# MACROINVERTEBRATE ECOLOGY

*MARYLAND STATE ENVIROTHON*

# Macroinvertebrate Ecology

Invertebrates are animals that do not have an internal skeleton of cartilage or bone.[1] For the Maryland Envirothon Aquatics Issue, we will concern ourselves with only the aquatic macroinvertebrates (can be seen with the naked eye) that are found in Maryland's freshwater streams. The purpose of this document is to give you a brief overview of macroinvertebrate anatomy, behavior, and ecology. You will also learn how to use macroinvertebrates as an indicator of water quality. It is strongly recommended that you visit a nearby stream, collect some insects, and practice identifying them in the field. You should also know what your samples tell you about the quality of water in your stream.

## Why are they important?

Macroinvertebrates play an important role in the ecosystem of which they are a part. Not only do they serve as food for fish, amphibians, and water birds, they are also involved in the breakdown of organic matter and nutrients.

Freshwater macroinvertebrates are used to assess the "health" of a stream. Taking samples of *all aquatic life stages* of macroinvertebrates can serve as an indicator of the water quality for several reasons:

- Some are sensitive *(intolerant)* to pollution, habitat changes, and severe natural events, while others are more tolerant;
- Many live in the water for over a year;
- They are generally sessile – they cannot escape pollution like fish and birds;
- They are easy to collect.

The biological evaluation of water quality is linked to the number of pollution-tolerant organisms compared to the number of *pollution intolerant* ones. If a survey of the stream yielded a *higher proportion* of pollution tolerant macroinvertebrates and no sensitive ones, that *could* indicate poor water *or habitat* quality index. A more favorable water quality index would be characterized by finding sensitive organisms as well as tolerant organisms. An index such as this is more useful when data is gathered over the long term and trends can be analyzed. The Macroinvertebrate Assessment Form is one sample of how you might assess the water quality of your stream using macroinvertebrates.

Two methods commonly used for evaluating water quality are *indicator organisms* and *diversity indices*. The *indicator organisms* method is based on the fact that every species has a certain range of physical and chemical conditions in which it can survive. Some organisms can survive in a wide range of conditions and can "tolerate" more pollution. Other organisms are very sensitive to changes in water conditions and cannot tolerate pollution. Examples of intolerant organisms are mayflies, stoneflies, and some caddisflies (members of the Ephemeroptera, Plecoptera, and Trichoptera orders, respectively). Examples of some pollution-tolerant organisms

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[1] Voshell,Jr., J. Reese. *A Guide to Freshwater Invertebrates of North America*. Mc Donald & Woodward Publishing Co. Blacksburg, VA. 2002.

include leeches, aquatic worms, and some midge *(Diptera)* larva. Water quality is evaluated by comparing the number of tolerant organisms to the number of intolerant organisms. A large number of pollution-tolerant organisms and few intolerant organisms may indicate poor water and/or habitat quality. However, remember that pollution-tolerant organisms can also be found in a wide range of conditions, including pollution-free environments.

Diversity refers to the number of different kinds of organisms found in a biological community. In general, communities with a high diversity are more stable. Pollution and/or frequent habitat disturbance can eliminate intolerant species, and therefore reduce diversity. So if an area becomes polluted, the total number of organisms may stay the same, but diversity may decrease.

## Macroinvertebrate classification

An astounding 95% of over a million species in the world are invertebrates. About 900,000 insects have been identified, and scientists believe there may be an equivalent number still to be identified.[2] A classification scheme is necessary to keep track of them all. Organisms are classified into groups of similar organisms that can be distinguished from other groups of organisms. The main categories of the groups used for classifying are: kingdom, phylum, class, order, family, genus, and species. These categories are hierarchical. Below is an example of the classification system for the common housefly:

- Kingdom: Animalia (animals)
  - Phylum: Arthropoda (arthropods)
    - Class: Hexapoda (hexapods)
      - Subclass: Insecta (insects)
        - Order: Diptera (true flies)
          - Family: Muscidae (muscid flies)
            - Genus: Musca
              - Species: domestica

Figure 1. Classification scheme for the common housefly.

## Adaptations for Aquatic Habitats

Most insects that land on water are trapped by the water surface tension, and tiny ones can even drown inside a water droplet, unable to break out of the bubble surface. Aquatic insects cope by having waterproofed skin so large amounts of fresh water do not diffuse into the body. Many are covered with a water-repellent waxy layer. They also usually have hairy or waxy legs, which repel water so they don't get trapped by the water surface tension. Many of these insects are strong swimmers or crawlers as nymphs or larvae and as adults can also fly, although the degree to which they use their

[2] Ibid.

ability to fly varies quite a bit. Water Boatmen are the only aquatic beetles that can take off from the water - without having to crawl out of the water first.

Aquatic insects have some other useful adaptations to help them live in aquatic environments:

<u>Life cycles</u>

Insects either go through complete metamorphosis or incomplete metamorphosis. Incomplete metamorphosis has three main stages: egg, nymph, and adult.

- Egg - A female insect lays eggs. These eggs are often covered by an egg case, which protects the eggs and holds them together.
- Nymph - The eggs hatch into nymphs. Nymphs looks like small adults, but usually don't have wings. Nymphs shed or molt their exoskeletons (outer casings made up of a hard substance called chitin) and replace them with larger ones several times as they grow. Most nymphs molt 4-8 times.
- Adult - The insects stop molting when they reach their adult size. By this time, they have also grown wings.

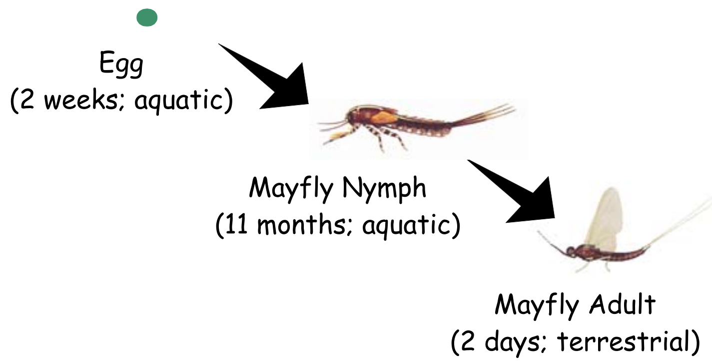


Figure 2. Incomplete metamorphosis.

Most insects go through complete metamorphosis. Complete metamorphosis has 4 stages:

- Egg - A female insects lays eggs.
- Larva - Larvae hatch from the eggs. They do not look like adult insects. They usually have a worm-like shape, but many have legs in the larval form. Caterpillars, maggots, and grubs are all just the larval stages of insects. Larvae molt their skin several times as they grow slightly larger.
- Pupa - Larvae make cocoons around themselves. Larvae don't eat while they're inside their cocoons. Their bodies develop into an adult shape with wings, legs, internal organs, etc. This change takes anywhere from 4 days to many months.
- Adult - Inside the cocoon, the larvae change into adults. After a period of time, the adult breaks out of the cocoon.

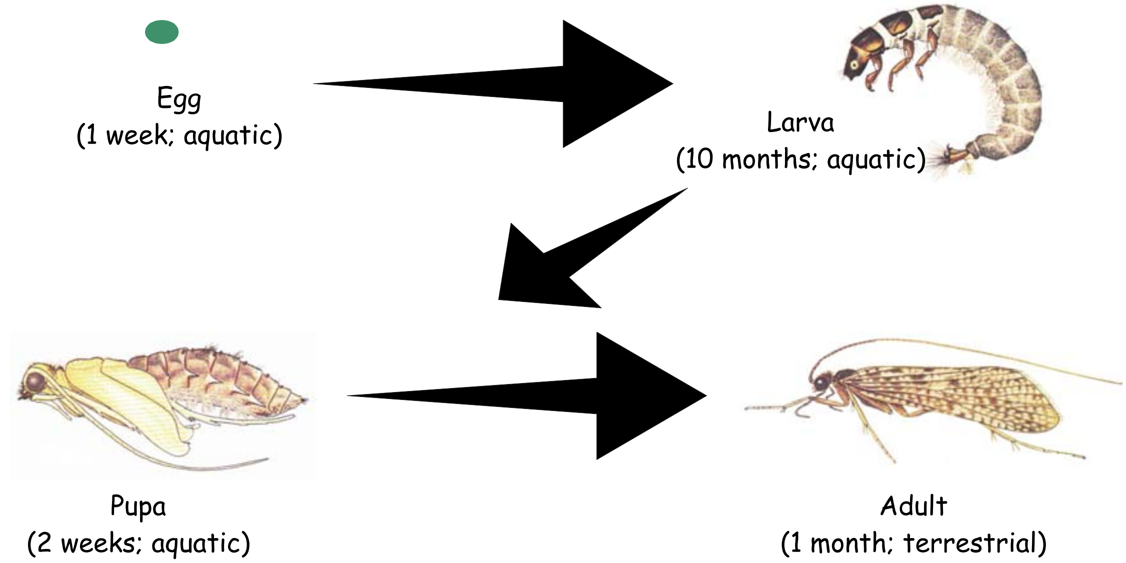


Figure 3. Complete life cycle of a caddisfly

Life cycles for aquatic insects may be very short or very long. For example, a mosquito has a life cycle of two weeks, while some hellgrammites take 4 or 5 years to complete one life cycle. There are three types of life cycles in a temperate stream:

*Slow season life cycle*. This may occur in cooler streams. The insects grow during fall and winter while feeding on leaf detritus. Pupae and adults will emerge from late winter to early summer. Examples of slow season life cycle insects include some mayflies, stoneflies, and caddisflies.

*Fast season life cycle*. A fast season life cycle is where the growth of the immature is fast after a long egg or larval diapause. They may stay in the egg stage from August to March, the larvae stage from March to May/June, and become an adult in June or July. An example of a fast season life cycle insect includes some caddisflies.

*Nonseasonal life cycle*. These are individuals where several stage or sizes are present in all seasons. An example would be hellgrammites.

<u>Breathing underwater</u>

Water is much heavier than air and there is much more oxygen in air (20%) than in the water. So, in order to extract oxygen from water, an insect will have to process a lot of water to get a sufficient amount of oxygen. That is probably one reason why adult aquatic insects continue to breathe air instead of developing gills. Usually only aquatic insect larvae develop gills to absorb oxygen from the water.