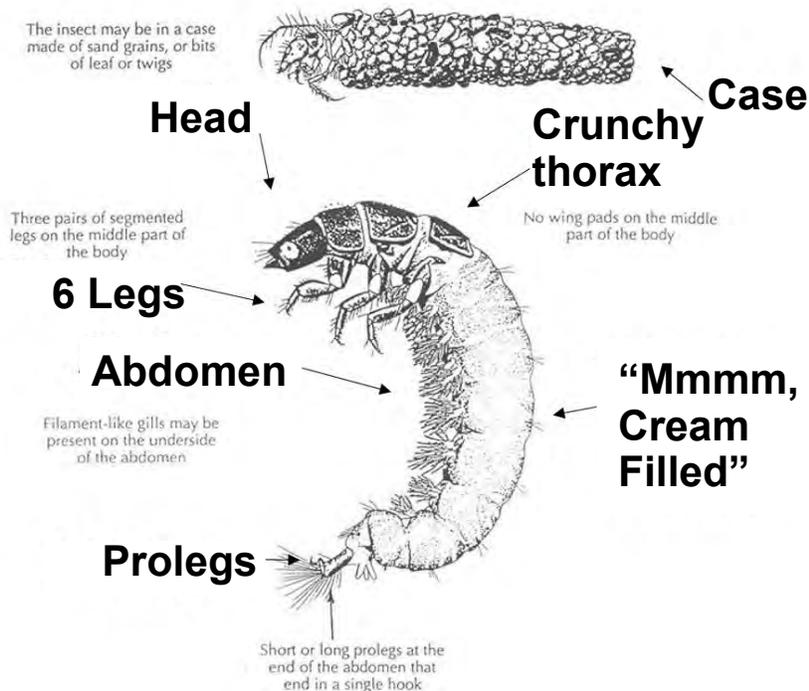


Distinguishing Features:

- Usually no gills on the abdomen.
- “Hairy armpits.” Stonefly gills may look like hairs and are located under the legs on the thorax.
- Two hooks (claws) at the end of each leg.
- Stonefly nymphs have 2 tails.

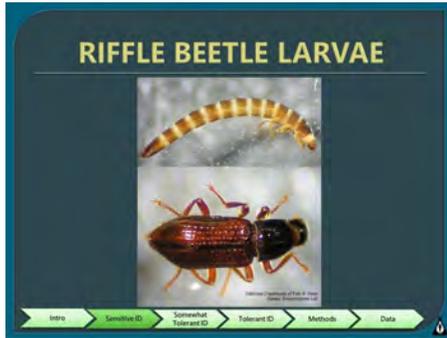


Pollution Sensitive: Caddisfly Larva



Distinguishing Features:

- No tails; instead they have hook-like features called prolegs.
- No wing pads.
- Crunchy thorax; soft abdomen.
- May build their own case made of sand grains or bits of leaves or twigs.
- Filament-like gills may be present on the underside of the abdomen.



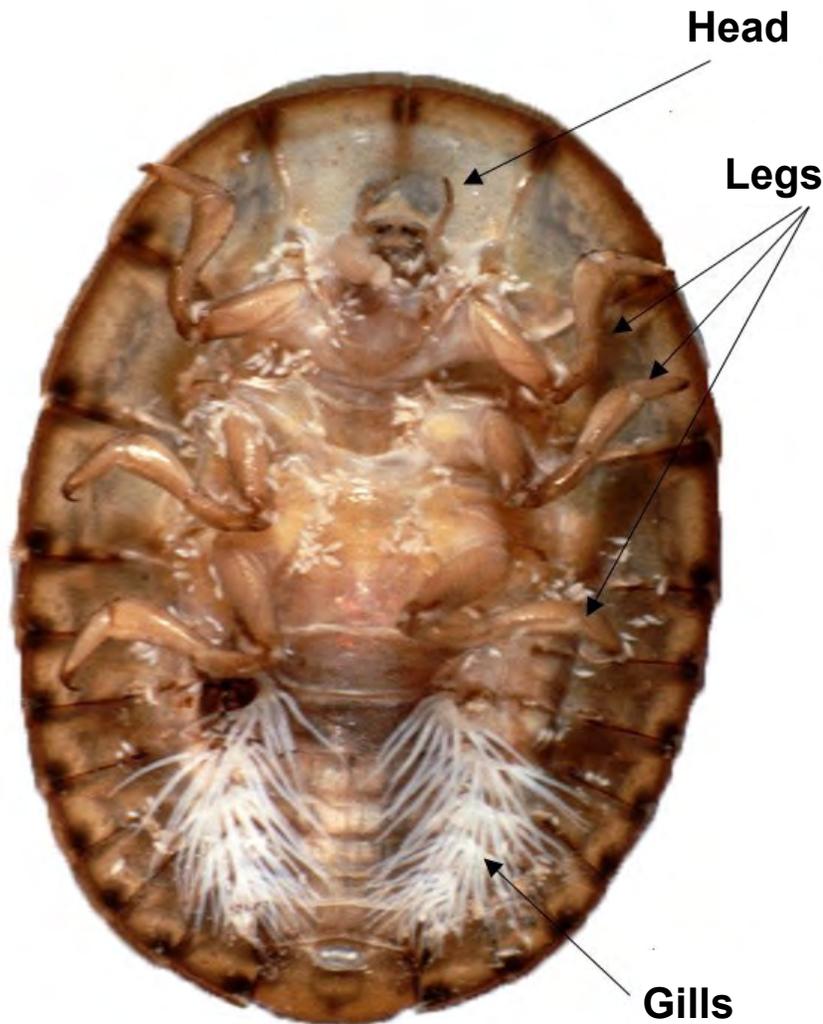
Pollution Sensitive: Riffle Beetle



Distinguishing Features:

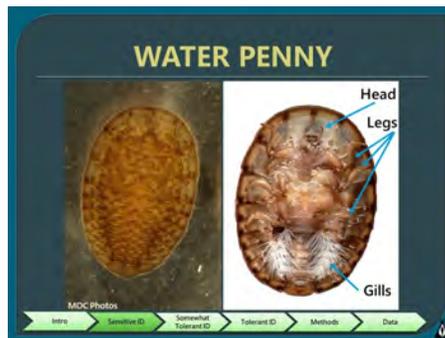
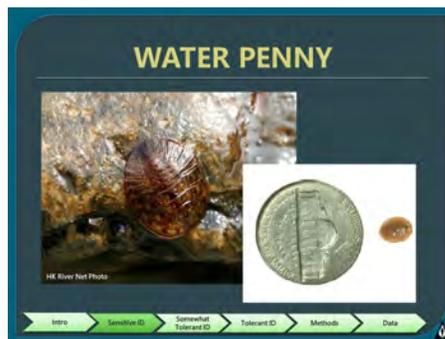
- Riffle beetles spend both their larval and adult life cycle in water. It is not uncommon to collect adults and larvae in net sets. Count the total of larvae and adults when recording these on the data sheet.
- Riffle beetle larvae are tiny and elongate. The head and 3 pairs of legs are visible; filamentous gills may emerge from the tip of the abdomen. The entire body is covered in hard plates.
- Adult riffle beetles are very small, dark, and hard-bodied. They have relatively long legs and tarsal claws. Adults will crawl slowly on the bottom of your ice cube

Pollution Sensitive: Water Penny



Distinguishing Features:

- Described as looking like a fish scale.
- Body is covered with a hard, oval carapace
- The head, legs, and gills are clearly visible on the underside of a water penny.
- Water pennies are immature aquatic larvae; the adults are terrestrial beetles.





Pollution Sensitive: Gilled Snail



Opening on right side



Distinguishing Features:

- When the snail is held point up, the opening is on the right side.
- The opening is often covered by a hard, plate-like operculum.
- Do not count empty shells on the data sheet



Dichotomous Key

Many resources are available to aid in identifying macroinvertebrates. The Key to Macroinvertebrate Life in the River is a simple dichotomous key with photos. A dichotomous key is a tool that biologists use to help identify organisms by asking questions about distinguishing characteristics. Use the Key to identify the invertebrate



**LET'S KEY OUT THE NEXT
MACROINVERTEBRATE**

Shell?

Legs?

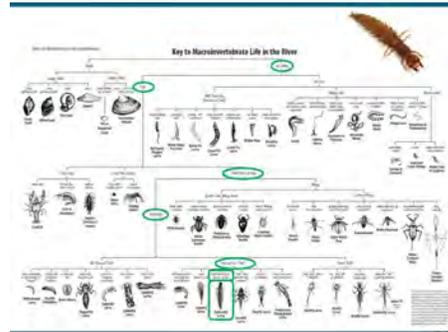
How many legs?

Wings?

Tails?

DNR Photo

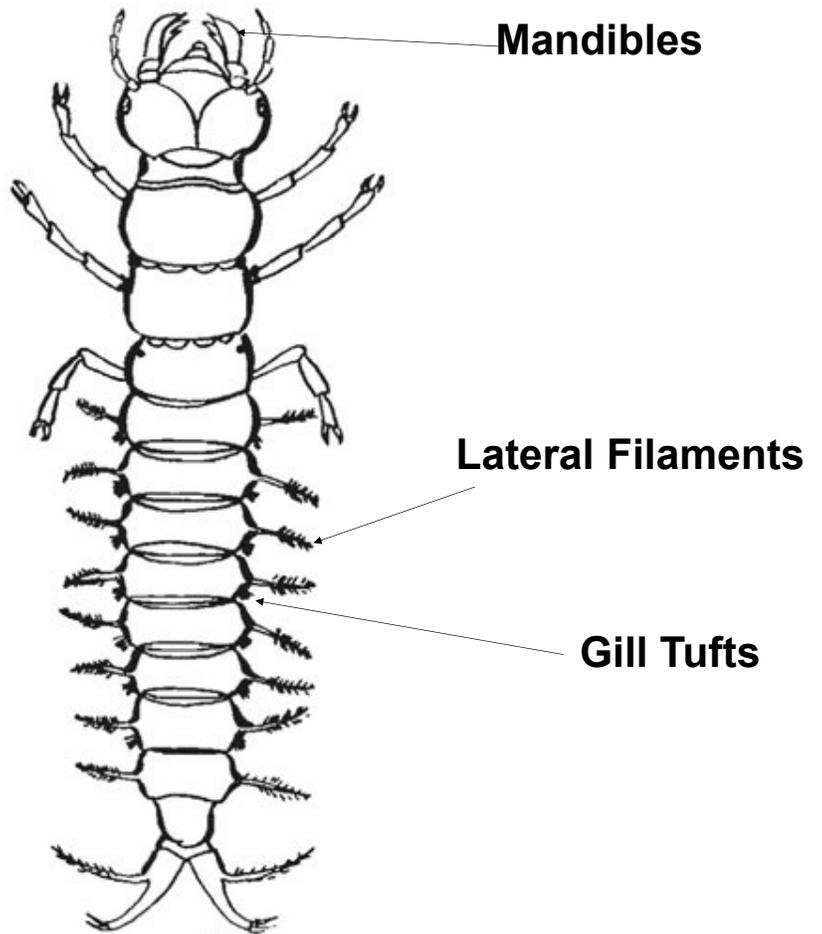
Intro
Shellfish ID
Somewhat Tolerant ID
Tolerant ID
Methods
Data



1. Is there a shell?
2. Does this organism have legs?
3. How many pairs of legs does this organism have?
4. Are wings present?
5. Does this organism have an obvious tail?
6. Use description and photo to identify this organism.



Pollution Sensitive: Dobsonfly larva (Hellgrammite)



Distinguishing Features:

- Hellgrammites, the larval stage of the dobsonfly, are one of the largest invertebrates.
- Large mandibles or pinchers used for feeding and mating.
- Lateral filaments (slender appendages) along sides of abdomen.
- Gill tufts located under the lateral filaments on abdomen.
- 3 pairs of segmented legs



Somewhat Pollution Tolerant Taxa

Somewhat pollution tolerant invertebrates can survive in streams with moderate pollution impairment. Invertebrates that belong to this group include:

- Crayfish
- Sowbug
- Scud
- Alderfly Larva
- Fishfly Larva
- Damselfly Nymph
- Dragonfly Nymph
- Watersnipe Fly Larva
- Crane Fly Larva
- Other Beetle Larva
- Freshwater Clam or Mussel



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 'roly poly'.

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 Corydellidae. 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.

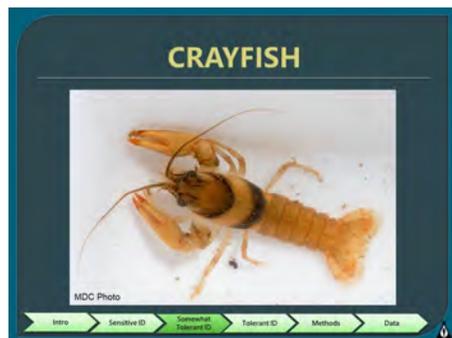
16 Watersnipe Fly larva: Family Athenoidae (Athenic). 1/4" - 1"; pale to green; tapered body; many caterpillarlike legs; conical head; two feathery 'horns' at back end.

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";



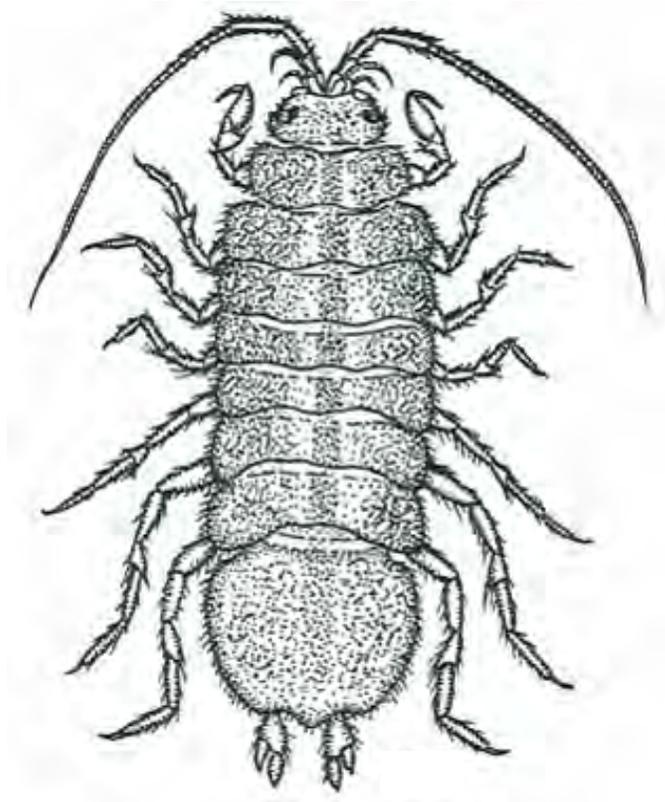
Somewhat Pollution Tolerant: Crayfish



Distinguishing Features:

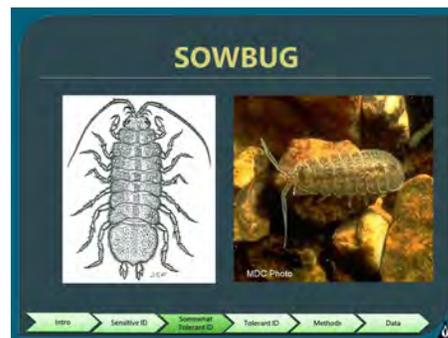
- One of the most recognizable macroinvertebrates.
- There are 36 species of crayfish in Missouri.
- If you find crayfish in your net, immediately record the number on your data sheet and return them to the water as this predator will consume other organisms on the net or in the sorting tray.
- Crayfish are a keystone species in aquatic ecosystems; they eat everything and are in turn eaten by a great diversity of larger aquatic and terrestrial animals.

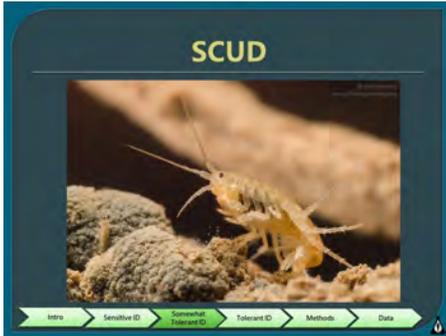
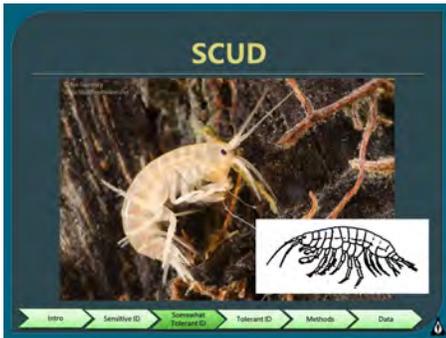
Somewhat Pollution Tolerant: Sowbug



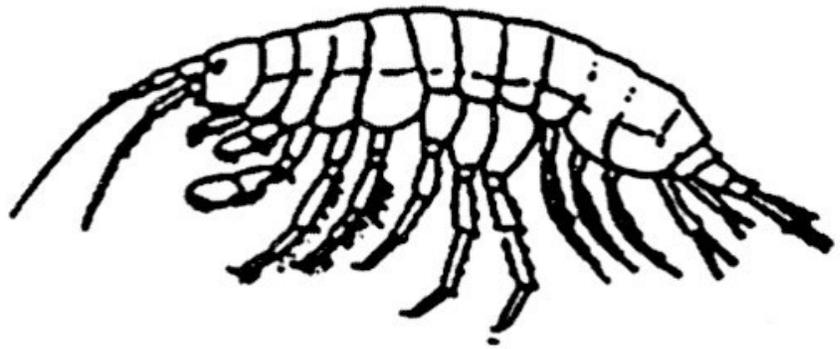
Distinguishing Features:

- A crustacean, similar to the crayfish.
- Resembles its terrestrial cousin, the roly-poly or pill bug.
- Flattened dorsoventrally from top to bottom.
- Seven pairs of legs





Somewhat Pollution Tolerant: Scud

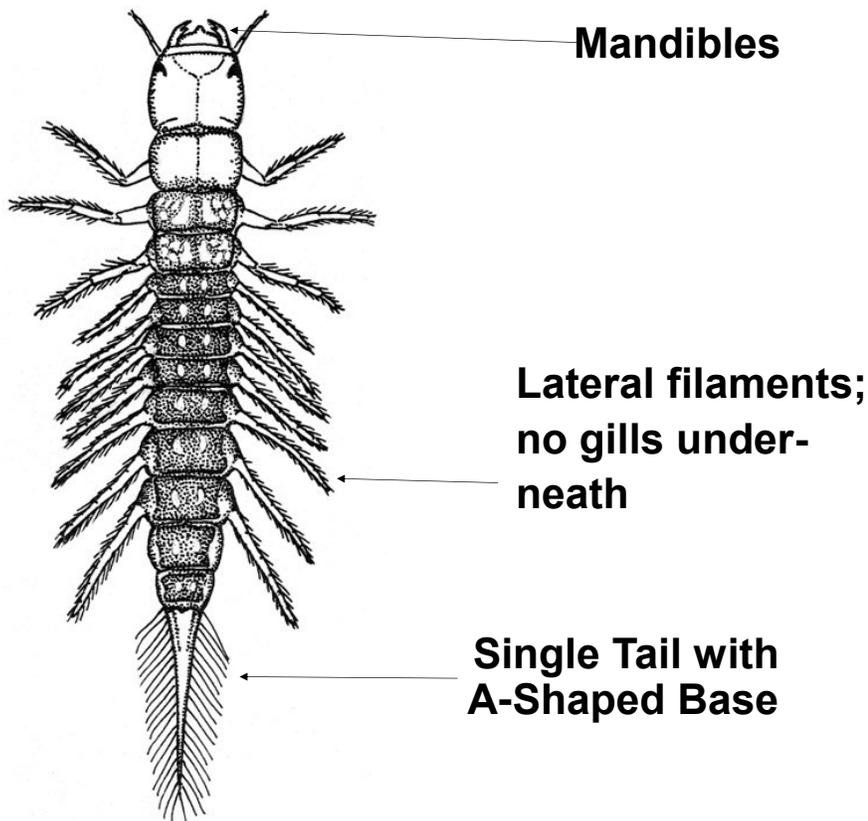


Distinguishing Features:

- Many appendages on their abdomen.
- Seven pairs of legs.
- Several pairs of pinchers.
- Segmented body.
- Flattened laterally from side to side.
- Also referred to as side swimmers.

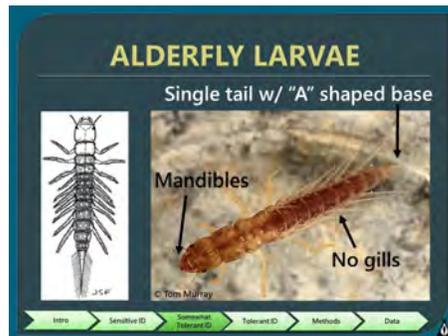


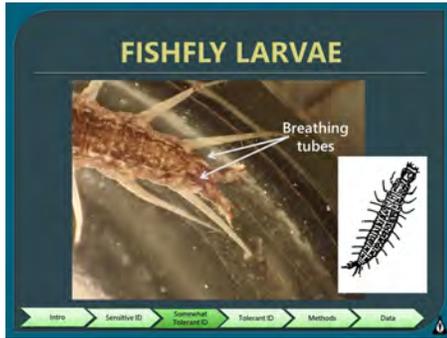
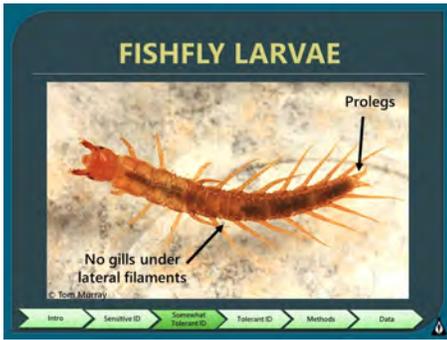
Somewhat Pollution Tolerant: Alderfly Larvae



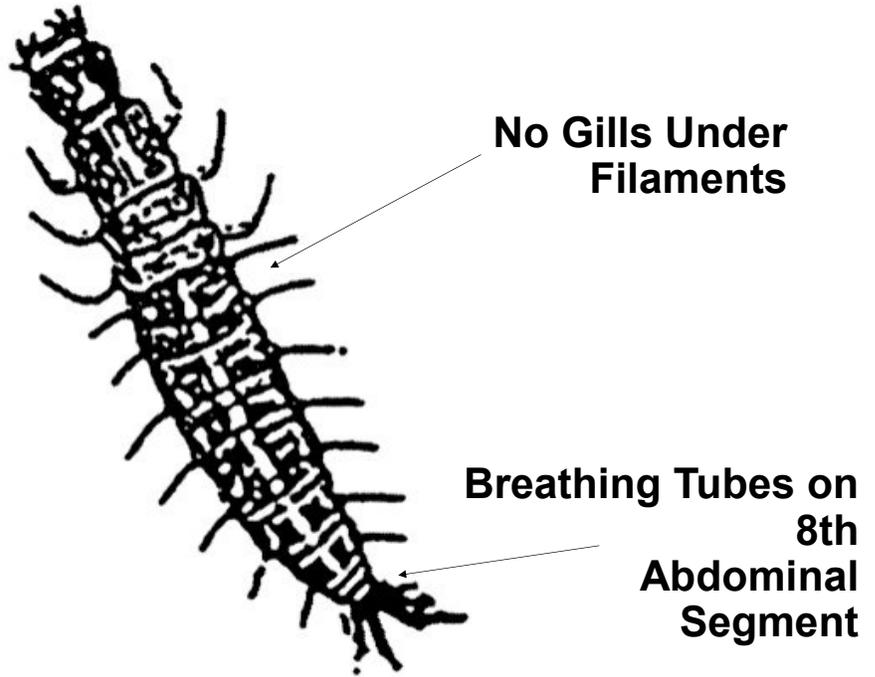
Distinguishing Features:

- Although similar to the hellgrammite, an alderfly is much smaller.
- Mandibles or pinching mouthparts.
- No gills under lateral filaments.
- Abdomen ends in a single filament that looks like a tail in the shape of a capital letter "A."





Somewhat Pollution Tolerant: Fishfly Larvae

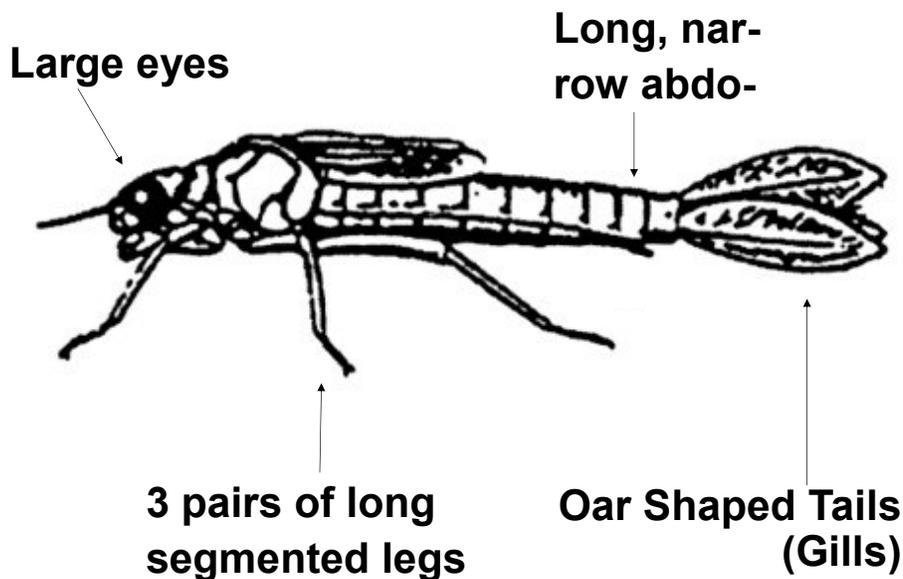


Distinguishing Features:

- Presence of breathing tubes near the end of the abdomen which are used in lower oxygen conditions to get atmospheric oxygen .
- No gills under lateral filaments.
- Fishfly larvae are relatively smaller in size than the hellgrammite.
- Fishfly larvae look similar to the hellgrammite, except gills are not present under the lateral filaments and they are smaller in size than the hellgrammite.

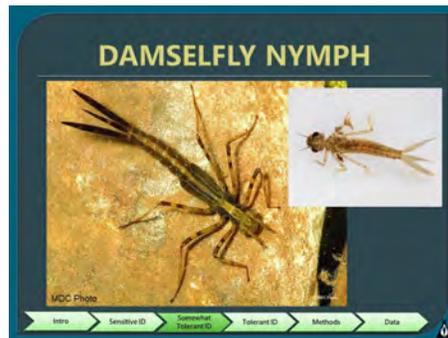
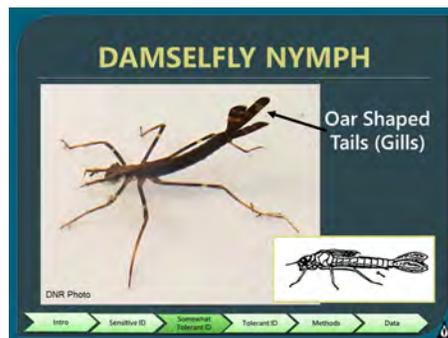


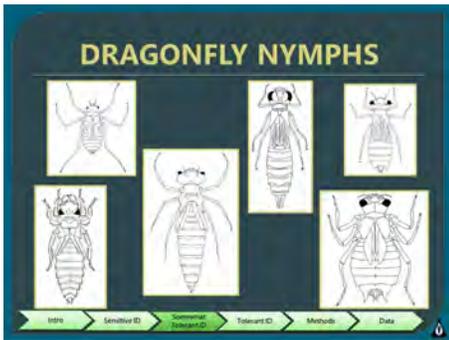
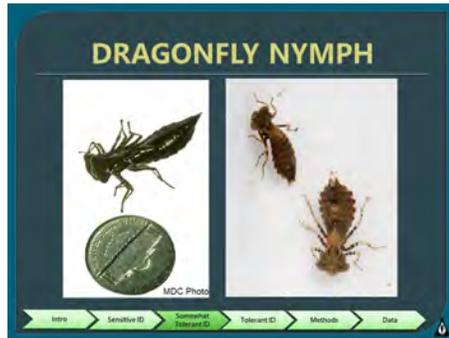
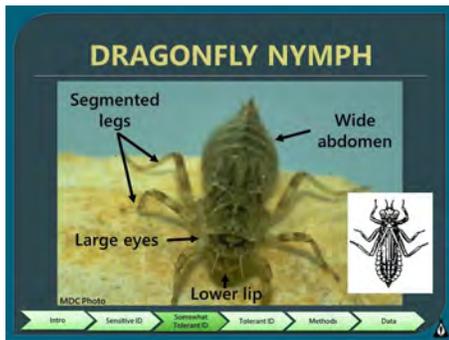
Somewhat Pollution Tolerant: Damselfly nymph



Distinguishing Features:

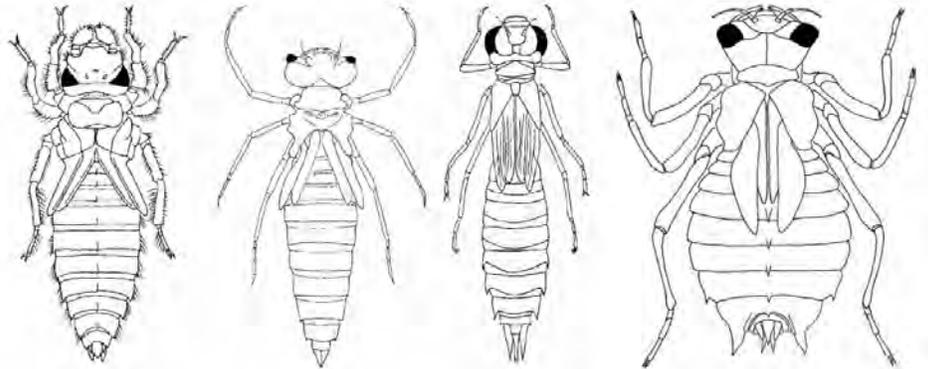
- Three broad oar or paddle-shaped gills at end of long, narrow abdomen which look like tails.
- Body shape is elongate and 6 legs are long and spindly.
- Extendible lower lip, or labium, for grasping prey.
- Large eyes





Somewhat Pollution Tolerant: Dragonfly nymph

6 long legs Large eyes



Wide abdomen that is oval, round, and or flat

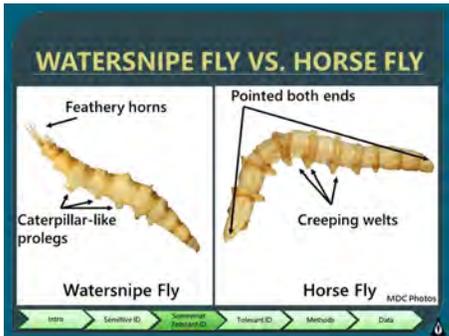
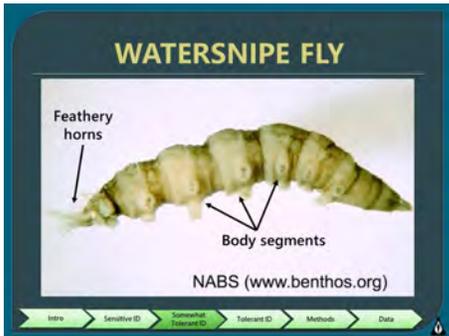


Distinguishing Features:

- Dragonfly nymphs can have a wide range of body shapes based on species.
- Long, segmented legs.
- Long, folded lower labium or lip used for capturing prey.
- Large eyes located on the front of their head.
- Abdomen is wide and has an oval or round shape.
- Abdomen may have a flat, leaf-like appearance.



Somewhat Pollution Tolerant: Watersnipe Fly Larvae

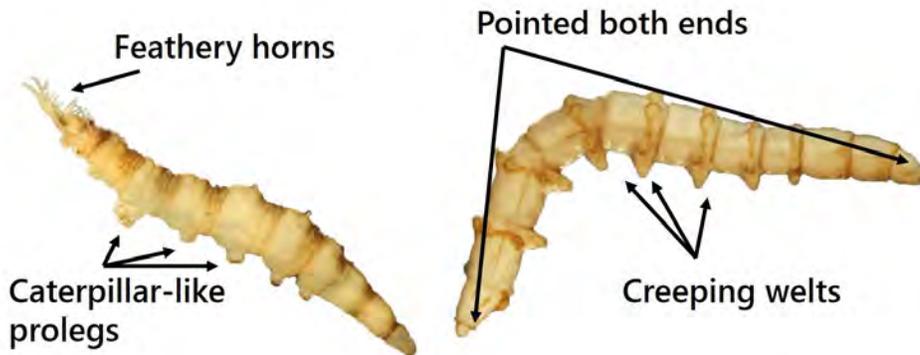


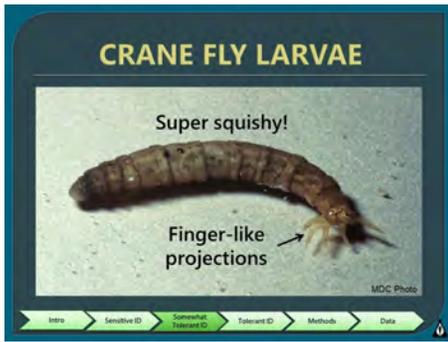
Distinguishing Features:

- Watersnipe fly larvae can be identified by caterpillar-like prolegs on each body segment and two feathery horns at the end of the abdomen.
- Medium size, about half an inch.
- Worm-like appearance with distinct body segments.
- Can be difficult to distinguish from other organisms such as horse flies and crane flies from the order Diptera.

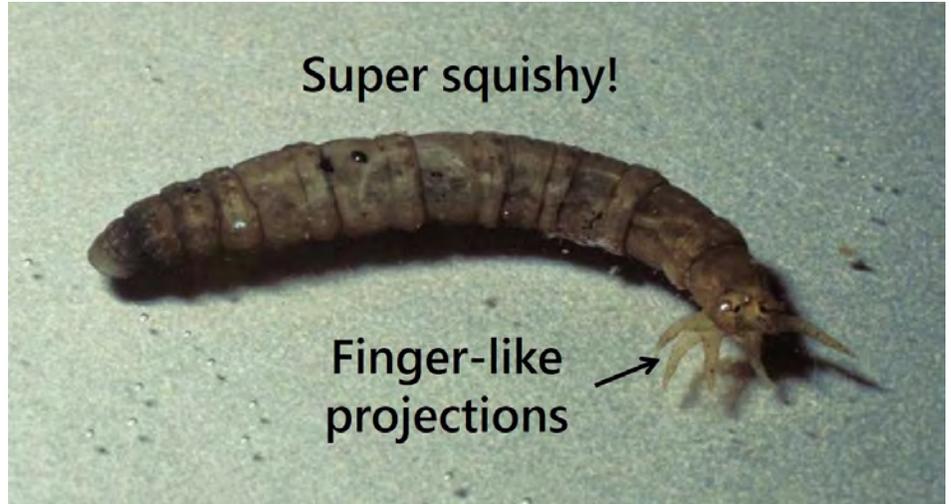
Watersnipe Fly

Horse Fly





Somewhat Pollution Tolerant: Crane Fly Larvae



Distinguishing Features:

- Very squishy segmented body.
- Often appear transparent.
- Common species found are quite large, up to several inches.
- Abdomen ends in several finger-like lobes. A smaller species of crane fly has an abdomen that ends in an enlarged lobe resembling a turnip shape.



Somewhat Pollution Tolerant: Other Beetle Larvae



OTHER BEETLE LARVAE

Many different types!
Process of elimination



NABS (www.benthos.org)

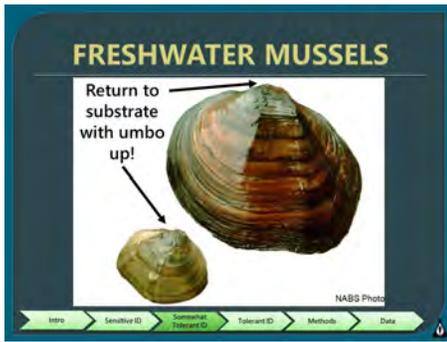
Intro
Sensitive ID
Somewhat Tolerant ID
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Data

Besides riffle beetles and water pennies, volunteers may find the larvae of other aquatic beetles. If a volunteer finds something they cannot easily identify, use the Blue Bug Card or a dichotomous key. It may be identified as an other beetle larva in a process of elimination. Beetles are a diverse group and have features similar to other taxa counted on the data sheet. When reporting these, simply lump them together under the **“Other Beetle”** category on your data sheet.

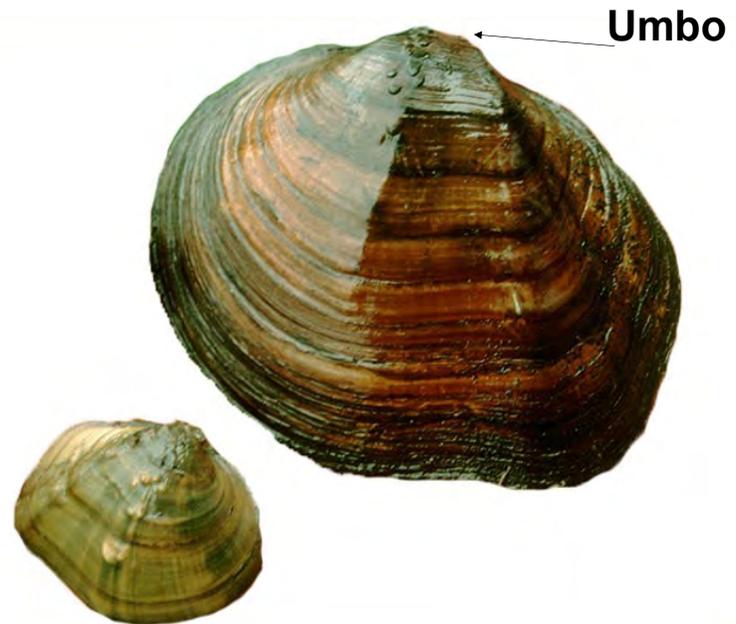
A few characteristics include:

- 6 segmented legs
- Visible mouth parts





Somewhat Pollution Tolerant: Freshwater Mussels and Clams



Nationwide, it is estimated that over 70% of native mussels are either threatened or endangered. Likewise, Missouri is facing similar declines in its native mussel populations. Native mussels and clams in Missouri include the maple leaf mussel and fingernail clam, so named because of its small, fingernail-like shape. The Asiatic clam is a foreign species to Missouri, although it has become very abundant in some watersheds. The Asiatic clam can typically be distinguished from native mussels by their symmetrical shape, centered umbo, and strong shell with many ridges. The zebra mussel is another non-native species in Missouri. They have distinctive stripes and unlike our other mussels, they attach themselves to any solid object, often forming extensive colonies that become a nuisance and negatively impact aquatic ecosystems.

Asiatic Clam

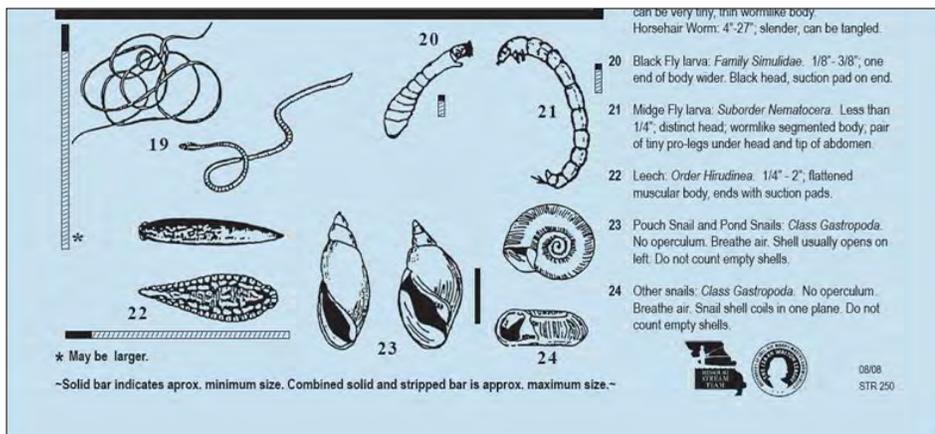


Volunteers are strongly encouraged to return all native clams and mussels to the stream as quickly as possible. Mussels must be placed upright in the substrate with the umbo pointed up. ***If you find an empty shell, do not count it on your Macroinvertebrate Data Sheet.***

Pollution Tolerant Taxa

The following set of macroinvertebrates are pollution tolerant organisms. These organisms can be found in all river systems, both healthy and impaired. The abundance of tolerant invertebrates compared to the abundance of sensitive invertebrates is an important observation when determining the health of a stream:

- Aquatic Worm
- Midge Fly Larva
- Black Fly Larva
- Leech
- Pouch Snail
- Other Snail





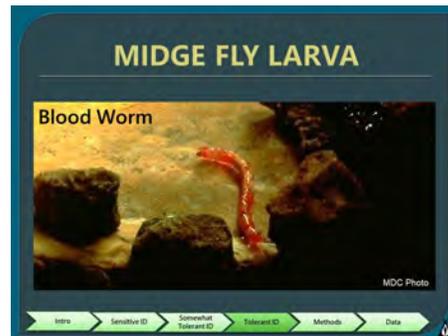
Pollution Tolerant: Aquatic Worm



Distinguishing Features:

- Segmented or unsegmented (horsehair worm).
- Long and thin.
- Often curl back around on themselves.
- Aquatic worms are longer than midge fly larvae.
- Count worms while picking from the net as they will become entangled and difficult to count from the tray.

Pollution Tolerant: Midge Fly Larvae



Distinguishing Features:

- Very small larvae, usually less than 1/4 inch in length.
- Head is visible when viewed with magnification.
- Presence of two small prolegs located by the head and at the end of the abdomen. Prolegs are not segmented.
- Slightly curved, segmented body.



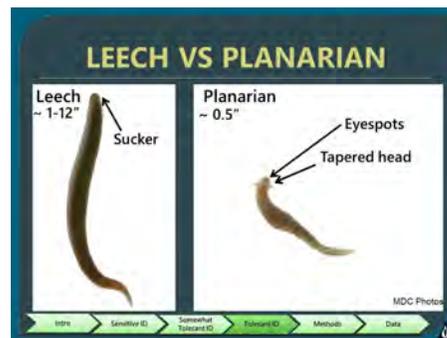
Pollution Tolerant: Black Fly Larvae



Distinguishing Features:

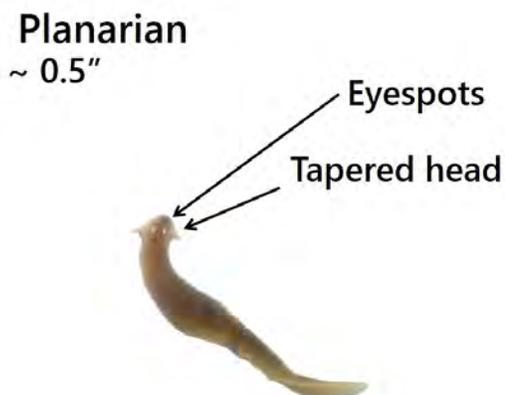
- Very small in size.
- Will readily attach to side of sorting tray or other objects in water.
- Wider on one end than the other(resembles a bowling pin), due to a ring on the posterior end of the animal used to attach itself to debris or rocks.
- Filter feeder with two fan-like structures on the head used to collect food out of the water.

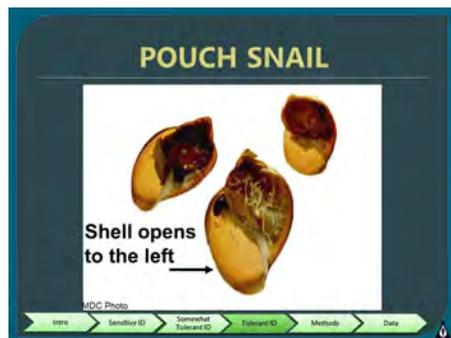
Pollution Tolerant: Leech



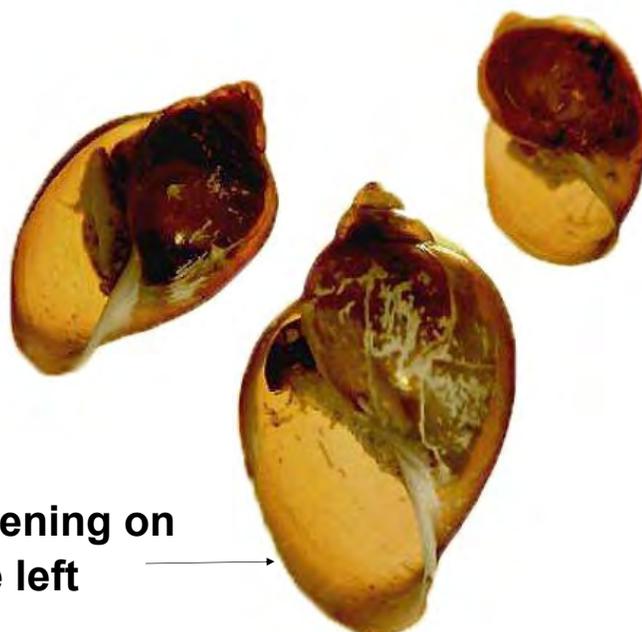
Distinguishing Features:

- Suction cup-shaped mouth. Another suction pad is located on the abdomen. These suction pads are used as the leech moves by muscular contraction and expansion.
- Long, flattened, muscular body 1-12 inches in length.
- Often brown, black, or mottled in color.
- Can be misidentified as a planarian. Planarians will have a tapered head, two eyespots, and have a gliding locomotion. The average length of a planarian is 0.5 inches while leeches can grow to several inches.





Pollution Tolerant: Pouch Snail



Distinguishing Features:

- Pouch snails are sometimes referred to as left-handed snails since the shell opens to the left when the point of the snail is held upwards.
- Also called lunged snails because they have a rudimentary lung to breathe air.
- No operculum.
- Do not count empty shells on data sheet.

Pollution Tolerant: Other Snails



Distinguishing Features:

- Snails that are **not** conical-shaped with an opening to the left or right.
- Shell will be coiled or look like a ram's horn.
- Do not count empty shells.

Invertebrate Species Preservation

Monitors may preserve specimens for aid in identification or as a reference collection. The preferred method of preservation is using ethyl alcohol (ethanol). Denatured alcohol with a high ethyl alcohol content may be used. See the Safety Data Sheet to determine alcohol content. If ethyl alcohol is not available, isopropyl alcohol (rubbing alcohol) may be used but is harsher on specimens.

1. Euthanize specimen in jar of 100% ethyl alcohol.
2. Place specimen in vial with 80% ethyl alcohol and 20% water.
3. Specimen may be placed in vial of hand sanitizer for easy viewing. This is best for small specimens. Instructions below:
 1. Euthanize specimen in alcohol.
 2. Fill vial part way with hand sanitizer; insert specimen
 3. Fill completely to top to avoid any air space between gel and cap; screw cap tightly. Use only for small specimens.
 4. Gel will break down and must be replenished occasionally.



OTHER SNAIL

Flat, not conical

ETHYL ALCOHOL (DENATURED ALCOHOL)

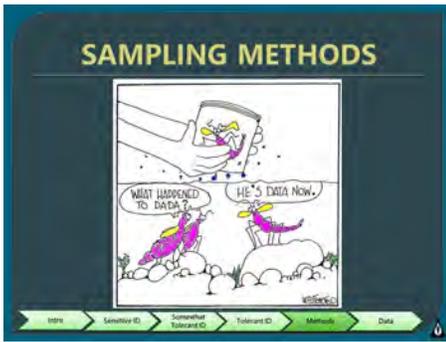
- Dilute to 80% alcohol solution.
- Best method for long-term storage.
- More expensive than isopropyl and may be more difficult to find at retailers.
- Located with painting supplies and may contain high percentage of methanol so check label or SDS for a product that is mostly ethyl alcohol.

ISOPROPYL ALCOHOL

- Dilute to 40% alcohol solution; buffer with a drop or two of glycerin or a pinch of calcium carbonate antacid tablets.
- Inexpensive and can be found easily at most general retailers.
- Often harsh on invertebrates and can make them brittle over time.
- Remember isopropyl alcohol comes in 70% or 90% concentrations.

HAND SANITIZER

- Fill vial part way with sanitizer, insert specimen, then fill completely to top to avoid any air space between gel and cap; screw cap tightly.
- Suspends invertebrates for easier viewing.
- NOT recommended for soft-bodied or large invertebrates because hand sanitizers are only 60% alcohol.
- Gel will break down into liquid over time; must be replenished occasionally.
- Organism must be euthanized before being placed in the hand sanitizer.

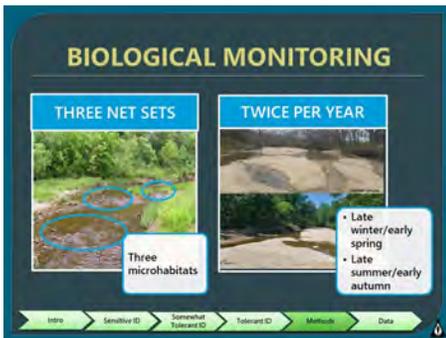


Sampling Methods: Equipment Needed

To collect, sort, and analyze the invertebrates in your stream, you will need the following equipment:

- 3' X 3' Net*
- Forceps*
- Magnifying Lens*
- Sorting Pan or Tray
- Squirt Bottle
- Macroinvertebrate Data Sheet*

** Indicates equipment provided by the Stream Team Program.*



Biological Monitoring

Macroinvertebrates should be sampled twice a year, once in the spring before the leaves appear and once in the fall before leaves drop. Sampling more often may destroy stream habitats.

When conducting your biological sampling, you will collect three net sets for replication within your 300-foot site. It is preferable that each net set is collected from three different microhabitats. For example, if you are sampling from riffles, choose three different microhabitats: the bottom of a riffle, a riffle area with vegetation, and a riffle area with leaf packs.



Habitat Types

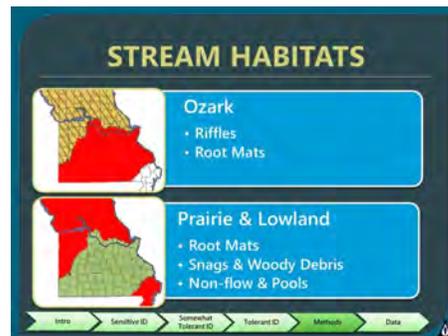
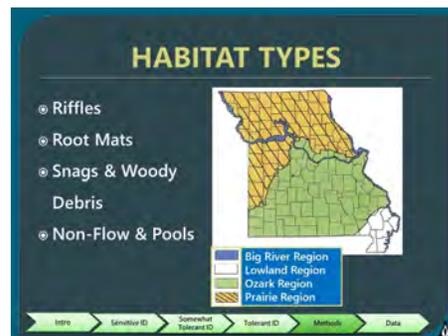
Missouri can be divided into four principle aquatic faunal regions: Big River, Lowland, Ozark, and Prairie. Each region is characterized by different habitats and fauna. Streams in the Ozark Region have many riffles, but they are less common in the Prairie Region due to the gradient of the land.

When sampling for macroinvertebrates, you will find different habitat types in different regions. You will commonly find riffles and root mats in the Ozark region. In the Prairie and lowland regions, you will characteristically have root mats, snags, and pools, but very few, if any, riffles.

Stream Team protocol prefers you to sample the habitats in the following order. If you do not have a riffle, then look for a root mat next. If you fail to find one, then you can sample a snag or woody debris. Sample a non-flow or pool only as a last resort.

Priority Order for Sample Habitats

1. Riffles
2. Root Mats
3. Snags and Woody Debris
4. Non-Flow and Pools



STREAM HABITATS

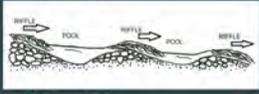


- Ozark**
 - Riffles
 - Root Mats
- Prairie & Lowland**
 - Root Mats
 - Snags & Woody Debris
 - Non-flow & Pools

Intro | Sensitive ID | Somewhat Tolerant ID | Tolerant ID | Methods | Data

RIFFLE

Riffle – Area that is shallow and swift due to a gradient drop



- ⊙ Aerates the water
- ⊙ Provides variety of habitats and food

Intro | Sensitive ID | Somewhat Tolerant ID | Tolerant ID | Methods | Data

MICROHABITATS



Intro | Sensitive ID | Somewhat Tolerant ID | Tolerant ID | Methods | Data

Sampling Riffles

A riffle is an area in your stream where water breaks over the rocks due to a gradient drop in the stream bed. This action incorporates atmospheric oxygen into the water which results in higher dissolved oxygen levels needed for invertebrates to thrive. A riffle provides a variety of microhabitats for a diverse community of organisms.

Since Stream Team protocol requires samples from three microhabitats, start with the most downstream microhabitat and work your way upstream. This prevents disturbing the other locations you will be sampling.



Sampling Riffles

Follow the process to collect samples of invertebrates in a riffle:

1. Place net in riffle.
2. Ensure bottom of net is on stream bottom and stretched taut side to side.
3. Weigh down the bottom of the net with large rocks.
4. Rub any large rocks in the sample area over the net, then set aside.
5. Agitate the stream bottom directly in front of the net in a 3' X 3' area, disturbing the substrate 3 to 6 inches deep. (*Benthic Boogie!*)
6. Remove and rub rocks weighing down the net.
7. Slowly lift the net from the stream, ensuring water does not pour over the sides.
8. Move the net to land to pick, sort, and identify invertebrates.

SAMPLE COLLECTION

1. Place net in the riffle
2. Ensure bottom of net is on the stream bottom
3. Rub all large stones within 3' area upstream of the net
4. Agitate the substrate 3-6" deep in 3' area by dancing and kicking

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1. Place net in riffle
2. Ensure bottom of net is on stream bottom
3. Weigh down bottom of net with large rocks

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4. Remove and rub large rocks over net, then set aside.
5. Do the *Benthic Boogie* in 3'x3' area, disturbing substrate 3-6" deep

Intro
Sensitive ID
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6. Rub large rocks in net and set aside
7. Slowly lift net from stream, ensuring water does not pour over sides

Intro
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Data



8. Move to land to pick and sort invertebrates from net

Intro
Sensitive ID
Somewhat Tolerant ID
Tolerant ID
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STREAM HABITATS



- Ozark**
 - Riffles
 - Root Mats
- Prairie & Lowland**
 - Root Mats
 - Snags & Woody Debris
 - Non-flow & Pools

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Minimum Data

ROOT MATS

• Root Mat - Matted roots of vegetation hanging into the water or growing out of stream bank



Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Minimum Data



Damselflies, dragonflies, mayflies, caddisflies, and midges are common in root mats

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Minimum Data



1. Place net downstream of root mat
2. Kick and swirl water through roots into net

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Minimum Data



3. Slowly lift net from stream, ensuring water does not pour over sides
4. Move to land to pick and sort invertebrates from net

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Minimum Data

Sampling Root Mats

Root mats are the fibrous roots from vegetation that hang over a stream bank and into the water. Damselflies, dragonflies, mayflies, caddisflies, and midges are common in root mats. Use the following process to sample macroinvertebrates from root mats:

1. Place net downstream of root mat.
2. Kick and swirl water through roots into the net.
3. Slowly lift the net from the stream, ensuring water does not pour over sides.
4. Move the net to land to pick, sort, and identify invertebrates.



Sampling Snags and Woody Debris

If your site has no riffles or root mats, you can sample snags or woody debris. When tree limbs, logs, and sticks fall into a stream and begin to decompose, the material becomes soft and provides a microhabitat for invertebrates. Follow the process below when sampling snags or woody debris:

1. Place net below the woody debris.
2. Scrub the debris using a brush.
3. Slowly lift the net from the water.
4. Move the net to land to pick, sort, and identify invertebrates.
5. Repeat steps 1 to 4 to sample three to five snags for one net set.

STREAM HABITATS



Ozark

- Riffles
- Root Mats



Prairie & Lowland

- Root Mats
- Snags & Woody Debris
- Non-flow & Pools

Intro
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SNAG

- Snag – Woody debris such as tree limbs, logs, and sticks in the water
- Decomposing worm-wood is best




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1. Place net horizontally underneath snag
2. Use a brush to scrub woody debris over the net
3. Move net to land to pick and sort invertebrates
4. Repeat steps to sample ~ 3-5 snags for 1 net set

Intro
Sensitive ID
Somewhat Tolerant ID
Tolerant ID
Methods
Data



STREAM HABITATS



Ozark

- Riffles
- Root Mats



Prairie & Lowland

- Root Mats
- Snags & Woody Debris
- Non-flow & Pools

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

NON-FLOW

⊗ Non-Flow or Pool – Areas of the stream with no observable flow



Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data



1. Hold D-frame net downstream of where you stand
2. Shuffle feet to disturb substrate 6-12" deep
3. Holding net just above substrate, sweep net back and forth through water

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data



4. Repeat as you shuffle upstream, sampling a 3' x 3' area of stream bottom

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

REMEMBER

- ⊗ Collect samples in an upstream direction
- ⊗ Don't collect inverts from disturbed areas
- ⊗ Consistency-sample same habitats each time you monitor

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

Sampling Non-Flow

If no other habitats exist at your monitoring site, you can sample in pools or non-flow areas. Use a D-net and the following process to collect your samples from these microhabitats:

1. Hold D-frame net downstream of where you stand in the water.
2. Shuffle feet to disturb substrate 6-12" deep if possible.
3. Sweep net side to side or in a circular motion just above substrate.
4. Repeat as you shuffle upstream, sampling a 3' by 3' area of stream bottom

Sampling Tips

- Prioritize habitats to monitor according to stream team protocol:
 1. Riffles
 2. Root Mats
 3. Snags and Woody Debris
 4. Non-flow or pools
- Collect samples in an upstream direction.
- Do not collect invertebrates from disturbed areas.
- Be consistent in the habitats you sample.
- Sample macroinvertebrates twice a year; once in the spring and once in the fall.

Completing the Macroinvertebrate Data Sheet

After you have collected a sample, begin the process of sorting, identifying, and counting each type of invertebrate. Record your findings on the Macroinvertebrate Data Sheet. This process will be repeated for each of the three net sets:

1. Remove invertebrates from the net and place them into your sorting tray.
2. Record the time spent removing invertebrates.
3. Identify invertebrates.
4. Count invertebrates and record your findings on the data sheet.

As with every data sheet you submit, be sure the header information is filled out entirely. For each of the three net sets, you will record the **Habitat Type** and select the **Net Type** you used. Record the amount of time it took to pick invertebrates from the net and the number of people that helped. Identify the organisms in the sorting tray and record the quantity of each variety found. After all three net sets have been completed, circle the number in the far right column called **Score**. If the taxa was present in any of the three net sets, circle the corresponding number. Once all data has been recorded, add up the scores to get the final water quality rating.

SAMPLE ANALYSIS

1. Remove invertebrates from net and place into sorting tray
2. Record time spent removing invertebrates (Picking Time)
3. Identify invertebrates
4. Count invertebrates and record on datasheet

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

Don't forget habitat and net type!

Time spent picking. NOT counting and identifying.

Do not use tally marks to record numbers.

Header information

Record actual numbers counted. Do not estimate!

Must have 3 net sets to calculate WQR

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

Instructions on back of data sheet!

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

SAMPLING SCENARIO 2008

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

SAMPLING SCENARIO 2009

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

MACROINVERTEBRATE DATA SHEET

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

Site # 3 Stream Southern Creek County Polaski

Site Location 1/4 mile SE corner Hwy 27 bridge, parallel to Flippin Rd.

Date 9/24/2024 Time (initials) 09:00 Rainfall (inches in last 7 days) 0 Water Temp. (°C) 20

Trained Data Submitter (optional volunteer) Chris Roberts Stream Team Number 2527

Participants Alicia Burke, April Perry

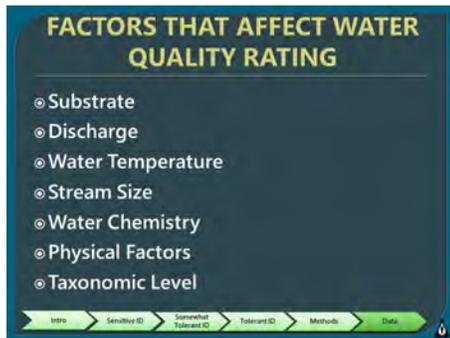
Invertebrate Type	Net Set #1	Net Set #2	Net Set #3	Score
Habitat type →	<i>riffle</i>	<i>riffle</i>	<i>riffle</i>	
Net Type (circle one) →	Kick Net <u>D-Net</u>	Kick Net <u>D-Net</u>	Kick Net <u>D-Net</u>	After entering the number(s) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the totals as your Water Quality Rating.
Time Spent Picking (Minutes picking x number of people picking)	min. picking <u>22</u> × # people <u>3</u> = total min. <u>66</u>	min. picking <u>25</u> × # people <u>3</u> = total min. <u>75</u>	min. picking <u>24</u> × # people <u>3</u> = total min. <u>72</u>	
Sensitive	# of Organisms	# of Organisms	# of Organisms	
Caddisfly Larvae	4	2	2	(3)
Hellgrammites		2		(3)
Mayfly Nymphs	2	2	4	(3)
Gilled Snails (right)	2			(3)
Riffle Beetles		2	2	(3)
Stoneworm Nymphs	2	2	2	(3)
Water Penny Larvae				3
Somewhat Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Other Beetle Larvae				2
Clams/Mussels				2
Crane Fly Larvae				2
Crayfish	2	2	2	(2)
Dragonfly Nymphs		2		(2)
Damselfly Nymphs				2
Scuds				2
Sowbugs				2
Fishfly Larvae				2
Alderfly Larvae			2	(2)
Watersnipe Fly	2			(2)
Tolerant	# of Organisms	# of Organisms	# of Organisms	Circle Types Present
Aquatic Worms	2		2	(1)
Black Fly Larvae				1
Leeches				1
Midge Larvae	2	2		(1)
Pouch Snails (left)	2	2	4	(1)
Other Snails (flat)				1

<12 = Poor 12-17 = Fair 18-23 = Good >23 = Excellent Water Quality Rating 24

Comments (mention any changes from your usual readings) Plentiful - 2

Fish Present (Please Mark) Yes or No

Volunteer Monitoring - 12/15



Factors Affecting Biological Water Quality Rating

There are many factors that affect the biological water quality rating. Some of these include:

- **Substrate:** The type of habitat the stream provides will affect the rating. Silt and sand-bottomed streams will generally have lower ratings than cobble-bottomed Ozark streams due to poor habitat availability.
- **Discharge, Depth and Velocity:** Sensitive organisms prefer water with some velocity because it helps to keep oxygen levels high. Too much velocity though, can result in a lower water quality rating. An example of this would be when rain events generate deep, fast flows in which organisms can be swept away.
- **Season:** Many invertebrates are insect larvae and emerge at varying times of the year. If you conduct your biological monitoring 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.
- **Stream Size:** Invertebrate communities are dependent on the characteristics associated with stream size.
- **Water Chemistry:** A balance of chemical constituents must be maintained to support aquatic life. Imbalances will result in changes in the stream that will alter what organisms can live there. Certain chemicals are toxic and if present in large enough quantities, will kill all life in a stream.
- **Physical Factors:** Habitat, flow, and rates of soil erosion are all physical factors that affect aquatic life. Poor ratings can often be attributed to physical problems in the stream.
- **Level of Taxonomy:** Our program identifies many macroinvertebrates to class, order, and family based on ability to identify stream-side. A general pollution sensitivity is assigned to this level. However, a given taxa may have a genus or species more tolerant than others. For example, mayflies are considered pollution sensitive on the data sheet, but there are some species of mayfly that are actually somewhat pollution tolerant.

Biological Monitoring Analysis

How does the collection and identification of macroinvertebrates aid in determining overall water quality of a stream? The four scenarios below illustrate how density and diversity of macroinvertebrates in a stream can aid in determining the health or impairment of a stream.

Scenario 1

Observations of Macroinvertebrates	Water Quality Analysis
<ul style="list-style-type: none"> • High density • High diversity • Many sensitive taxa (stoneflies, caddisflies, mayflies) 	

Scenario 2

Observations of Macroinvertebrates	Water Quality Analysis
<ul style="list-style-type: none"> • Low density • High diversity 	

Scenario 3

Observations of Macroinvertebrates	Water Quality Analysis
<ul style="list-style-type: none"> • High density • Low diversity 	

Scenario 4

Observations of Macroinvertebrates	Water Quality Analysis
<ul style="list-style-type: none"> • Low density or no invertebrates • Low diversity • Stream appears clean 	

ANALYSIS SCENARIO 1

Observation:

- ⊗ High density
- ⊗ High diversity
- ⊗ Many sensitive taxa (ex. stoneflies, caddisflies, mayflies)

Analysis:

No problem. Good water quality.

Intro → Sensitive ID → Somewhat Tolerant ID → Tolerant ID → Methods → Data

ANALYSIS SCENARIO 2

Observation:

- ⊗ Low density
- ⊗ High diversity

Analysis:

Possible poor habitat conditions or recent flooding.

Intro → Sensitive ID → Somewhat Tolerant ID → Tolerant ID → Methods → Data

ANALYSIS SCENARIO 3

Observation:

- ⊗ High density
- ⊗ Low diversity

Analysis:

Organic pollution or sedimentation; Excessive algal growth from eutrophication

Intro → Sensitive ID → Somewhat Tolerant ID → Tolerant ID → Methods → Data

ANALYSIS SCENARIO 4

Observation:

- ⊗ Low density or no invertebrates
- ⊗ Low diversity
- ⊗ Stream appears clean

Analysis:

Toxic pollution (e.g. chlorine, acid, heavy metals, pesticides); unproductive

Intro → Sensitive ID → Somewhat Tolerant ID → Tolerant ID → Methods → Data

ENDANGERED SPECIES

Niangua darters

- Small fish listed as state endangered and federally threatened
- Spawns in riffles
 - Spawning period: March 15 through June 15
 - Sampling invertebrates can be detrimental to spawning



Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

NIANGUA DARTER RANGE AS OF 2017



- Localized in a few tributaries of the Osage River
- Highest Remaining populations:
 - Niangua River
 - Little Niangua

Intro Sensitive ID Somewhat Tolerant ID Tolerant ID Methods Data

Other Organisms to Consider

As you begin your monitoring efforts, there are a few additional organisms for you to consider. Niangua Darters are small fish that are endangered in Missouri and federally threatened. Located in a few tributaries along the Osage River, their highest remaining populations can be found in the Niangua and Little Niangua rivers. Because the Niangua Darter spawns in riffles, kicking up macroinvertebrates can be detrimental to spawning and future populations. Consequently, do not conduct macroinvertebrate monitoring in the following streams from March 15 through June 15.

Niangua River Watershed

- Niangua River
- Greasy Creek
- Little Niangua River

Little Niangua River Watershed

- Macks Creek
- Starks Creek
- Thomas Creek
- Cahoochie Creek

Sac River Watershed

- Sac River
- Bear Creek
- Brush Creek
- Panther Creek
- North Dry Sac River

Tavern Creek Watershed

- Tavern Creek
- Barren Fork
- Brushy Fork
- Kenser Creek
- Little Tavern Creek

Other Streams

- Pomme de Terre River
- South Fork Pomme de Terre River
- Little Pomme de Terre River
- Maries River
- Little Maries Creek



Other Organisms to Consider

Please be mindful of nuisance species, too. Some of the invasive species in Missouri’s streams include:

- Zebra mussel
- Chinese mystery snail
- Rusty crayfish
- Hydrilla

To prevent spreading these species to even more streams, be sure to clean and dry your equipment, boots, and boats after being in the water. This is especially true if you monitor more than one stream. The table below provides guidelines on how to prevent the spread of these species from one stream to another.

Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	1 gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use, rinse with water but do not let the solution runoff directly to a stream
Air Drying	3-5 days	NA	NA	Equipment must dry completely
Freezing <32° F	24 hours	NA	NA	Must be below freezing for duration of contact time
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged



The infographic has a green header with the title 'NUISANCE SPECIES PREVENTION'. Below it is a table with five rows, each representing a different prevention technique. The table columns are: Technique, Duration, Concentration, Solution, and Comments.

Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	1 gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish.
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use rinse with water but don't let the solution runoff directly to the stream.
Air Drying	3-5 days	NA	NA	Equipment must dry completely.
Freezing < 32°F	24 hours	NA	NA	Must be below freezing for duration of contact time.
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged.

Aquatic Macroinvertebrates Characteristics Chart

This chart was designed to aid in the identification of aquatic macroinvertebrates and is a supplement to the dichotomous key in Chapter 4 of your Introductory Notebook, Stream Insects & Crustaceans “blue bug card” and the Key to Macroinvertebrate Life in the River.

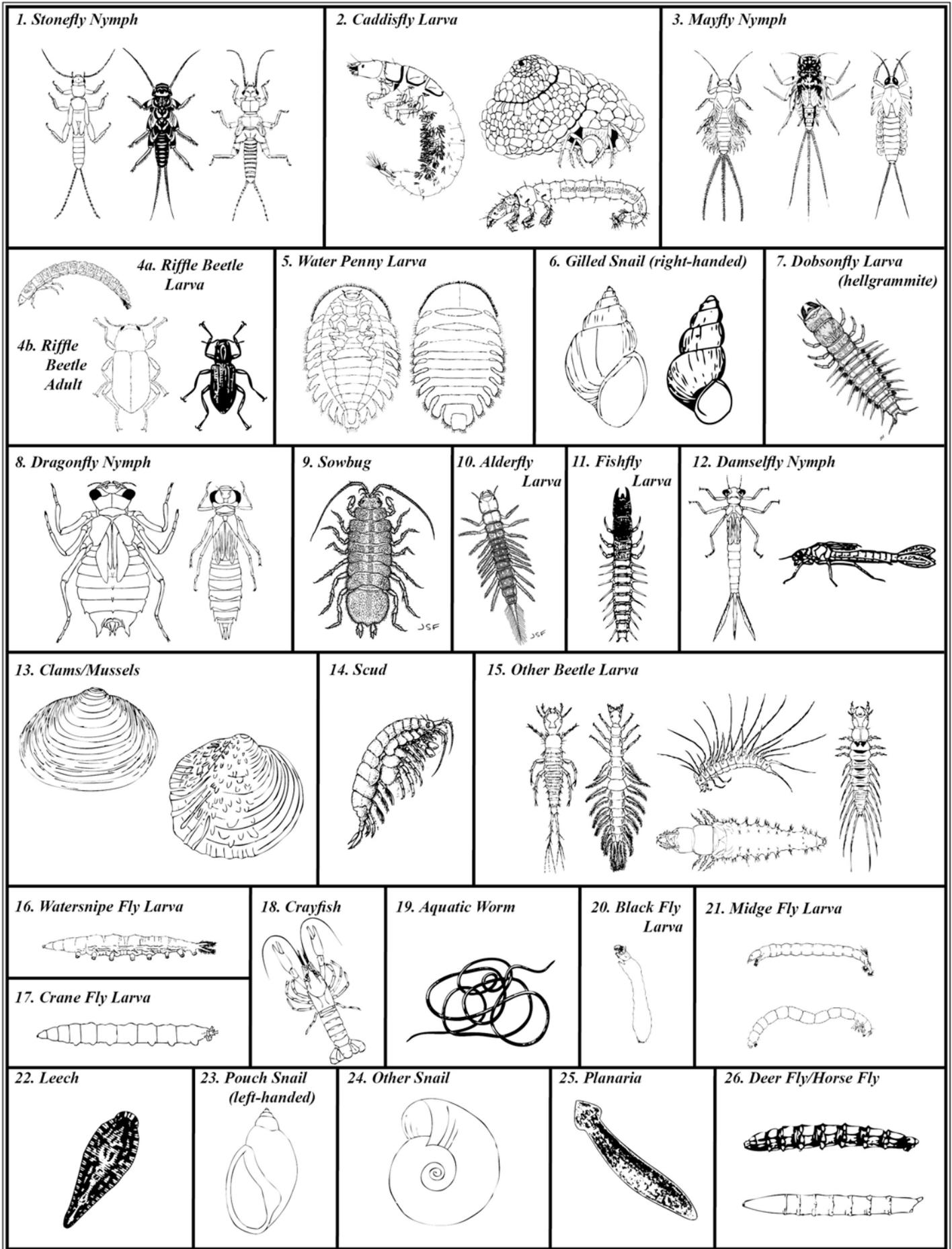
Key:
 x = present
 ✓ = sometimes present

	Head							Thorax					Abdomen									
	Flattened body	Shell	Caterpillar-like	Distinct head	Large eyes	Obvious antennae	Obvious mouth parts	Mask-like lower lip	No legs	Prolegs	Six segmented legs	More than six segmented legs	Gills	Hard plate(s)	Wings/Wing pads	Gills	Hard plate(s)	Lateral filaments	Prolegs	Hooked prolegs	Suction pad(s)	Tail(s)
1. Stonefly Nymph	✓			x	x				x			✓	x									x
2. Caddisfly Larva			x						x			x		✓					x			
3. Mayfly Nymph	✓		x		✓				x				x	x								x
4a. Riffle Beetle Larva			x						x				x			x						
4b. Riffle Beetle Adult			x		x				x				x									
5. Water Penny Larva	x		x						x			x		✓	x							
6. Gilled Snail (right-handed)		x						x														
7. Dobsonfly Larva (helgrammite)	✓		x			x			x			x		x		x			x			
8. Dragonfly Nymph	✓		x	x	x	x	x		x				x									
9. Sowbug	x				x					x			x			x						
10. Alderfly Larva	✓		x			x			x				x				x					x
11. Fishfly Larva	✓		x			x			x				x				x			x		
12. Damselfly Nymph			x	x	x	x	x		x				x									x
13. Clam/Mussel		x						x														
14. Scud	x		x		x					x			x			x						
15. Other Beetle Larva	✓		x		✓	x			x			✓		✓	✓							✓
16. Watersnipe Fly Larva			x					x										x				
17. Crane Fly Larva			x					x														
18. Crayfish					x	x				x			x			x						x
19. Aquatic Worm								x														
20. Black Fly Larva			x					x	x													x
21. Midge Fly Larva			x					x	x									x				
22. Leech	x							x														x
23. Pouch Snail (left-handed)		x						x														
24. Other Snails		x						x														

Other macroinvertebrates you may encounter that are not included in our count/protocol.

25. Planaria	x			x				x														
26. Deer Fly/Horse Fly			x					x														

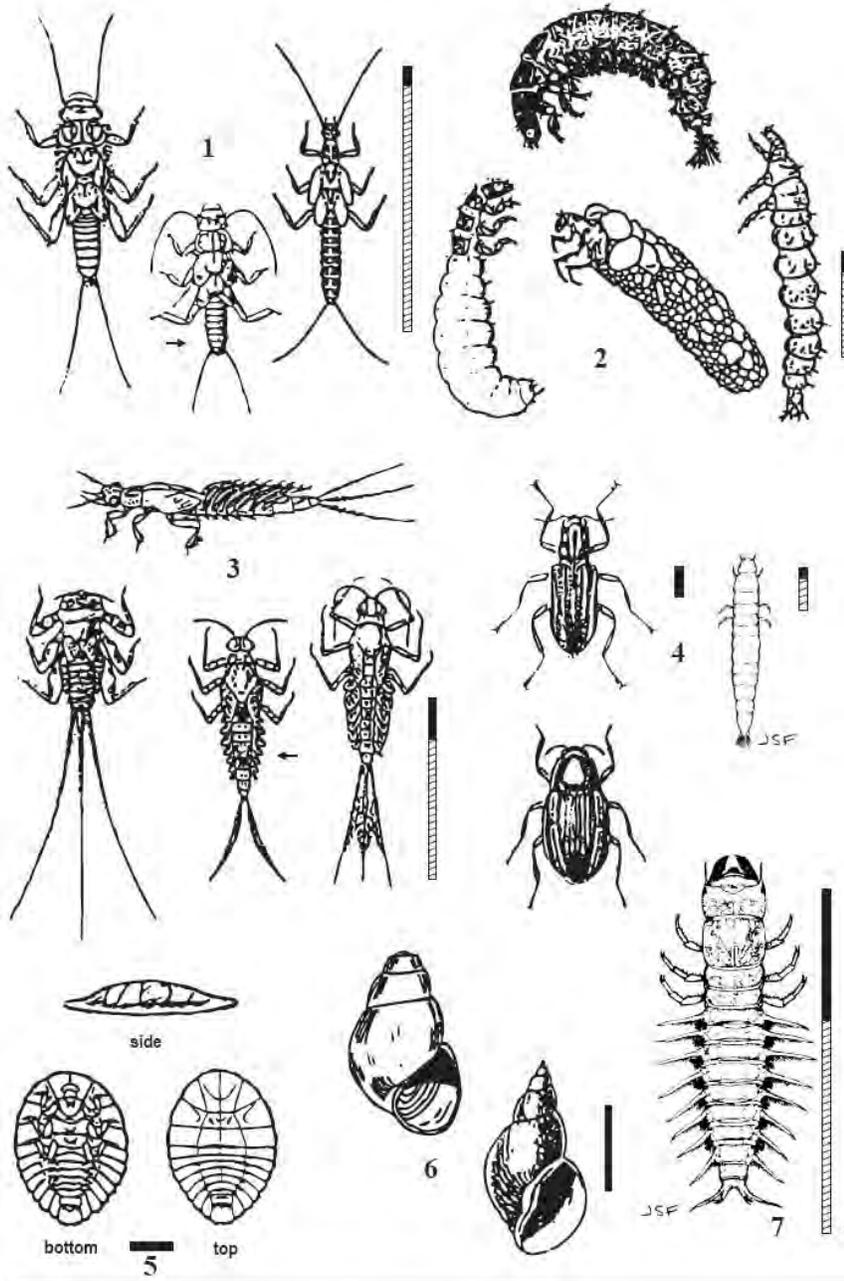




Stream Insects & Crustaceans

GROUP ONE TAXA

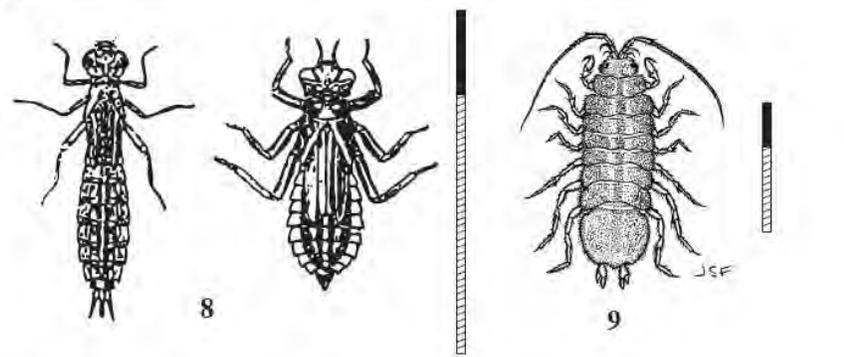
Pollution sensitive organisms found in good quality water.



- 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"; 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 or black color. Combine number of adults & larvae 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 lateral filaments on lower half of body with paired cottonlike gill tufts along underside of lateral filaments; short antennae; 2 pairs of hooks at back end.

GROUP TWO TAXA

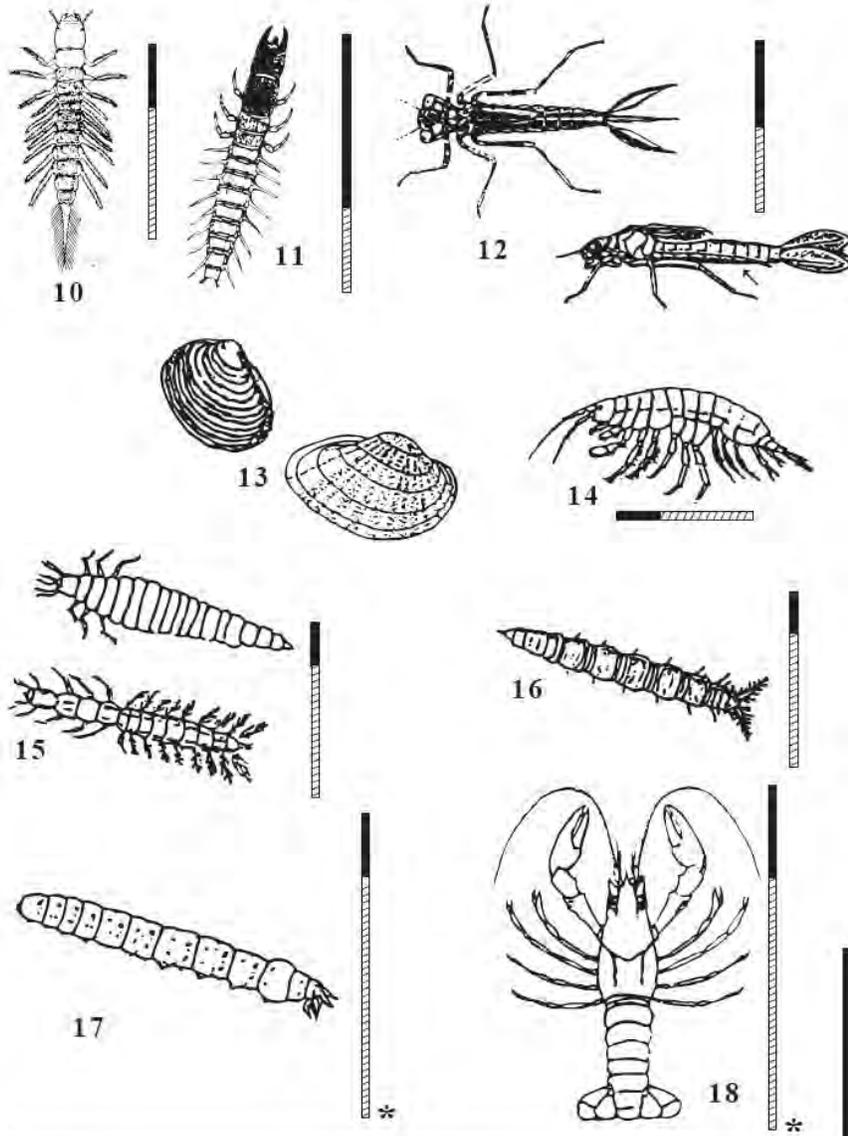
Somewhat pollution tolerant organisms can be in good or fair quality water.



- 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 'roly poly.'

* May be larger.
 ~Solid bar indicates approx. minimum size. Combined solid and striped bar is approx. maximum size.~

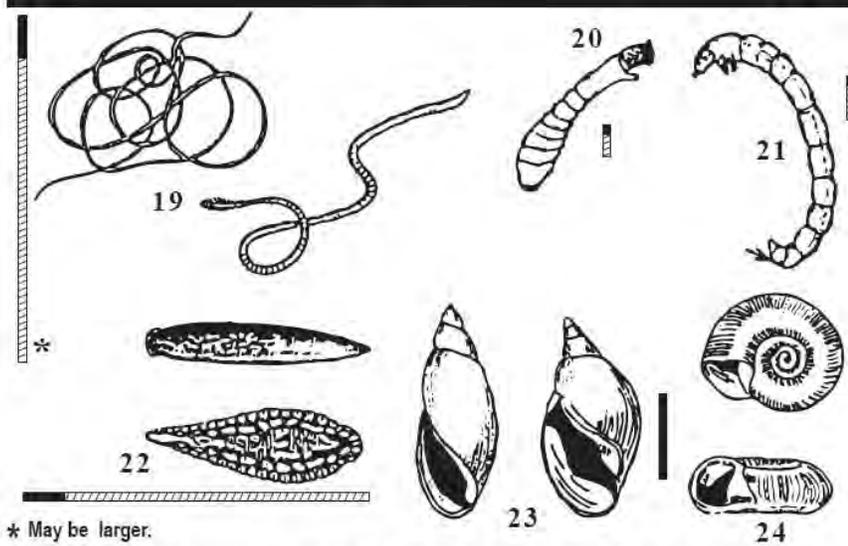
Save Our Streams



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 (gills); 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 caterpillar-like legs; conical head; two feathery 'horns' at back end.
- 17 Crane Fly larva: *Suborder Nematocera*. 1/3" - 4"; milky, green, or light brown; plump caterpillar-like 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 walking 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 prolegs under head and tip of abdomen.
- 22 Leech: *Order Hirudinea*. 1/4" - 6"; 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.

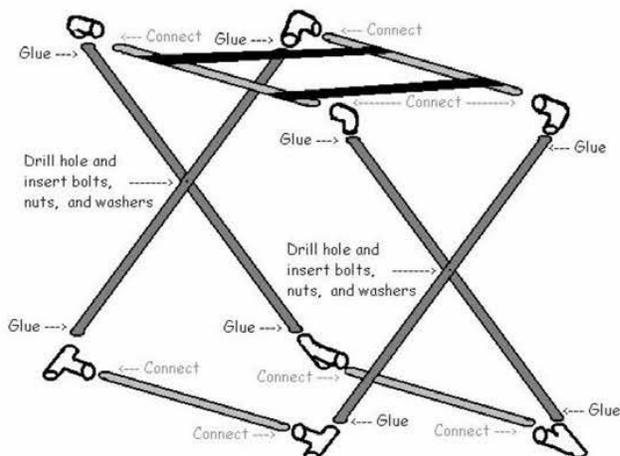
* May be larger.
 ~Solid bar indicates approx. minimum size. Combined solid and striped bar is approx. maximum size.~



PVC Net Rack

Materials

- Three 10 foot sections of 1 inch PVC pipe
- Four PVC elbows (1 inch - 90°)
- Four PVC 'T' connectors (1 inch - 90°)
- Two bolts (3 X 1/4 inch)
- Three lock nuts (1/4 inch)
- Four washers (1/4 inch)
- Canvas
- Heavy duty thread / twine
- Needle
- PVC cleaner and glue
- Tape measure
- Hacksaw and scissors
- Pliers
- Drill and 3/8 inch bit

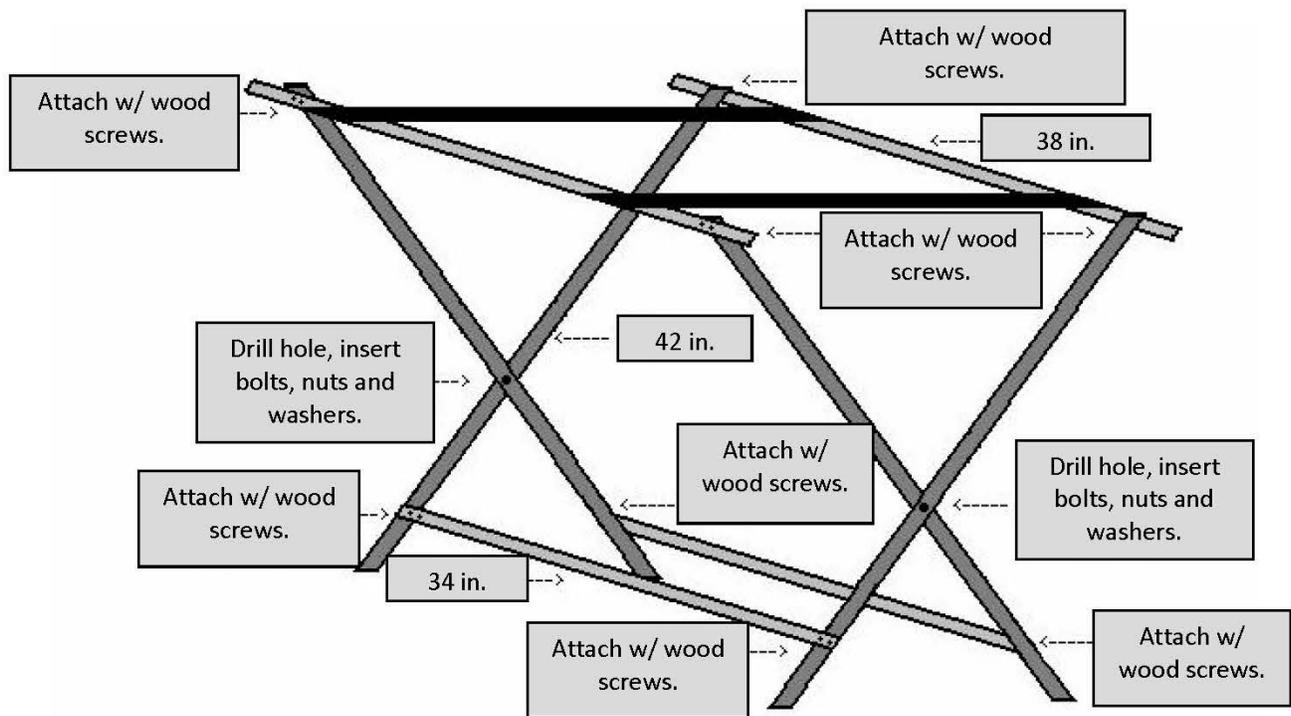


Procedure

1. Cut two 10ft. PVC pipes into one 4ft. section and two 3 ft. sections.
2. Cut the third 10ft. PVC pipe into two 4 ft. sections.
3. Steps 1-3 will give you the legs (4ft. sections) and the cross supports (3 ft. sections).
4. Drill a hole in the 4ft pieces (2 ft. from the end).
5. Connect the legs (4 ft. sections) with a bolt, washer and lock nut.
6. Clean the ends of the legs and inside the 'T' connector with pipe cleaner and wipe off.
7. Put the 'T' sections (bottom of the 'T') onto either end of two cross pieces and make sure the 'T's' are lined up the same way. **Note: Do not glue these together. This allows you to disassemble the rack for transport.**
8. Apply PVC glue to both ends of the legs and inside the 'T' sections.
9. Attach the 90° elbows to the other end of the legs.
10. Cut the canvas to a length that will allow you to work off your bug rack at a comfortable height. **Note: The shorter the canvas the taller the rack.**
11. Loop the ends of the canvas around the top cross bar to the desired length and sew canvas loop closed.
12. Let the glue cure before use.

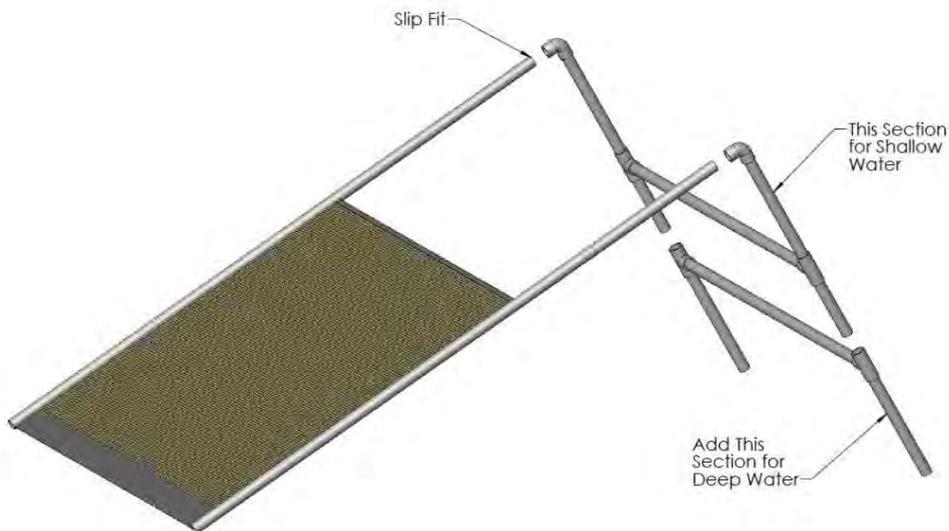
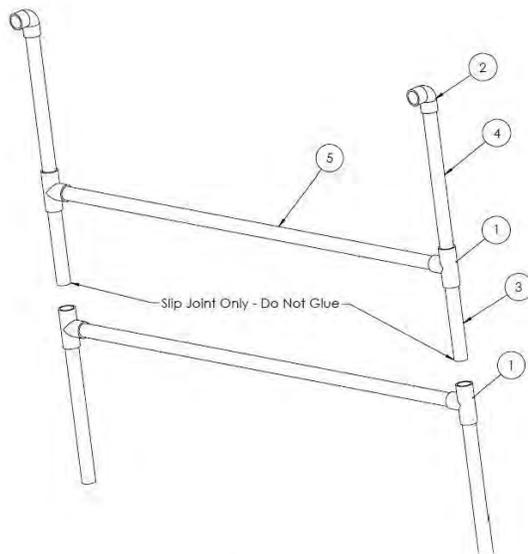
Wooden Net Rack

Part	Length
Lumber 1x2	42"
Lumber 1x2	1-34", 1-36" and 2-38"
Drywall Screws	1 3/4"
Bolts wit lock nuts	3"
Canvas strips	6" wide x 40" long



Free Standing Net

Item Number	Part	Length	Quantity
1	PVC 3/4" Tee		4
2	PVC 3/4" Elbow		2
3	PVC 3/4" Upright	8"	2
4	PVC 3/4" Upright	13"	4
5	Cross Bar	43" using 1 inch PVC	2



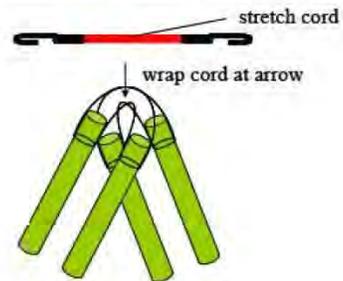
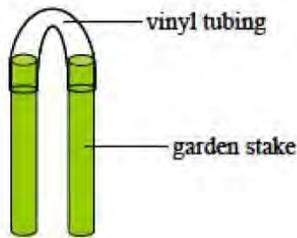
Plans for Freestanding Kicknet Support

Materials

Quantity	Part	Length	Diameter
4	Steel core, plastic-coated garden stakes	4ft	3/8"
1	Clear vinyl tubing soft	6"	7/16" outside, 5/16" inside
1	Long stretch bungee cord with hooked ends or rope	10"	

Procedure

- Place a 3-inch piece of vinyl tubing onto the end of the garden stakes.
- Wrap the stretch cord around both pieces of vinyl tubing and interlock the hooks to create a flexible joint.



Practical Use

- Guide the looped edges on opposite sides of the kicknet onto tow supports.
- Lower the kicknet into the stream and step on the bottom edge to hold it in place in the flowing water.
- Place large rocks on the submerged edge of the kicknet to hold it firmly on the stream bottom.
- Position downstream supports to make a stable structure.
- When removing the kicknet from the stream, grab the bottom edge as you remove the rocks to prevent the loss of the sample.

