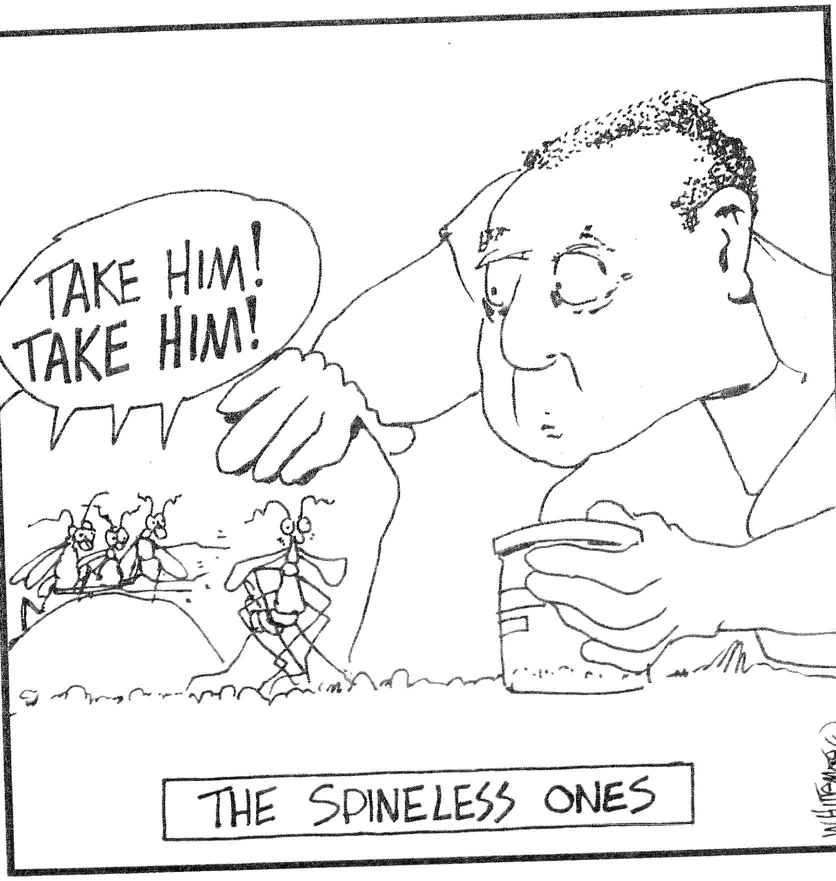
CHAPTER SIX

The Spineless Ones

BENTHIC MACROINVERTEBRATES (BMIS)



Macroinvertebrates are animals that do not have backbones, but are visible to the naked eye. Many of these organisms live on the stream bottom or on other substrates. These bottom dwellers are referred to as **benthic** macroinvertebrates. In this chapter, we will refer to benthic macroinvertabrates as **BMIs.** Many BMIs are insects, but many others are represented by freshwater aquatic worms, snails, clams, **crustaceans** (crayfish, crabs, shrimp, etc.), and **arachnids** (spiders and other 8-legged invertabrates).

In this chapter, you will learn how to gauge the general health of your stream by using a **simplified field method** to evaluate the BMI population. You'll be able to use inexpensive or home-made equipment. The sorting and identification takes some time and practice, but is kept at a fairly general level.

The method is designed so you can conduct it at the stream site and release the BMIs to the stream when done. It is **qualitative**, which means it does not analyze numbers of BMIs, but instead the presence or absence of different types. Nevertheless, it is detailed enough to diagnose the overall health of your stream.

This chapter also introduces a more **detailed lab method**, which requires "sacrificing" your specimens in order to conduct a more thorough and higher level analysis. It is a **semi-quantitative method**; it involves counting a portion of the BMIs in your sample. For this method, you'll need a lab equipped with more expensive equipment, such as lighted magnifyers and microscopes. You'll also have to become familiar with some rather minute body parts, because this method requires identifying the BMIs at a more detailed level. The reward is that you'll be able to detect more subtle impacts to your stream.

If you have little or no experience with BMIs, start out with the field method. If you have some experience, you may want to try the lab method, but read through the field method first. It introduces concepts and procedures you'll need for the more detailed analysis. You may find that some combination of the two procedures works best for you; feel free to adapt the methods as appropriate to your own situation.

Also, don't let a lack of resources stand in your way. If you are interested in the lab method but cannot afford microscopes, you may be able to recruit a school to help you that has an equipped lab.

BMIs as Indicators of Stream Health

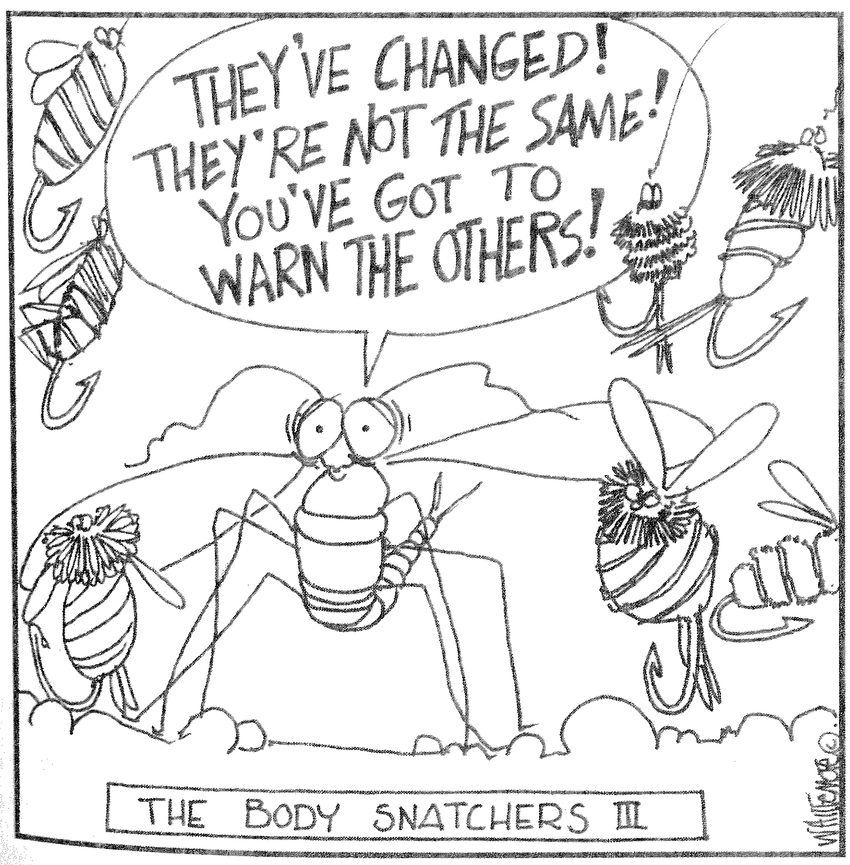
Benthic macroinvertebrates have come to play key roles as biological indicators of stream health and water quality for the following reasons:

- BMIs represent important links in the food chain as recyclers of nutrients and food for fish.

- Because they are relatively sedentary residents of the stream bottom, BMIs often become a pollutant's captive audience. Fish can (hopefully) swim away from some pollution problems. However, even regular chemical tests of the water column may fail to detect transitory events. And because they cannot swim away from pollution and can be affected by even subtle levels of degradation, BMIs are good indicators of stream health.

- There are many different types of stream BMIs. Each type has a specific set of requirements which the stream must provide for the organism to survive. Alterations to the stream may have a great impact on the abundance and distribution of different macroinvertebrate types.

- Some are intolerant of pollution. Their presence in the stream, like a canary in a mineshaft, suggests healthy conditions. However, some BMIs are quite tolerant of pollution. Taken together, the presence or absence of tolerant and intolerant types can indicate the overall health of the stream.



- Many BMIs (especially those that are insects), tend to have short life cycles, usually one season or less in length. To assess the effect of a pollutant or flood on this year's population of juvenile salmonids, we would have to wait two, three or four years, depending on the species, to see a decreased number of returning adults. With BMIs we wouldn't have to wait nearly as long to detect a problem.

- BMIs are easy to collect and the equipment used is fairly simple and inexpensive.

- BMIs are easier to identify than algae, which also have pollution tolerant and intolerant groups.

Classifying Macroinvertebrates

In order to use macroinvertebrates for assessing the health of a stream, you need to know how to identify them. Biologists categorize all forms of life into various levels of **taxonomic** groupings. The categorization is usually based on anatomical similarity and evolutionary relatedness.

Taxonomic levels, from most general to most specific, include **kingdom**, **phylum**, **class**, **order**, **family**, **genus**, and **species**. All animals are in the Kingdom Animalia. Insects and crustaceans are in the Phylum Arthropoda (critters with exoskeletons and segmented bodies and legs). Insects are in the Class Insecta or Hexapoda (six legs). To take a more specific example, black flies are in the Order Diptera ("true" flies) and the Family Simuliidae. Within this family, there are over 150 species in North America alone!

You may be picturing yourself in horror, trying to distinguish between the 150 species of black flies while they swarm around you biting ferociously. Fear not. If you use the simplified field method in this guide, you will only need to sort BMIs into **major groups** (mostly orders).

Beyond the major group level, you will only need to distinguish one individual from another by noticing differences in body parts or overall **morphology** (body form and structure). For those of you who want more detail, the lab method involves identifying and sorting the BMIs into different families. In neither case will you need to sort through the 150 different species of black flies!

BENTHIC MACROINVERTEBRATE CLASSIFICATION

Kingdom

Animals (Animalia)

Phylum

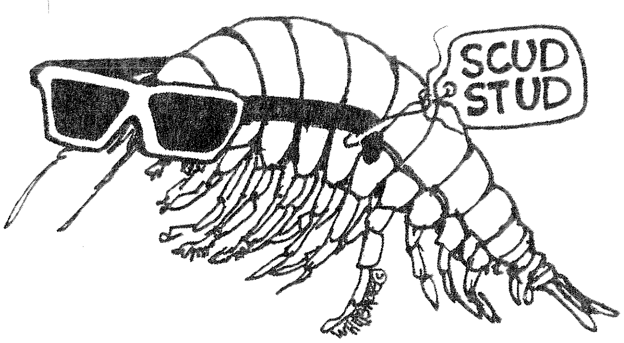
- Segmented Worm-like Creatures (Annelida)
- Segmented Animals with Exoskeletons (Arthropoda)
- Clams, Snails, etc. (Mollusca)

Class

- Leeches (Hirudinea)
- Segmented Worms (Oligochaeta)
- Crayfish, Crabs, etc. (Crustacea)
- Insects (Hexapoda or Insecta)
- Snails (Gastropoda)
- Clams & Mussels (Pelecypoda)

Order

- Scuds (Amphipoda)
- Sowbugs (Isopoda)
- Crayfish (Decapoda)
- Mayflies (Ephemeroptera)
- Stoneflies (Plecoptera)
- Caddisflies (Tricoptera)
- Crane Flies, Black Flies, Midges, and other "True" Flies (Diptera)
- Dragonflies, Damselflies (Odonata)
- Dobsonflies, Alderflies, Fishflies (Megaloptera)
- Beetles (Coleoptera)
- Backswimmers, Water Boatmen, Water Striders, and other "True Bugs" (Hemiptera)



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

Basic BMI Morphology

Clams and snails are perhaps the easiest BMIs to identify to the class level (Class Gastropoda for snails and Class Pelecypoda for clams) because of their well-known morphology. To identify something as an insect (Class Insecta), crustacean (Class Crustacea), or a worm (Class Oligochaeta) can be more difficult. The best clues to look for are the presence of a head and legs, the number of legs, and the presence of wings and an **exoskeleton** (an outer covering that provides support in lieu of an internal skeleton).

All adult insects have exactly six legs, while most crustaceans have more than six legs. Most adult insects have wings, while crustaceans do not. Both insects and crustaceans have heads and exoskeletons. Worms do not have any legs, heads, wings, or exoskeletons.

The insect body is segmented and divided into three major regions - head, thorax, and abdomen. The head appears to be a single segment but is actually composed of several fused segments. Just below the head, the **thorax** is composed of three distinct segments, with one pair of legs attached to each (hence a total of six legs). If an insect has wings, they are also attached to

figure 6.2

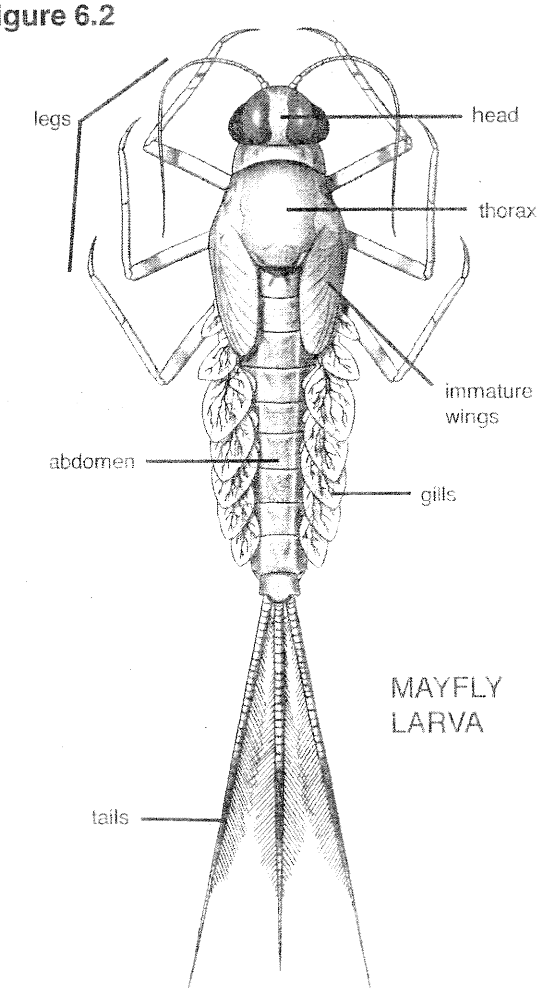
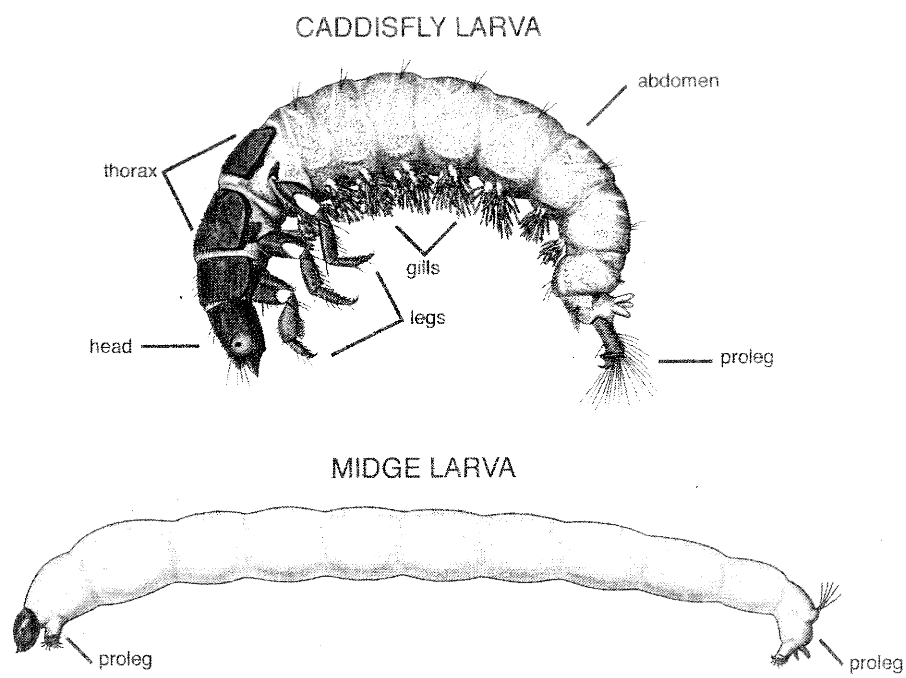


figure 6.3

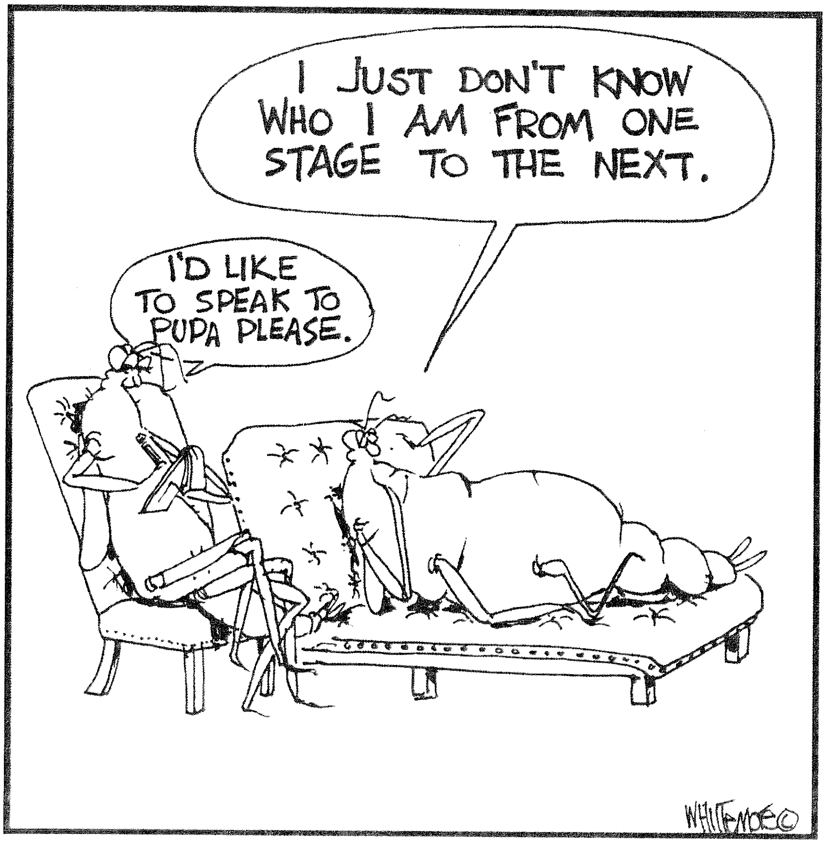


Illustrations on this page are from W.P. McCafferty, *Aquatic Entomology*, Jones & Bartlett Publishers, © 1981. Reprinted with permission.

the thorax. Just below the thorax, the **abdomen** is usually the longest region of an insect's body and is composed of several segments.

Unfortunately, aquatic insects can be difficult to identify as belonging to the Class Insecta because many are immature forms and thus are not fully developed. While many immature forms do have six legs, a distinct thorax and abdomen, and even undeveloped wings, many lack these features, and even appear headless.

In order to distinguish these immature insects from worms, look for other appendage-like attachments, such as gills, tails, filaments, and prolegs. **Prolegs** are fleshy, unsegmented, nubby leg-like structures attached to the thorax and/or abdomen of some immature insects. They are not to be confused with the regular legs of insects, which are segmented and usually longer and more slender. Some immature aquatic insects may have prolegs in addition to their six regular segmented legs.



Aquatic Insect Life Cycle

By now you've probably realized that in order to understand stream BMIs, a Streamkeeper needs to learn about the life cycles of aquatic insects, because many of our benthic buddies are immature, or **larval** forms of aquatic insects. Their adult forms are often winged, and can be seen flying alongside streams during the spring and summer.

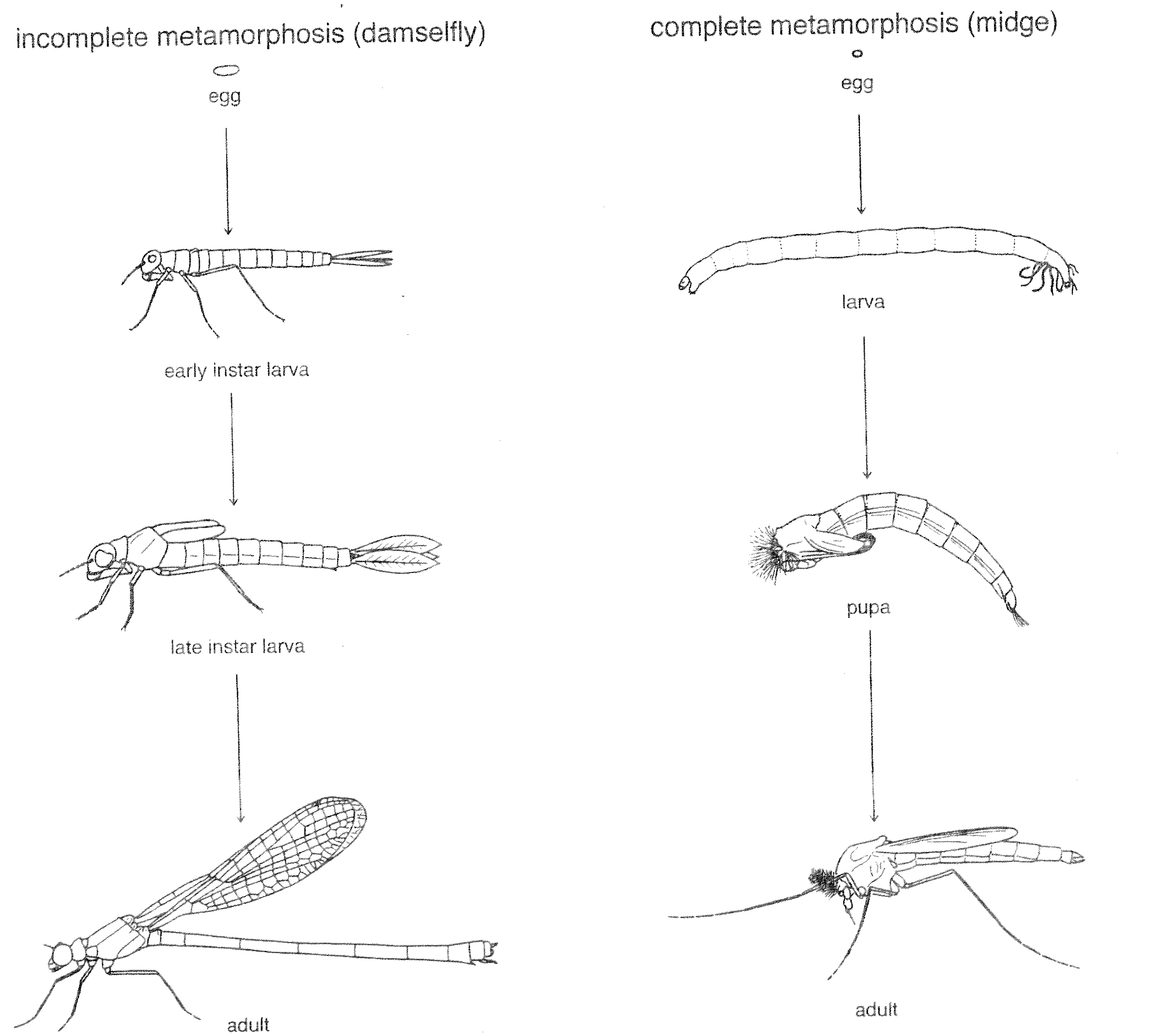
The change from one form to another is known as **metamorphosis**. Some insects go through a complex set of changes known as **complete metamorphosis**. Insects such as flies, beetles and caddisflies begin their aquatic existence as an egg, laid in the water by the winged adult. The egg develops into a **larva**. The larva gradually transforms into a **pupa**. Pupae are generally non-moving and encased, like the cocoon of a butterfly or moth. The pupa undergoes drastic changes in anatomy and physiology, eventually emerging as a winged adult.

Other insects, such as dragonflies, stoneflies and mayflies, undergo a less complex set of changes known as **incomplete metamorphosis**. These insects also begin their lives in streams as an egg which metamorphose into a larva. The larva metamorphoses into a winged adult; there is no pupal stage (see figure 6.4).

The larval forms of insects which undergo incomplete metamorphosis are sometimes referred to as **nymphs**. In general, nymphs resemble their adult counterparts much more than the larval forms of insects which undergo complete metamorphosis.

As an immature insect develops, its exoskeleton does not grow like an internal skeleton would. Thus, a growing larva must shed or **molt** its exoskeleton and replace it with a new, larger one, to make room for its growing body. A larva during the interval between molts is referred to as an **instar** (figure 4.1). The number of instars an insect goes through to become an adult varies, even within a particular species, and can range from four to forty.

figure 6.4



Drawings from W.P. McCafferty, *Aquatic Entomology*, Boston, MA: Jones and Bartlett Publishers, ©1983. Reprinted with permission.

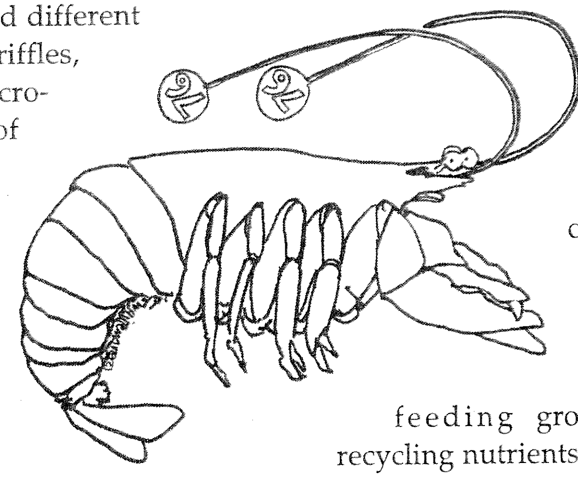
Most aquatic insects spend the greater part of their lives as larvae. It is this larval stage which we most frequently encounter in our stream surveys. The larvae of some insects can remain in the water for more than a year, while others hatch into their adult forms after a shorter growth period.

The whole duration of aquatic insect life cycles ranges from less than two weeks to four or five years, depending on the species. For any particular species, life cycle events can also vary, depending on temperature, dissolved oxygen levels, day length, water availability, and other climatic and environmental conditions.

The adult lifespan of some aquatic insects, such as some species of mayflies, may be as brief as a few hours. This can be a hectic time for these ephemeral adults. They must quickly find another of the same species, mate, and deposit their eggs before they die to begin the cycle anew.

Remember that all macroinvertebrates are not insects. We must not forget our friendly aquatic worms, and freshwater snails, clams, and crustaceans. Most of these "bugs" spend their entire lives in water, from egg to adult, and do not undergo the same type of metamorphosis. Nevertheless, they share the habitats provided by the stream bottom with aquatic insect larvae.

This book has discussed different stream habitats such as riffles, runs, pools, and glides. Macroinvertebrates inhabit all of these. Typically, riffles where cobbles predominate with some boulders and gravel, contain the most diverse assemblages of BMIs. Because they often are the most rich in oxygen, riffles also tend to be home to those BMIs that are sensitive to pollution.



Within runs, pools, and glides, there are a variety of **microhabitats** that provide food and shelter for macroinvertebrates, including rocky and gravel bottoms, finer sediments, living plants, **detritus** (litter, accumulations of leaves, twigs, bark, and other plant parts), and the surfaces of large boulders and woody debris.

There are also many critters, such as some species of freshwater mussels, burrowing mayflies, leeches, and aquatic worms, that prefer the more stagnant areas of fine sediments.

BMIs in the Stream Food Chain

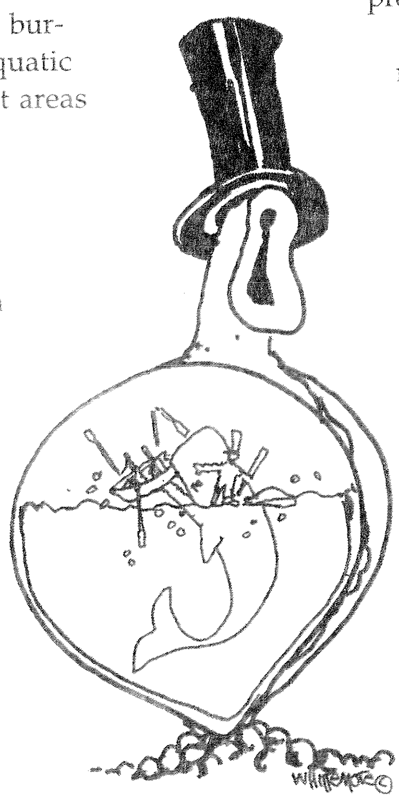
Macroinvertebrates play an important role in stream food chains as the intermediate link between higher and lower feeding levels. They are food for **consumers** such as fish, birds, amphibians, reptiles, and other BMIs. For juvenile sal-monids, resident trout, and many other species of fish, macro-invertebrates can be a principal diet item.

Some macroinvertebrates are **herbivores**. They feed upon plants or algae, which are known as **primary producers** because of their

sis to produce their own food. Other BMIs are **carnivores**, feeding on other macroinvertebrates, and even small fish and amphibians. Still others are **detritivores**, feeding on coarse or fine organic matter that falls into and is carried by their stream habitat. Macroinvertebrates in all feeding groups play an important role in recycling nutrients in the stream ecosystem.

Functional Feeding Groups

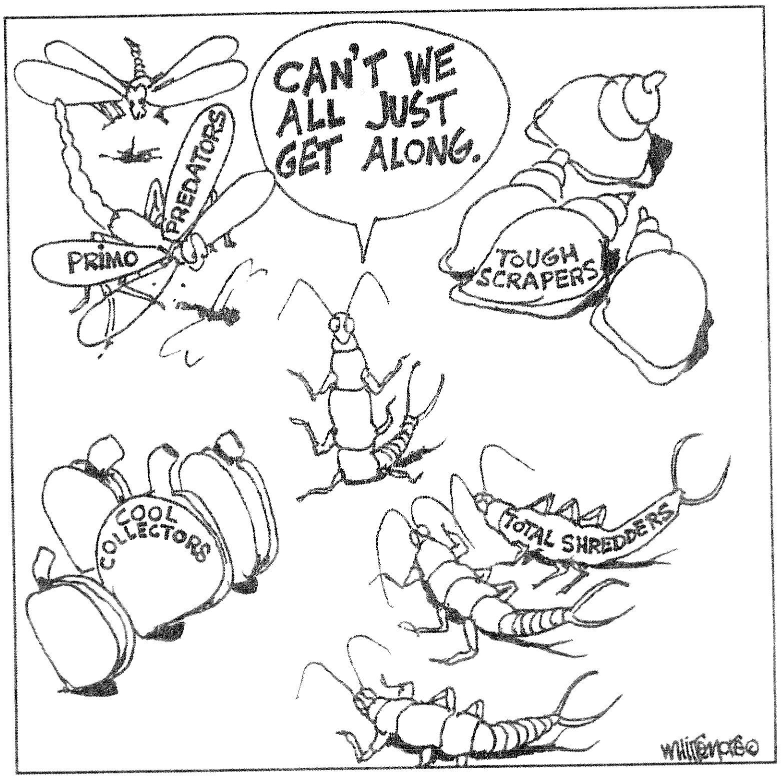
Macroinvertebrates do not always select food on the basis of whether it is plant, animal, or detritus. Many are more apt to select food simply because it fits the design of their food-gathering body parts. Macroinvertebrates are classified by their feeding habits into four **functional feeding groups**. They have developed a variety of adaptations which maximize the effectiveness of their preferred feeding strategy.



Shredders possess chewing mouthparts which allow them to feed on large pieces of decaying organic matter, such as leaves and twigs, which fall into the stream from trees and other plants in the riparian zone. Some have strong enough mouth parts to chew dead animal parts and/or living plant material when detritus is in short supply.

Scrapers or **grazers** remove attached algae from rock and wood surfaces in the current. They are found in areas where sunlight is able to reach the stream bottom, because without sunlight, algae cannot grow. Because these conditions often occur in larger, wider streams, many scrapers have developed adaptations for "hanging on" in relatively swift currents, such as flat, streamlined bodies or suction disks.

Collectors depend on fine particles of organic matter. **Filtering Collectors** are adapted for capturing these particles from flowing water.



Some caddisfly larvae spin nets for this purpose. Black fly larvae attach themselves to the substrate and filter particles using sticky hair-like fans.

Gathering Collectors gather small sediment deposits from the stream bottom or other substrates. Their mouth parts and appendages are designed for such activity, and many are adapted for burrowing into bottom sediments.

Predators consume other macroinvertebrates; they have behavioral and anatomical adaptations for capturing prey. Many have extensible mouthparts or raptorial forelegs adapted for grasping prey, and strong opposable mouthparts for biting and chewing. Some predators pierce their prey and suck body fluids with tubelike mouthparts. **YUM!**

The River Continuum Revisited

Recall the discussion on the river continuum in Chapter 1. The gradual changes that occur in a stream from headwaters to mouth affects the habitat structure and food base of the stream. As the habitats and food base change, so does the proportion of different functional feeding groups of BMIs.

- **Shredders** tend to inhabit headwater streams and other areas with a high percentage of canopy cover. They play an important role in processing coarse organic matter into finer particles, which in turn can be used by other macroinvertebrates.

- **Scrapers** are more common in the middle reaches of a watershed where sunlight is able to reach the stream bottom, and thus algae is able to grow.

- **Collectors** tend to be common in all reaches, because fine particles are present in all stream types to some degree. However, they make up a greater proportion of the BMI population in the lower reaches of a system where fine sediments tend to accumulate and the habitat is not suitable for shredders and scrapers.

- **Predators** are found in all habitat types. Because it takes many other BMIs to supply their food, predators are usually found in small proportions relative to other feeding types.

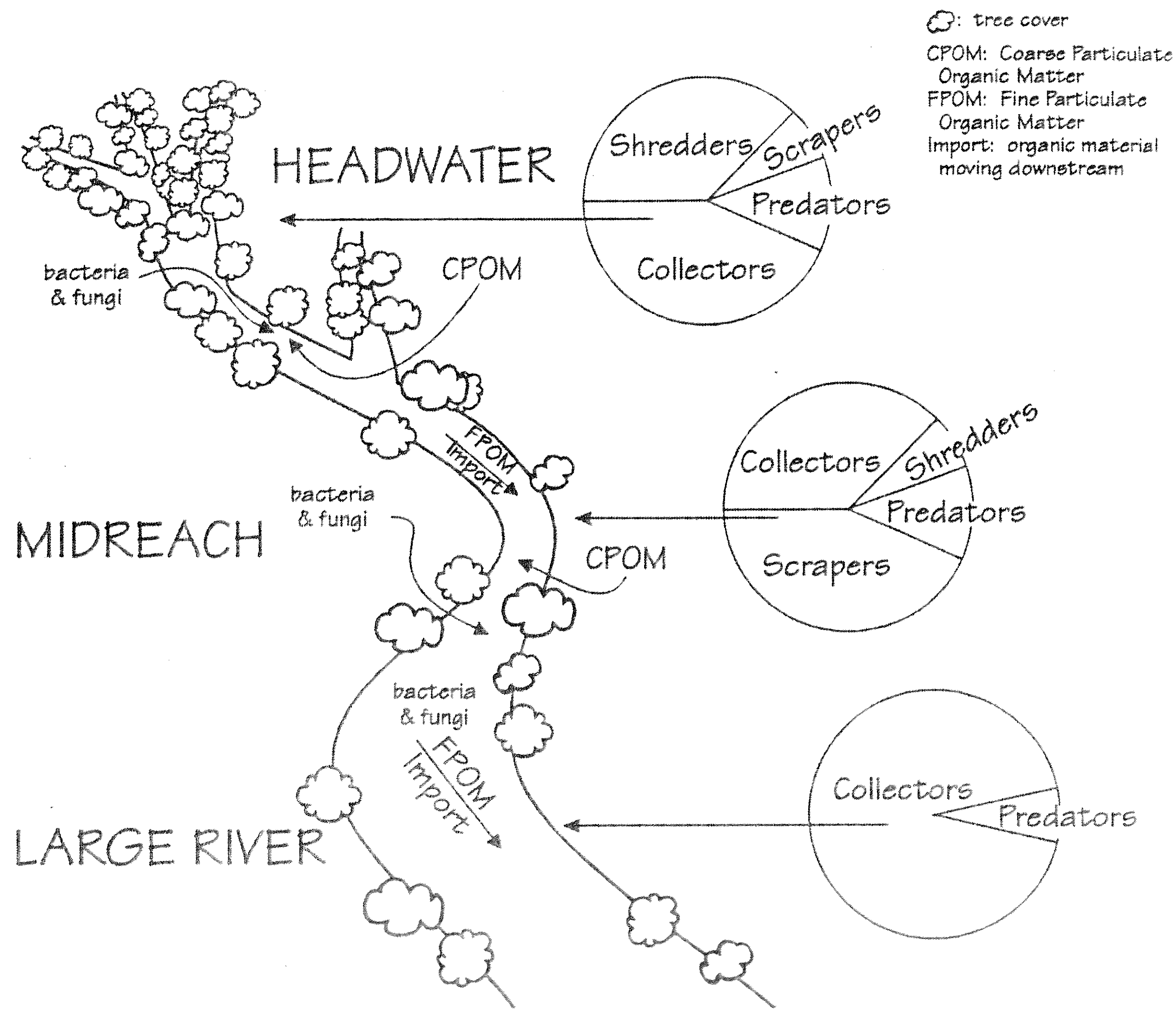
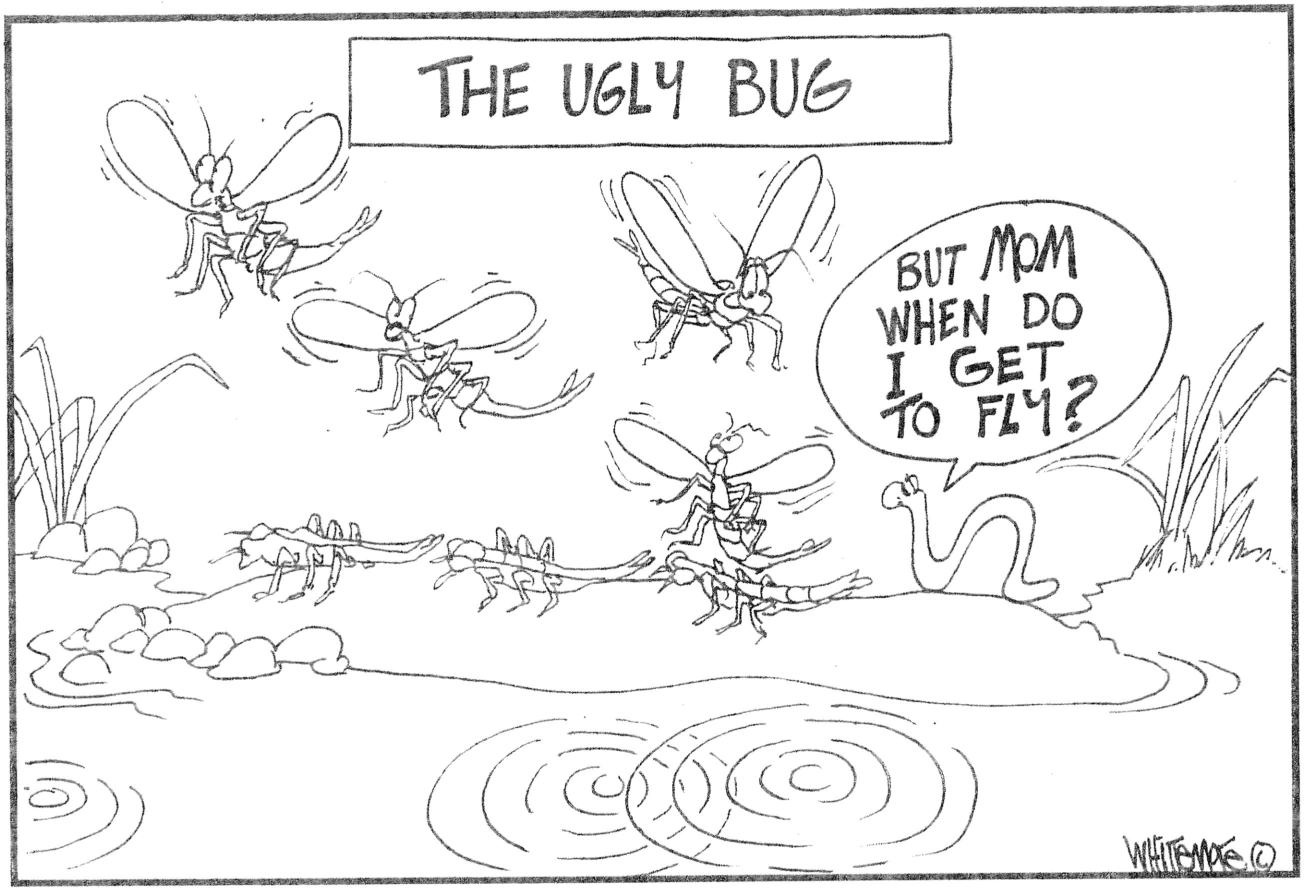


figure 6.6 The River Continuum - Changes in the Macroinvertebrate Community as a Stream Widens

Breathing Adaptations

The art of breathing in an aquatic environment poses a great challenge to macroinvertebrates, because oxygen in water exists as **dissolved oxygen**, which is less abundant than the atmospheric oxygen available to terrestrial beings. To utilize dissolved oxygen in their underwater home, stream BMIs have developed countless anatomical and behavioral strategies:

- Most have soft or membranous areas of the body wall through which oxygen diffuses.
- Many have external **gills**, or membranous outgrowths of the body wall, which increase the surface area for oxygen uptake. These gills can be platelike, filamentous, tubelike, or fleshy.
- Some ventilate parts of their bodies to increase their available oxygen supply. Certain mayfly larvae beat their abdominal gills;



some caddisfly larvae are known for their undulating abdominal movements.

- Some possess functional **spiracles**, openings on the outer body wall which lead directly to a network of tubes that distribute oxygen throughout the body. These spiracles, however, must not be in direct contact with the water or the organism will drown.

- The spiracles of some macroinvertebrates are covered and kept dry by a **plastron**, a thin film of air held by tiny hairs. The plastron looks like an air bubble through which dissolved oxygen can diffuse. Examples of organisms which exhibit this strategy include riffle beetle adults and some midge and crane fly larvae.

- Other aquatic macroinvertebrates with spiracles maintain some bodily contact with the air-water interface via tubelike structures and actually breathe atmospheric oxygen. Mosquito pupae and water scorpions are examples of such organisms.

- Others who breathe atmospheric oxygen through spiracles are able to carry their own air supply under water via a plastron or bubble held by wings or other hair-covered body parts. Many adult water beetles and aquatic true bugs utilize this strategy.

Creatures which breath atmospheric oxygen are generally not benthic; rather, they are free swimming or float in the waterstream. They are also able to inhabit areas with low dissolved oxygen levels.

unrepresented. Some BMIs are very small, so look carefully with your hand lense.

4. Use Data Sheet 6A to record the number of distinct taxa that fall within each major group. Use the dichotomous key or the mayfly/stonefly/caddisfly picture key to determine the feeding strategy of each taxon. For each major group, record the number of taxa that are shredders, scrapers, gathering collectors, filtering collectors and predators.

5. There may be some BMIs that you have difficulty placing into a major group. You can preserve them in a 70% ethyl alcohol solution (a mixture of seven parts ethyl alcohol and three parts water). Bring your preserved specimens to a BMI expert who can help you identify them. You may also want to preserve representative specimens of each known taxon in separately labeled vials.

Having such a BMI library on hand will help you with further macroinvertebrate sort-

6. If you are able to pick every last individual "bug" out of the sample, you can take your analysis one step further. You can find a value for **sample density**, the total number of individual BMIs in the sample. You can also find the density of each taxon, major group, and functional feeding group. With all this information, you can use most of the analyses found in the more detailed lab method. Refer to the section entitled "Lab Procedure, Macroinvertebrate Survey" on page 140.

7. (For this step, you can retreat indoors if you like). Add up the columns on Data Sheet 6A to find the total number of taxa, the number of **EPT** taxa, and the number of taxa in each functional feeding group. EPT refers to mayflies (Order Ephemeroptera), stoneflies (Order Plecoptera), and caddisflies (Order Tricoptera).

NOW WHAT?

Analyzing Your Results

Taxa Richness

The taxa richness, or total number of taxa, tells you important information about the diversity of the BMI population in your stream. Knowing that there are caddisflies in your stream is good information, but knowing there are three different families (taxa) of caddisflies is even better information. The greater the taxa richness, the higher the diversity of your BMI population.

In general, streams with a higher diversity of BMIs are considered healthier than those with a lower diversity. Pollution often causes a decline in diversity by favoring a fewer number of pollution tolerant taxa that are able to outcompete the more sensitive ones.

However, a moderate amount of **organic**

BMI Tolerances to Pollution

Biologists have determined the pollution tolerance of many common macroinvertebrates. Usually, in discussions on BMI pollution tolerance, the pollution in question is excess nutrients or sediments, causing low dissolved oxygen conditions. In general, mayflies, stoneflies, and caddisflies have the lowest tolerance to pollution, while midges, aquatic worms, leeches and blackflies have the highest. Beetles, craneflies, and crustaceans tend to be in the middle ("somewhat tolerant").

Of course, the life of BMIs is not so simple. Because there are so many species within each major group, there are also many variations in pollution tolerance within each major group. Some caddisflies are very tolerant, while some midges are very sensitive. Because of this variation, a pollution tolerance analysis is best left for the more detailed lab method, which involves family level identification.

EPT Richness

The EPT richness, or number of mayfly, stonefly, and caddisfly taxa, provides important information about your stream because these orders are, in general, some of the most sensitive to pollution. The EPT richness usually declines with pollution (although some mayflies and caddisflies are moderately pollution tolerant).

Many species of midges, black flies, crustaceans, aquatic worms, leeches, and snails are more tolerant of pollution, and thus they tend to move into niches vacated by mayflies, stoneflies and caddisflies when areas become polluted. This shift may simplify and destabilize the structure of the BMI community, and thus reduce the biotic integrity of the stream ecosystem.

In general, between 8-12 EPT is considered good, but some naturally unproductive high altitude streams may have lower EPT richness and still be in a pristine state.

Number of Taxa in each Functional Feeding Group

In general, a healthy stream should support a variety of functional feeding groups. Certain human impacts may create an overabundance of a particular food source, which could lead to the predominance of a particular feeding type and an unbalanced biotic community. Recall, however, that the natural variation of the river continuum will influence the relative proportion of feeding groups present.

The nature of your sampling sites will also affect the diversity of feeding groups. The more various the types of habitats you sample, the greater the diversity of feeding groups you should find.

Seasonal changes will also affect the presence of feeding groups. Shredders tend to be more abundant in the fall when organic litter is most plentiful. In streams with canopy cover, scrapers will likely be present in the winter but absent during the summer when leaves shade the stream, limiting algae growth.

Drawing Conclusions

Table 7, adapted from the Canada Department of Fisheries and Oceans, British Columbia Salmonid Enhancement Program, can help you figure out what your BMI results might mean for your stream.

It may be difficult to attach a formal rating to the health of your stream (e.g. "good," "fair," etc.) based on the taxa richness, EPT richness, and the relative proportions of feeding groups present. The relationship between these results and the health of your stream depends on the character of your particular stream.

As you know, the macroinvertebrate community is affected by many factors, such as the condition of the stream bottom, the depth and velocity of the water in the stream, day length, temperature, and water quality factors such as pH, dissolved oxygen, organic nutrients, bacteria, and toxics. As you collect BMI data in combination with your stream reach survey, stream bottom analysis, flow measurement, and water quality tests, you will become more famil-

TABLE 7 ANALYZING BMI DATA

Observation	Analysis
• high diversity, lots of stoneflies, mayflies, and caddisflies	• no problem, good water quality
• low diversity, high density, lots of scrapers and collectors	• organic pollution (nutrient enrichment) or sedimentation; lots of algal growth resulting from nutrient enrichment
• only 1 or 2 taxa, high number of collectors	• severe organic pollution or sedimentation
• low diversity, low density, or no BMIs but the stream appears clean	• toxic pollution (e.g. chlorine, acids, heavy metals, oil, pesticides), or naturally unproductive due to limited light or nutrients (small high altitude streams).

iar with the character of your stream and how different parameters affect its BMI population.

Probably your biggest challenge will be to sort out the natural variation of your stream from human impacts. If you are doing a macroinvertebrate survey to assess the impact of human activity on your stream, you need to know what you would expect to find in your stream under natural conditions and at different times of the year. See Chapter 3 for more information about how to design your stream monitoring program to sort out natural from human-caused variation.

As you survey your stream's benthic macroinvertabrate community over time, make sure that your methods are consistent. Be aware that taxa and EPT richness will increase with increasing sample size (total number of bugs collected). With this qualitative field method, it is difficult to factor out the effect of sample size on your results, because you are [illegible]

sample other habitats, try to standardize your sample size as best you can, e.g., pick up a set number of leaf packs of a given size; make a set number of "jabs" with your long-handled net; and sample boulders and large woody debris until you pick a set number of BMIs.

There are other BMI **metrics** (values or measurements calculated from raw data) that can better attach a formal rating to your stream. However, these metrics can only be used with a more quantitative method in which you preserve the BMIs so you can count and identify them in more detail. If you are interested in such further analyses, see the section entited "Lab Procedure, Macroinvertebrate Survey" on page 140.

While a more detailed method can provide a more sensitive analysis of your stream's BMI community, rest assured that the simplified field method still provides invaluable information. In fact, that data may be the only macroinvertebrate information available on your stream. While

Data Sheet 6A Macroinvertebrate Survey (Field Method)

Name__________ Date__________ Time__________

Stream Name__________ Reach Name/#__________ Site Name/#__________

Driving/Hiking Directions __________

Weather Conditons: _____Clear _____Cloudy _____Rain _____Other __________

Air Temperature________ o___ Water Temperature________ o___

Recent Weather Trends__________

major group	SH	SC	GC	FC	P	# taxa
	# taxa in each Feeding Group*					
mayflies						
stoneflies						
caddisflies						
trueflies: midges						
craneflies						
blackflies						
others						
dobsonflies,alderflies, fishflies						
beetles						
dragonflies/damselflies						
crustaceans: crayfish						
sowbugs						
scuds						
others						
snails						
clams & mussels						
worms & leeches						
others						
Totals →						

Total # mayfly, stonefly, caddisfly taxa → EPT Richness

Taxa in each functional feeding group

Taxa Richness (total # of taxa)

Site Description:

Habitat Type__________

Avg. depth__________

Avg. current velocity __________

Other Comments__________

Site Location (lat/long. transect # and/or rivermile)__________

***Major Feeding Groups**

- SH - Shredder
- SC - Scraper
- GC - Gatherer Collector
- FC - Filter Collector
- P - Predator

DATA SHEET 6B MACROINVERTEBRATE SURVEY (LAB METHOD) (P.1)

Name____________________ Group__________ Date_____ Time______

Stream Name__________________ Reach Name/#________ Site Name_____

Site Description: Habitat type________________ Avg. depth______________

Avg. current velocity________________ Other comments______________

Site Location (lat. & long., transect #, and/or river mile__________________

Driving/Hiking Directions______________________________________

Weather Conditions: ❒ Clear ❒ Cloudy ❒ Rain ❒ Other __________

Air Temp. ____ Water Temp. ____Recent weather trends:________________

Families in major groups	feeding group	density (D)			avg. D	tolerance value	tolerance X avg. D	avg. D (major group)
		rep.1	rep.2	rep. 3				
mayflies							→	
stoneflies							→	
caddisflies							→	
total avg. density EPT (mayfly, stonefly, caddisfly)							→	