Benthic Macroinvertebrates
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Please see *River Watch Network* pages and *The Conservationist* article titled "Canaries of the Stream."

Benthic macroinvertebrates—think of them as your **PET**s; you'll see why in a moment.

"Benthos" is Greek for bottom. So benthic organisms are those living part or all of their lives on—or within sediment on—the bottom of a sea, lake, stream, or other body of water. But what about the term "macroinvertebrates"?

Invertebrates (minus the 'macro') are, of course, animals without backbones and can be terrestrial or aquatic. In this case we're generally concerned with benthic invertebrates that are large enough to be visible without a microscope, hence the prefix "macro," meaning large. (The organisms themselves may not be *micro*scopic, but magnification is often helpful or necessary when trying to distinguish one order, family, genus, or species from another.)

Although insects—particularly the three groups we'll discuss in a moment—may dominate macroinvertebrate samples, other taxonomic groups are also represented in aquatic environments, including: mollusks (snails, clams, etc.); crustaceans (isopods, crayfish, etc.); and annelids (worms).

Among the insect orders, three tend to stand out in the minds of those who study freshwater streams. These are, by name: **P**lecoptera, **E**phemeroptera, and **T**richoptera. The **PET** reference earlier is just a hokey suggestion for a pnemonic that may help you remember these important groups. The following table gives their common names.

Insect Order	Common Name
Plecoptera	Stoneflies
Ephemeroptera	Mayflies
Trichoptera	Caddisflies

Why study macroinvertebrates?

One simple and valid reason is that they are fascinating. But it turns out that in addition to being of academic interest, the kinds and numbers of macroinvertebrates inhabiting a stream can indicate something about water quality. This is analogous to the way in which the numbers and kinds of white blood cells, counted in blood samples, is diagnostic in human health.

The insect orders mentioned above, and even species within each, differ in their tolerances of various water conditions. Stoneflies (Plecopterans) as a group, for example, tend to be among the *least* tolerant of polluted waters. Therefore, when combined with other factors, the presence of a certain percentage of stonefleis in a given stream, or section of stream, often indicates good water quality and relatively healthy stream conditions. A lack of stoneflies, on the other hand, could mean degraded water quality.

Using standard protocols for collection and analysis, an interested person can be trained to participate in water quality monitoring using macroinvertebrates, a process that has come to be termed *Rapid Bioassessment.*

Canaries of the Stream

by Janet Essman and Stephanie Zarpas

Stroll by a stream and you will see water spilling over rocks, glinting in the sunlight. Shadowy forms of fish dart in still pools. Opalescent insects skim the surface.

But there is more life in that stream than you can see from the water's edge. Reach in; turn over a rock. Stir up the bottom with your hand. Look closely: you will see the tiny inhabitants of the stream. Some are barely visible, others are easier to spot: crayfish, worms, tiny clams and snails, the nymphs of aquatic insects and the worm-like larvae of flies.

Anglers know them, especially the mayflies, stoneflies and caddisflies that tell them this stream is likely to be full of fish. Scientists know them, too, as a handy and reliable way to identify a healthy stream.

Living barometers

Stream-dwelling insects, worms, mollusks and crustaceans are macroinvertebrates, visible creatures without backbones. Like the canaries once used by coal miners to detect poisonous gases in the mines, these critters are living barometers that can tell us whether their watery environment is clean or polluted.

But unlike the canaries that had to be carried into the mines, macroinvertebrates live in streams naturally. What happens to the water affects them in observable ways that help us to discover and understand pollution.

Contamination changes the picture

Clean streams are full of life. An abundance of clean-water species thrives in just the right numbers — neither too few nor too many. Each species is in balance with the others in a complex web of life.

But as streams become contaminated, the picture changes. Organic pollution, such as runoff of fertilizers, can produce an overabundance of algae and nuisance weeds. Other contaminants, such as chlorine and pesticides, can kill certain forms of life, allowing more pollution-tolerant species to flourish and disrupt the stream's natural balance.

As early as 1908, scientists noticed that some types of macroinvertebrates found in clean waters were absent in polluted streams where other types were predominant. But it was not until about 20 years ago that macroinvertebrates were commonly used for monitoring water quality.

Conventional testing procedures are limited

Scientists and engineers test stream water for contamination in several ways. They collect and test water samples to identify chemicals, check the pH to see whether the water is acid or alkaline, measure the amount of oxygen dissolved in the water, test for bacterial contamination and an overabundance of nutrients. They also analyze bottom sediments for the presence of certain chemicals, including toxic substances and heavy metals.

Water tests provide a great deal of information about the condition of a stream on the days it was tested. But only repeated testing, which is expensive and time-consuming, can give a picture of stream water quality over time. And sometimes contaminants are so diluted by the water that it is difficult to test for them at all.

Some toxic substances gradually accumulate in animals as they continue to live in polluted environments. Scientists examine fish flesh to identify pollutants too dilute to be apparent in water samples. But fish may move from stream to stream making it hard to tell where they picked up the contamination.

Macroinvertebrates fill in the pollution picture

Aquatic biologists employ biomonitoring — the use of organisms to test water quality — to fill in the gaps left by conventional water quality tests.

"A single sampling of a macroinvertebrate community provides a 'fingerprint' of water quality in that stream for the last several months," says Robert Bode, who heads a staff of three in DEC's stream biomonitoring unit, a part of the division of water.

Why they work so well

Macroinvertebrates make valuable tools for water quality studies because they stay put. They are not very mobile and cannot move to avoid pollution. Like fish and other forms of life, macroinvertebrates accumulate toxic substances in their bodies. Because macroinvertebrates do not travel far, however, they are ideal subjects for studies that will pinpoint the source of pollution.

Most macroinvertebrates have life cycles of a year or less, making them well-suited for studies of streams over a relatively short span of time. If a macroinvertebrate community appeared normal and uncontaminated when it was last checked, but now appears to be affected, the pollution must have occurred during the interim.

Macroinvertebrates vary in their ability to tolerate pollution. Some species, such as worms and midges, can thrive in a wide range of water conditions, from clean to polluted; others can live only in clean waters.

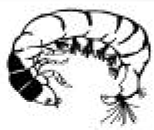
Because moderate to severe pollution alters the macroinvertebrate population so drastically, it is easy to assess the condition of the water by looking to see which species are present. Pollution is readily apparent if a sampling reveals a population composed entirely of pollution-tolerant species and no pollution-sensitive species.

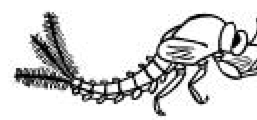
More often, pollution is less severe. More subtle cases are detected by using precise organism identification and detailed analysis of data to map slight shifts in species composition.

EPT values and other indicators

The three key groups most indicative of health are the old favorites of fly fishermen: mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera). Scientists calculate a numerical value — called an "EPT value" from the initials of the Latin names of the three insects — based on the numbers of species of these key organisms present in an average 100-organism sample from a stream.

EPT values greater than 10 usually indicate that a stream is not impacted by pollution. From six to 10, it is slightly impacted;





from two to five, moderately impacted and from zero to one, severely impacted.

Along with the EPT value, scientists look at other biological indicators to make a complete stream quality assessment, including the total number of species in the stream, the diversity of species present and the total numbers of each species in relation to the others.

You can get involved

Macroinvertebrate biomonitoring is so quick and inexpensive, its use is becoming more widespread. You do not have to be a scientist or engineer to do it. Using simplified biomonitoring techniques, you can learn to assess your local streams. It is easy to get involved — ~~check the resources listed on the facing page.~~ All you need are instructions and a few simple tools.

Biomonitoring in New York State

DEC has used macroinvertebrate biomonitoring since the early 1970s. DEC's stream biomonitoring unit evaluates streams across the state in conjunction with DEC's overall water quality monitoring program, keeping track of changes in water quality over time by sampling the same sites periodically.

Stream biomonitoring is one aspect of the division of water's rotating intensive basin studies (RIBS) program. The division routinely gathers data from different stream basins. Such data are used to determine whether the water meets standards for drinking, swimming or supporting fish, and to regulate industrial and municipal wastewater discharges.

DEC also uses macroinvertebrate biomonitoring for special surveys, to document water quality changes following improvements to a sewage treatment plant, gather evidence after a fish kill or assess biological damage caused by violation of a wastewater discharge permit.

Biomonitoring indicates the presence of toxic substances such as PCBs or mercury in New York waters where contamination may be too dilute to detect in water samples. The contaminants accumulate in the tissues of macroinvertebrates up to levels that are thousands of times higher than the levels in the water. When these organisms are eaten by fish, the contaminants become magnified as they go higher up the food chain, sometimes resulting in fish that are unhealthy for human consumption. By collecting macroinvertebrates and analyzing their tissues for these toxic contaminants, biologists can measure the levels of contamination in the aquatic food chain and identify the responsible source.

The stream biomonitoring unit has studied macroinvertebrate communities to track PCBs in the Hudson River, determine the effects of acid rain on Adirondack and Catskill streams, document water quality improvement in the Mohawk River and assess impact of wastewater discharges in the Ramapo River.

Scientists and anglers alike know which members of the macroinvertebrate aquatic community should be present in a healthy habitat. When some of these stream canaries are missing, nature is sending a signal that water quality problems are almost surely present.