SC ADOPT-A-STREAM IN THE CLASSROOM
High School Curriculum

Macroinvertebrates

Feeding frenzy

Clemson University Center for Watershed Excellence

LEARNING OBJECTIVES: Experience the flow of energy from the river to flora and fauna, describe relationships and patterns, and describe them statistically.

INTRODUCTION

A habitat is the specific natural environment where a particular species lives. All habitats have physical and biological attributes that strongly affect survival of all of the species that live in them. As a result, all species exhibit adaptations to their specific habitats. These adaptations can affect how the organisms look (morphological), how they function (physiological), and/or how they act (behavioral). Scientists study these adaptations to understand how organisms fit into their habitats.

Stream ecosystems are **lotic**, or flowing, and are unique among aquatic ecosystems where new water is constantly replacing water at any point as it flows. In **lentic**, or non-flowing, ecosystems found on land, photosynthesis from phytoplankton, algae, and rooted aquatic plants provide the primary energy source. Think of lakes, wetlands, and ponds! But in streams there is typically little photosynthesis happening under the nearly or partially closed forest canopies. Instead, inputs of dead leaves and other organic matter are high and provide the energy for the system. Therefore, most **consumers** in the streams are **decomposers** feeding on this detritus, and not **herbivores** feeding on green plants. This results in a major change from other ecosystems: streams tend to have inverted biomass pyramids where a relatively small biomass of plants is found alongside a much larger biomass of consumers.

Attending the right dinner party

Macroinvertebrates can be classified either by their taxonomy or by which **functional feeding group (FFG)** they belong to, depending on which aspect of stream health is studied. Classification using FFGs is unique because it allows researchers to study a group of organisms at one time, based on their physical characteristics and behavioral feeding patterns. Because feeding behavior relies solely on the ability of organisms to obtain food in their environment, macroinvertebrate presence representing a variety of FFGs reflects the function and stability of the ecosystem in terms of nutritional changes. By looking at which types of macroinvertebrates from each FFG are present, scientists can learn about what types of organic matter are present, and the methods of energy transfer within the ecosystem. Food for thought:

Functional Feeding Groups (FFGs)

The main macroinvertebrate FFGs are collectors/gatherers, collector/filterers, shredders, scrapers/grazers, and predators. There are common adaptations among different species in each of the FFG.

- **Shredders** have sharp mouthparts for cutting and shredding leaf litter, wood, and other coarse particulate organic matter (CPOM).
- **Collectors/gatherers** have adapted to have fine hairs and other filtering appendages to feed on fine particulate organic matter (FPOM) from the stream bottom.

- **Collector/filterers** have similar adaptations for feeding on FPOM, though they do so in the water column. Because the water column makes them vulnerable to predators, many collector/filterers have also developed hard casings for protection.
- **Scrapers/grazers** have claws and suctioning appendages to latch onto hard surfaces where they scrape off algae and associated materials with their razor-like mouthparts.
- **Predators** tend to be larger in size and have claws, pinchers, teeth, and jaws for catching and eating other consumers.

In headwaters of a stream, CPOM such as fallen leaves from overhanging vegetation fall into the water. These serve as food for "shredders," such as the larvae of mayflies and stoneflies. Shredders ingest CPOM along with the decomposers (*e.g.,* bacteria, fungi) that grow on them. Shredders prefer CPOM about 1 mm in size, so they break up the larger plant material into finer, bite-size pieces before eating. This shredding provides finer organic matter to other organisms downstream.

Collectors use particle traps to gather food or other feeding structures adapted to filter and catch FPOM in the water. They consume material in the range of 0.5-50 micrometers. This group includes true fly and mosquito larvae, caddisfly larvae, nematodes, and filter feeders such as bivalves. The grazers or scrapers such as snails and beetle larvae feed off periphyton, the mix of algae, microbes, and debris that accumulates on stones, wood, or aquatic plants.

The final FFG are the predators, which includes the larvae of dobsonflies and dragonflies. These macroinvertebrates feed on other macroinvertebrates and even on small vertebrates such as juvenile fish and amphibian larvae.

Note on natural selection

Natural selection reinforces habitat adaptations over long periods of time. Unrelated or dissimilar species that occupy similar habitats often evolve similar features that are useful in that habitat, in a process called **convergent evolution**. On the other hand, species that are similar initially, but colonize different habitats, may become ecologically more different as their requirements and tolerances change to match their distinct environments. Such divergence in habitat adaptations is one of the major mechanisms leading to increased diversity of species.

Classifying macroinvertebrates into FFGs demonstrates this concept of convergent evolution by allowing researchers to observe firsthand the common adaptations organisms have developed after feeding in the same environment for an extended period of time. As time progresses, an organism's adaptations are further enforced, leading to stronger patterns of features within FFGs. It can be difficult to visualize the process of adaptation and evolutionary change simply because these processes take many years and are often nonlinear. FFGs, however, provide a framework in which cause and effect of adaptations are easier to identify.

The river continuum concept and FFGs

Another way we can look at macroinvertebrate FFGs is by examining how the proportion of each group changes along the river continuum concept (RCC). The RCC connects river systems, providing clear links between changes in the physical and chemical/biological communities as the river size increases from the small creeks in the headwaters to the mile-wide waters of the Mississippi River. Imagine a small creek in a forested area. Now think about standing on the bank of a giant river. Different, right? As the river moves through its watershed, changes along the different stretches of river alter the type and amount of organic matter that ends up in the river.
The food type then will change the potential for different macroinvertebrates to succeed. Therefore, different FFGs will thrive along different stretches of the waterway. The shaded and cool nature of the headwaters produces an abundance of leaf and woody matter, ideal food supply for shredders. In the mid-reaches, the river widens, producing less shade and a higher capability for the diversity of FFG presence. Food sources at the lower reaches are dominated by FPOM from upstream, lending itself to collector/gatherers and collector/filterers. The RCC is another influencer of macroinvertebrate/FFG presence that is important to consider when making observations.

- Shredders and collectors are dominant in the headwater streams.
- As the streams widen and flow further down into mid-reaches, primary productivity increases, and while the collectors remain common, the shredders are gradually replaced by grazers. The increased availability of nutrients and sunlight allows phytoplankton, algae, mosses and other photosynthetic organisms to survive in the mid-reaches. (Remember how food availability drives species diversity!)

- Collectors dominate again downstream where the river widens and becomes too deep (and turbid) for aquatic plants.
- Predators occur throughout the continuum.
- The abundance of predators in all sections remains largely the same. This is because the predators are not dependent on the size of the organic matter in the stream, but on the availability of prey animals and the physical and chemical environmental conditions of the stream such as water temperature, dissolved oxygen content, and water depth.

LOOKING TO THE FUTURE

When planning your path, the information taught in this chapter could lead you down a new road. When hearing that people are biologists, it is often only associated with plants and mammals, but there are biologist positions that exist to monitor streams in similar fashions to those encouraged by Adopt-a-Stream. If working at a fishery, the biologist coordinates and participates in limnology (study of inland aquatic ecosystems) surveys, manages stream flow and water temperature monitoring efforts, and directs macroinvertebrate surveys. These responsibilities combined with activities like snorkeling, exploring wildlife, and fishing could make this type of position your perfect fit.

FEEDING FRENZY ACTIVITY

ACTIVITY OVERVIEW

This activity is designed in two parts: a field portion and classroom portion. Students will work in groups of 3-5 for the duration of the activity. The field portion involves the collection of stream samples and identification of macroinvertebrates according to the SC Adopt-a-Stream Macroinvertebrate Monitoring Protocol. If the stream samples are collected by the teacher without the students present in the field, the students can identify macroinvertebrates when back in the classroom. If visiting the stream sites and collecting/identifying macroinvertebrates is not feasible for either the

teacher or the students, have the student use the reference guide to categorize macroinvertebrates into FFGs.

MATERIALS AND METHODS

MATERIALS

- Kick Net (Preferable)
- Dip/D-Net
- Sorting Bins (Preferable)
- Ice Cube Trays
- Eye droppers
- Turkey Basters
- Popsicle sticks
- Tweezers
- Microscopes
- Magnifying Glasses
- Loops
- Permanent Markers

FIELD PORTION

The field portion of this activity can be completed either by the teacher ahead of time or by the students as a field trip addition to the lesson. The goal is to collect samples from all macroinvertebrate habitat types present at the field site. A total of twenty-one (21) samples from five different habitats will be collected; if your site does not have a particular habitat type, skip those samples. SC Adopt-a-Stream categorizes these habitats as present in either rocky bottom or sandy/muddy bottom streams.

1. When you arrive at the stream, record your observations of the site on the provided data sheet. Does there appear to be many different types of habitats in the stream? Also consider how this site will change with the seasons. Make notes on the provided data sheet.

2. Identify all stream habitats from the stream bank so as not to disturb the water. Once all areas have been located, collect samples as outlined below.

Number of samples from each habitat present:

- 3 Riffle Ares Samples (Rocky Bottom Stream)
- 4 Leaf Pack Samples (Rocky Bottom Stream)
- 7 Vegetated Margin Samples (Sandy/Muddy Bottom)
- 4 Organic Matter Samples (Sandy/Muddy Bottom)
- 3 Sand/Rock/Gravel Samples (Sandy/Muddy Bottom)

ROCKY BOTTOM STREAM SAMPLES:

Riffles - Riffle areas constitute shallow areas of a stream or river with a fast-moving current bubbling over rocks. The water in riffle areas is highly oxygenated and provides excellent habitat, shelter, and food for a variety of macroinvertebrates.

First, identify three different riffle areas, or different sections of a riffle. Collect macroinvertebrates in all three riffles with a kick net, sampling a 2 x 2 foot area (the kick nets are usually 3 x 3 feet). Look for an area where the water is 3 to 12 inches deep.

Place the kick net downstream and firmly wedge the net into the streambed, weighting the bottom edge with rocks. Gently rub any loose debris off rocks and sticks so that you catch everything in the net. When you have "washed off" all the rocks in a 2 x 2 foot area, kick the streambed with your feet. Push rocks around; shuffle your feet so that you really kick up the streambed. Now gently lift the net, being careful not to lose any of the macroinvertebrates you have caught. Take the net to an area where you can empty it into a white sorting pan and look it over, or wash the contents into a bucket.

Leaf Packs - Leaf packs are tightly-packed clumps of submerged, decomposing leaves caught up on sticks and rocks. Leaf packs serve as a food source for organisms and provide shelter from predators.

Look for submerged, decaying (old, dead) packs of leaves next to rocks, sticks, or logs in the stream. Leaf packs may be found throughout your designated stream reach, in areas with good flow. Add four (4), approximately 1 square foot each, handfuls of decayed leaves to your sample. The total area of stream you will sample is 16 square feet.

SANDY/MUDDY BOTTOM STREAM SAMPLES:

Vegetated Margins - This habitat is the edge of the waterbody consisting of overhanging bank vegetation, submerged root mats (which are sometimes hidden beneath undercut streambanks), and any underwater plants. Vegetated margins may be home to a diverse assemblage of dragonflies, damselflies, and other organisms. Move the dip-net quickly in a bottom-to-surface motion (scooping towards the stream bank), jabbing at the bank to loosen organisms. Each scoop of the net should cover one square foot of submerged (underwater) area.

Organic Matter/Woody Debris - Organic matter/woody debris consists of dead or living trees, roots, limbs, sticks, leaf packs, cypress knees, and other submerged organic matter. It is a very important habitat for macroinvertebrates as the wood helps trap organic particles that serve as a food source for the organisms and provides shelter from predators such as fish.

To collect woody debris, approach the area from downstream and hold the net under the section of wood (such as a submerged log) you wish to sample. Rub the surface of the log for a total surface area of one square foot. It is also good to dislodge some of the bark as organisms may be hiding underneath. You can also collect sticks, leaf litter, and rub roots attached to submerged logs. Be sure to thoroughly examine any small sticks you collect before discarding them. Macroinvertebrates are excellent at blending in with their environment! There may be caddisflies, stoneflies, and midges attached to the bark. If you find a large clump of roots, place the whole clump into your net, and, keeping it underwater, shake the roots to dislodge any macros living there. Gather a leaf pack with much the same motion of picking up leaves after you have raked them together. Transfer the whole pack to a collection tub with water. Remove and examine each leaf. While this is time consuming, there are potentially loads of tiny invertebrates living between each leaf.

Sand/Rock/Gravel or Coarsest Area of the Streambed - In slow moving streams, the streambed is generally composed of only sand or mud because the velocity of the water is not fast enough to transport large rocks. Sample the coarsest area of the streambed—gravel or sand may be all you can find. Sometimes, you may find a gravel bar located at a bend in the river. The streambed can be sampled by moving the net forward (upstream) with a jabbing motion to dislodge the first few inches of gravel, sand, or rocks. You may want to gently wash the gravel in a screen bottom bucket and then discard gravel in the water. If you have large rocks (greater than two inches in diameter) you should also kick the streambed upstream of the net to dislodge any burrowing organisms. Remember to disturb only one square foot of upstream sample area. If the coarsest streambed you can find is almost entirely silt and mud, you can separate the organisms by placing the sample in a bucket with water and stirring. Pour off the water into the D-frame net and repeat three times. Macroinvertebrates will separate from the collected mud and be caught in the net. Check any remaining material in the bucket for organisms.

Samples from the same habitat type can be consolidated into the same sorting bins (for example, multiple leaf packs put together), though be careful to keep samples from different habitats separate.

CLASSROOM

Once samples have been collected, students will work in groups to make hypotheses, observations, and draw conclusions about the macroinvertebrates present in the samples. Stream samples should be distributed among groups so that each group has stream samples of one or two different habitat types. Students will record their predictions and observations on the provided lab sheet.

1. Formulating Hypotheses
    a. Use your senses to make observations about your stream sample(s) and to answer the pre-lab questions on your lab sheet. These questions will guide you through the hypothesizing process.

2. Collecting, Sorting, and Identifying
    a. Use the tools provided by your teacher to find, capture, and sort the macroinvertebrates in our stream sample(s) into the ice cube trays. Organisms of the same order can be consolidated into a single tray depression.
    b. Once all visible macroinvertebrates have been collected and sorted, use the provided SC Adopt-a-Stream field guides to record the order/name of each macroinvertebrate on your lab sheet. You may also choose to write the order/name of the macroinvertebrate on the ice cube tray with permanent marker as well.
3. Making Observations
    a. Next, make and record observations about the macroinvertebrates you have identified. Pay special attention to methods of locomotion, feeding, and any other unique appendages or features. You may use microscopes, magnifying loupes, magnifying glasses, and other tools to help make these observations.
    b. Once observations have been made and recorded, group the macroinvertebrates based on commonality of the previously noted features (for example, group all macroinvertebrates together in which you observed sharp mouth pieces).
4. Proposing Connections
    a. Use what you have learned about common adaptations among the five functional feeding groups to hypothesize matches between your groupings and the potential FFG they represent (for example, you may choose to match the group with sharp mouth pieces to the shredder FFG).
5. Validating Predictions

   a. Once predictions have been made, use the provided key to individually match the macroinvertebrates in your groupings to their FFG. Then compare these FFG classifications to your predictions to determine if you were correct.
6. Concluding and Reflecting
   a. Conclude your findings by answering the post-lab questions on your lab sheet. Be sure to provide in-depth explanations and justifications of your conclusions using the information you have learned both in class and through this activity.

Digging Deeper Activity

For advanced classes, ask students to create a food web highlighting the connections between macroinvertebrates and other aquatic organisms.

CHAPTER ASSESSMENT

1. Explain the relationship between habitats and species adaptation. List examples of how one affects the other.
2. What is the difference between a decomposer and herbivore when it comes to macroinvertebrates?
3. List the five main functional feeding groups for macroinvertebrate organisms in rivers and ponds. Provide one unique attribute for each group.
4. Explain convergent evolution and how the FFGs demonstrate this concept.
5. If you are in a wide, slow flowing river continuum with lots of sunlight and very little vegetation along the banks of the stream (plenty of nutrient runoff), what species would be predominant there? Would predators live in this part of the stream? Are shredders or grazers more common in this area?