Aquatic Insects: A Teacher's Resource Guide

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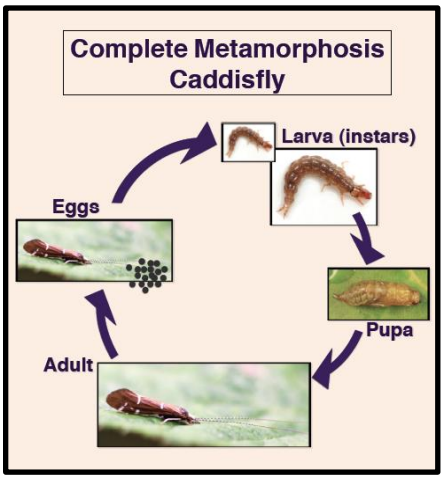
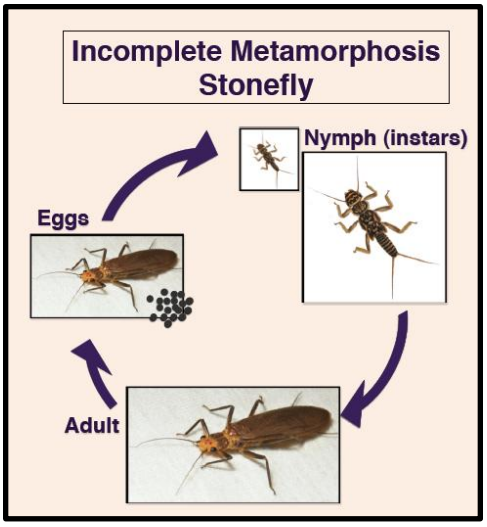
Who are the aquatic insects?

Many insects that we see flying around water actually spend their juvenile stage under the water. Such insects include dragonflies, damselflies, mayflies, stoneflies, caddisflies, and whirligig beetles. The nymphs and adults often look nothing alike, but each can be identified by unique morphological features, such as tails, gills, and overall shape (see table on page 2).

Insect Life Cycles

There are two ways that insects can develop from juvenile to adult stages. The first and perhaps more familiar process is called complete metamorphosis. In this type of life cycle, the insect hatches from the egg as a larva, then grows via a series of molts (each growth stage along the way is called an instar). Once the larva is fully grown, it becomes a pupa: a transitional stage in which it encases itself, becomes immobile, and undergoes drastic transformations, including the growth of wings. Butterflies are the most common example of this development pattern, but caddisflies and beetles also undergo complete metamorphosis.





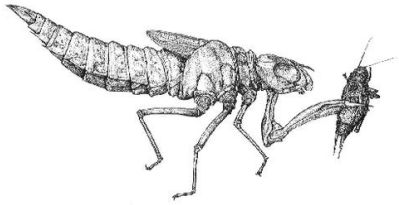
In contrast, many other insects undergo incomplete metamorphosis. Examples include dragonflies, damselflies, mayflies, and stoneflies. Rather than undergoing pupation, these insects go directly from a nymph stage to the adult form (juveniles of insects that undergo incomplete metamorphosis are called "nymphs," rather than "larvae.") After hatching, the nymph grows via a series of molts, and the wings begin developing inside the body. When the insect is ready to emerge as an adult, it comes out of the water, splits open its old exoskeleton (equivalent to hard skin), and crawls out of this shedded skin. It then only needs to expand and stiffen its wings before taking flight.

Note that all groups of aquatic insects, regardless of developmental path, may spend several years underwater as nymphs or larvae before emerging as adults. In some groups, like mayflies, stoneflies, and caddisflies, emergences are timed so that hundreds, or thousands, of individuals emerge simultaneously. This coordination enables the short-lived adults to quickly find mates, and may help overwhelm the fish so that the vulnerable young adults can find safety in numbers.

		**Whirligig Beetle (complete metamorphosis):** Larvae are grub-like with projections coming off the abdomen. Adults live on the water's surface and have split eyes for seeing above and below the water.
		**Caddisfly (complete metamorphosis):** Larvae either live in cases or make nets to catch food suspended in flowing water. Adults look like moths, with hairy wings and long antennae.
		**Dragonfly (incomplete metamorphosis):** Nymphs and adults are both predators. Nymphs have lower jaws that extends out to catch insects. Adults are aerial predators.
		**Damselfly (incomplete metamorphosis):** Nymphs have three gills at their tail end. Adults hold their wings over their back (compared to dragonflies, which hold their wings open).
		**Stonefly (incomplete metamorphosis):** Nymphs have two tails, and gills in their armpits. Adults hold their wings flat over the back.
		**Mayfly (incomplete metamorphosis):** Nymphs have three (sometimes two) tails, and have gills along the abdomen. Adults hold their wings straight up over their back.

Foraging Adaptations

Aquatic insects fill many ecological niches. Some are predators, others are omnivores, and others are herbivores. Although all insects have specialized morphologies and behaviors for foraging, dragonflies and the net-spinning caddisflies have particularly interesting foraging adaptations.

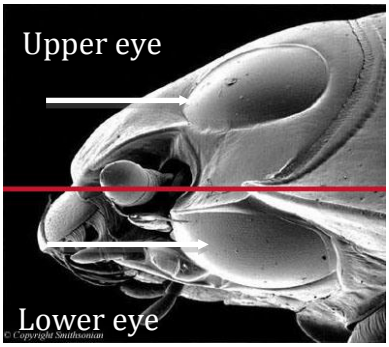


Dragonfly nymphs have a lower jaw called the labrum that is specialized to reach out and grab smaller insects. It essentially functions like a bowl with pincers at the end of an extendible arm (see image at left). They are ferocious predators that prey on anything they can capture, including other aquatic insect larvae and small fish.

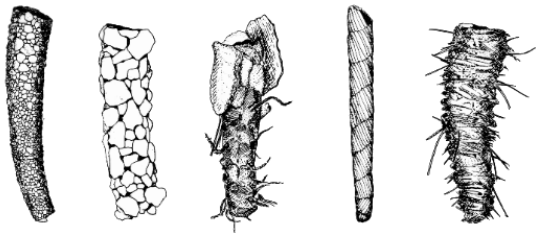
The net-spinning caddisflies live primarily in fast-flowing sections of streams. They attach themselves to the sides of rocks, where they build a net to catch algae, detritus, and small invertebrates suspended in the flowing water. These nets filter the water and funnel the prey towards the place where the caddisfly larva sits. Depending on the type of food they're trying to catch, different species construct different types of nets.

Avoiding Predators

Aquatic insects are susceptible to a range of predators, including fish, birds, larger insects, and an assortment of other animals. They thus need to avoid predators in any way possible. Some methods include vigilance, staying hidden, camouflage, speed to escape predators, being active at times when their predators are not, and having noxious qualities that make them unappetizing to predators. The case-making caddisflies and the whirligig beetles are two examples of interesting predator-avoidance adaptations.



Whirligig beetles have a particularly cool adaptation for increasing vigilance. These beetles are omnivores that live on the surface of the water, where they are very vulnerable to predators both above and below. To decrease their chances of being eaten, as well as aid in foraging, they have split eyes that can see both above and below the water's surface (see photo to left, depicting the beetle's upper and lower eye).



The case-making caddisflies are represented by several families that live in streams, ponds, and lakes. They use materials around them to construct a protective case and help them blend in with the local environment. For example, caddisflies in shallow ponds surrounded by forest may use small twigs to construct a "log cabin" case. Some species in streams use small pebbles to construct a cylinder-like shape. Other species build something like an elongated pyramid using plant matter. Interestingly, artisans have discovered that, if given gold or tiny gems, caddisflies will use these materials to construct extremely valuable cases!

Environmental Threats to Invertebrates

Aquatic insects are also vulnerable to a wide range of human-induced factors. Because they live for several years under water, many of these insects are extremely sensitive to water quality. In fact, the assemblage of species present can serve as an indicator of the stream's health, and scientists can monitor stream quality using what is called a biodiversity index. For example, stoneflies are known to have low tolerance to poor water quality, so the presence of stoneflies indicates a healthy stream. If the stream only contains worm-like animals and fly larvae, however, it may be experiencing pollution problems, as these animals have high tolerance to poor water quality.

Some factors that can reduce water quality include trash dumping near streams, runoff from areas with improper drainage, city storm drains where people dump a variety of liquids, and changing habitat around the stream. Agricultural areas can be especially problematic, as fertilizers and pesticides may leach into the stream, and rain may wash an excess of sediments into the stream. As these sediments cover the streambed and darken the water, they make it difficult for insects to breath, hunt, and access shelter. Furthermore, changing the habitat around the stream can alter the stream's ecosystem. When a forest is cleared and leaf litter ceases to enter the system, there may be less decaying organic matter in the stream, changing the natural flow of the food chain.

Exploring Streams and Ponds

Streams and ponds are easy and fun to explore! Riffles (the shallow, rocky potions of streams) are a great place to flip rocks and look for aquatic insects underneath. You can also find many critters by using a net to dig through the mud and vegetation in ponds. Below is a list of helpful websites and books with more information. Feel free to contact me (Hope Batcheller, hjb58@cornell.edu) if you, or your students, have any additional questions!

Additional Resources

The Xerces Society: www.xerces.org/aquatic-invertebrates. Although this organization is primarily focused in the northwest, they have resources and publications that are very helpful for understanding stream conservation and monitoring strategies.

Troutnut.com: www.troutnut.com/common-names. Understanding the biology of aquatic insects is an essential component of fly-fishing, and there is a huge array of books, websites, magazines, and other resources devoted to the topic. This site has a helpful listing of aquatic insects' common names, and may be of particular interest to those who fly-fish.

Identification Key: people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML. This dichotomous key, published by The Stream Study, has helpful illustrations that walk through the steps towards aquatic insect identification.

A Guide to Common Freshwater Invertebrates of North America, by J. Reese Voshell Jr. Published 2002. This is a good overall guide to biology and identification of freshwater insects and other invertebrates.

Pond Life (Golden Guide), George K. Reid. Published 2001. This is an informative book about the basics of pond biology, including insects, plants, fish, and others.

Photo Sources

Caddisfly larva: www.flickr.com/photos/ophis
Caddisfly pupa: bugguide.net/node/view/396136/bgimage
Caddisfly adult: flickrhivemind.net/Tags/caddisfly,macro/Interesting
Stonefly nymph: www.scioly.org/wiki/index.php/Water_Quality/Macroorganism_List
Stonefly adult: www.flickr.com/photos/77995220@N00
Whirligig beetle larva: ecolinc.vic.edu.au/
Whirligig beetle adult: www.lurvely.com/
Dragonfly nymph: www.flickr.com/photos/7935974@N05/
Dragonfly adult: www.flickr.com/photos/75562171@N00
Damselfly nymph: www.flickr.com/groups/1382462@N21
Damselfly adult: www.flickr.com/photos/30636847@N00
Mayfly nymph: www.flickr.com/photos/51747468@N06
Mayfly adult: www.flickr.com/photos/21242200@N06
Dragonfly nymph mouthparts: www.kenwildman.com
Net-spinning caddisfly: www.flickr.com/photos/janhamrsky
Whirligig beetle eyes: www.gyrinidaegyretes.wordpress.com
Caddisfly cases: www.drgeoffbalme.com
Stream: http://www.flickr.com/photos/68162516@N07