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BIODIVERSITY
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THE WILD AND WONDERFUL WORLD OF STREAM BUGS

Trey Simmons[1*], *Eric C. Dinger*[2] *and E. William Schweiger*[3]

[1] *Central Alaska Inventory and Monitoring Network, National Park Service, Fairbanks, AK, United States*
[2] *Klamath Inventory and Monitoring Network, National Park Service, Ashland, OR, United States*
[3] *Rocky Mountain Inventory and Monitoring Network, National Park Service, Fort Collins, CO, United States*

YOUNG REVIEWERS:

CLAREMONT MIDDLE SCHOOL

AGES: 11–12

MS. WARD'S AND MS. SHEIN'S 6TH GRADE SCIENCE CLASSES, PACIFIC CREST MIDDLE SCHOOL

AGES: 11–13

Under the surface of most streams a strange world exists, made up of hundreds of small critters called aquatic invertebrates. "Aquatic" means they live in the water and "invertebrate" means they have no backbones or even skeletons. Some have body parts that look like they came from an alien planet. Some have slippery bodies adapted to rushing stream water. These organisms play many important roles. Some live for up to 7 years and others live for as little as 2 weeks. Some eat slime growing on stream rocks and others eat leaves. Some, like the golden stonefly, even stalk and eat other invertebrates, like a tiger in a jungle. In national parks and around the world, scientists use these insects, worms, leeches, and mites to tell if the water is healthy. We can do this because certain stream invertebrates disappear if water is polluted, or if the stream habitat is degraded.

AQUATIC INVERTEBRATE

Animals that do not have backbones, or even skeletons ("invertebrate") and that spend all or most of their lives in the water ("aquatic").

CRUSTACEAN

A type of invertebrate with a hard shell and more than 10 legs. Crustaceans include crabs, lobsters, crayfish, and roly-poly bugs.

BIOMASS

The total weight of all the organisms in a particular area, including all the plants and animals that live there.

BIODIVERSITY

All the different kinds of life found in a particular area, including all the animals, plants, and microorganisms.

HABITAT

A way to describe the natural home of an animal or plant. Each animal or plant prefers its habitat to be a certain way.

LARVA

A larva is an immature insect. Usually a larva looks very different from an adult insect. A larva changes into an adult through metamorphosis.

METAMORPHOSIS

The process by which a larva changes into an adult. Its body shape usually changes dramatically over a very short time. It may also grow legs or wings.

WHAT ARE AQUATIC INVERTEBRATES?

Have you ever picked up a rock in a stream and looked at it? If you have, you have probably seen some bugs crawling on it. These bugs are called **aquatic invertebrates**. Aquatic invertebrates are mostly insects, but they also include worms, leeches, clams, snails, mussels, **crustaceans** (like crabs) and mites (tiny spiders) that live in the water. When people think about what lives in streams, rivers, and lakes, most think about fish, or maybe tadpoles. But invertebrates are much more important. They make up most of the **biomass** and most of the **biodiversity** in freshwater. There might be hundreds of kinds of invertebrates in a stream or lake, but only a few kinds of fish, and sometimes no fish at all.

Invertebrates live in almost every stream or lake on earth. They can live in extreme conditions, even hot springs that would scald your hand! In desert places like Death Valley National Park (California, United States) or Canyonlands National Park (Utah), invertebrates can live in temporary puddles. When there is water in the puddle, they hatch and grow quickly. Then they lay eggs that can survive when the puddle dries up. No matter where you look, if there is water, there are probably aquatic invertebrates. Although many invertebrates can swim, most of them spend their lives among the rocks or in the mud at the bottom of the stream. That is why we often do not notice them. Each species has its own unique **habitat** needs, so scientists can tell a lot about a stream by which aquatic invertebrates are there—or not there. For example, some like really cold, clean water, and others like warm, dirty water. In this article, we will focus mainly on aquatic insects, the largest group of aquatic invertebrates.

LIFE CYCLE

Aquatic insects typically spend most of their lives as youngsters in the water (Figure 1A). They live only a short time as adult flying insects (Figure 1B). These youngsters are the **larva** stage of the insect's life. In the same way, a caterpillar is the larval stage of an adult butterfly. Larval insects transform into winged adults through **metamorphosis**. Metamorphosis is the process by which caterpillars transform into butterflies. The flying adults that emerge from the water live for only a few days or weeks. Because of their short lives, some adult aquatic insects do not even have mouths to eat with (Figure 1C)! The adult's main purpose is to lay eggs to create the next generation of insects. Males fertilize the eggs that are carried by females. How do males and females meet? To make it easier to find each other, the adults of a particular species emerge from the water at the same time. This is why you often see large swarms of aquatic insects flying around over a stream or lake.

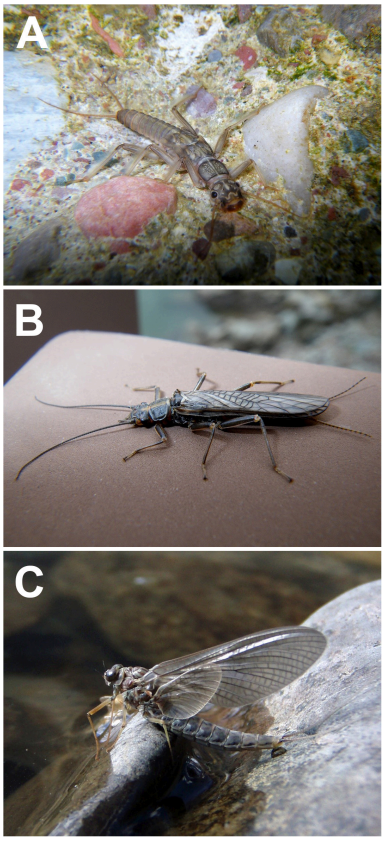

Figure 1

Figure 1

(A) A stonefly larva (about 3 cm long) on the bottom of a stream in Glacier National Park (Montana). **(B)** An adult stonefly, with awesome red eyes, resting on a rock. When it is resting, it keeps its wings flat. This giant one might be more than 6 cm long. **(C)** An adult mayfly emerging from the water right after metamorphosis. Many kinds of mayflies do not eat as adults and have no mouths. A mayfly sticks its wings straight up when it is resting. They are usually <3 cm long (Photograph credits: Joe Giersch, USGS).

Climate can have a big effect on how long an aquatic insect stays in a stream before emerging as an adult. Some midges (teensy flies that are annoying but do not bite) that live in really cold places like Gates of the Arctic National Park in Alaska might stay in the stream as larvae for up to 7 years before changing into adults. That is because it takes longer for them to grow in the cold. But in a warm place like Everglades National Park in Florida, those same midges might only live in the water for a few weeks, since they grow faster in the warm water.

VARIETY AND SPECIAL ABILITIES

Aquatic insects come in all shapes and sizes. Some are really flat and streamlined to help them cling to rocks in strong current. Lots of mayflies and stoneflies have this shape (Figure 2A). Another kind of aquatic insect called a caddisfly builds a house out of tiny rocks or twigs or leaves (Figure 2B). Some caddisflies glue their house to a rock and stay put. Other caddisflies take their protective houses with them when they move around, like a snail does. When there is danger around, they pull themselves back inside to hide. Some aquatic insect larvae look like worms because they do not have any legs (Figure 2C). They grow legs when they turn into adults (Figure 2D).

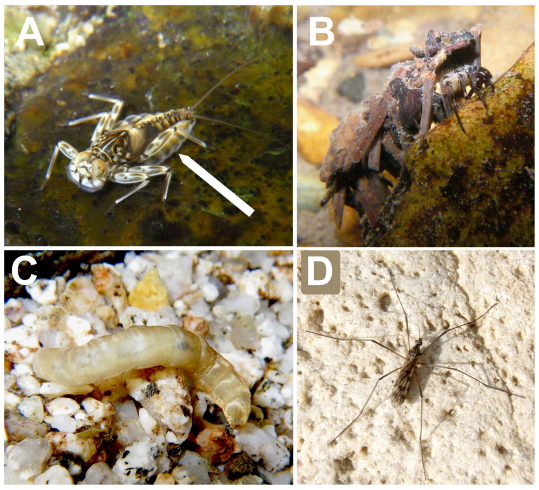

Figure 2

Figure 2

(A) A streamlined mayfly larva (about 2 cm long). Note the rounded gills that stick out along its body behind its back legs. The mayfly breathes through the gills and can use them as "suction cups" to stick to rocks. **(B)** A caddisfly larva (about 3 cm long) crawling across the bottom of a stream. Different kinds of caddisflies build their houses out of different things. The one in this picture used tiny sticks, but others use rocks or leaves. **(C)** A cranefly larva (about 4 cm long) is legless. It grows legs as an adult. **(D)** An adult cranefly (about 5 cm across) with really long legs (Photograph credits: Joe Giersch, USGS).

Have you ever seen insects that look like they are running around on top of the water? These are called water striders or water scooters. They have special long legs covered in tiny hairs that do not get wet. Their legs repel the water and that is why they can stay on top without sinking. They are also really fast! If a water strider were as big as you, it would be able to run across the water at over 320 kilometers per hour (or 200 miles per hour).

Most aquatic insects breathe through gills, like fish. But one peculiar kind, called a water boatman, breathes from an air bubble that it carries around with it under the water. Occasionally, it has to swim to the surface to refill its air bubble. Water boatmen are really good swimmers because their hind legs are shaped like flippers. Another aquatic insect that carries an air bubble is called a backswimmer. It is like a water boatman, except it swims upside down.

EATING AND BEING EATEN

Aquatic insects eat all kinds of things, including each other, and all kinds of things eat them. Some aquatic insects are grazers—they eat the algae that grows on top of the rocks. Algae is what makes rocks in a stream feel slippery. Grazers are like the buffalo in Yellowstone National Park (Wyoming) eating grass. Some are scavengers—they eat the dead leaves that fall into streams and lakes and the fungus that grows on them. Scavengers are sometimes called shredders because they shred dead leaves into tiny pieces. If they did not, streams and lakes might fill up with leaves completely. Another kind of aquatic insect is called a collector. Collectors have nets that let them grab tiny bits of food out of the water as they float by. Some collectors build nets out of silk to catch their food (like a spider builds a spiderweb). Other collectors have built-in nets on their legs that they wave back and forth in the water to grab their food.

PREDATOR

An animal that kills and eats other animals. Most predators do not eat plants.

Some aquatic insects are **predators** that eat other aquatic insects. They can even eat tadpoles and small fish! Many of these predator insects stalk their prey like wolves in Glacier National Park (Montana), hunting for them amongst the rocks. Those super-fast water striders grab their prey on top of the water, stab them, and then suck out their juices. A dragonfly larva will ambush its prey like a crocodile. It waits until its prey gets close and then suddenly grabs it. Dragonflies have a special weapon that lets them do this: their lower jaws are really long and spring loaded, and they have sharp hooks. The jaw shoots out with lightning speed and snags the prey as it swims or walks by (Figure 3). Another predator insect is the giant water bug, which is also called the "toe biter"—can you guess why? This predator is big enough to hunt and eat small fish and tadpoles...or to bite your toes! Like the water strider, the giant water bug stabs its prey and sucks out the juices.

Figure 3

A dragonfly larva (right, about 4 cm long) catches and eats a mosquito larva (left, about 1 cm long) using its special spring-loaded jaw. Click here to watch! (Gif credit: Josh Cassidy/Deep Look, KQED).

Figure 3

What eats aquatic insects, besides other aquatic insects? Lots of animals do! Fish are probably the most important predator of aquatic insects—they can eat a lot of them. That is one reason that aquatic insects spend most of their time underneath rocks in a stream—it makes it harder for fish to catch them. Fish also eat lots of flying adult insects that settle on the surface of the water. Besides fish, many other animals eat aquatic insects, including tadpoles, frogs, salamanders, baby alligators, birds, bats, and spiders. There is even a tiny mammal called the water shrew, found in mountain parks like Olympic National Park (Washington) and northern ones like Glacier Bay National Park (Alaska), that can swim and dive for aquatic insects. People mostly do not eat aquatic insects, but we do eat other kinds of aquatic invertebrates, like crayfish and mussels.

HEALTHY AQUATIC INSECTS, HEALTHY STREAMS

Aquatic invertebrates are extremely important to freshwater ecosystems. They come in different shapes and sizes, eat different things, and lead many different types of lives. Each aquatic invertebrate is specially adapted to its environment. When the environment changes, so do the kinds of invertebrates that live there. Scientists in national parks use these differences to understand what is happening in these ecosystems [1]. If a stream changes from a healthy environment to one that is unhealthy, for example as a result of

pollution from industrial chemicals, the kinds of invertebrates that live there will also change. Some kinds do not mind polluted water, while other kinds might die in it. By going to a stream and observing the invertebrates, scientists can determine whether it is polluted or otherwise damaged, and what is causing the problem. This can help with efforts to clean up the stream and to restore its water quality. Lots of countries around the world use invertebrates to measure stream health in this way.

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CONFLICT OF INTEREST: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

CLAREMONT MIDDLE SCHOOL, AGES: 11–12

We are 6th grade scientist kids from the heart of Oakland, and we like anime, playing music, making art, being in in-person school, and reptiles. Not necessarily in that order!

MS. WARD'S AND MS. SHEIN'S 6TH GRADE SCIENCE CLASSES, PACIFIC CREST MIDDLE SCHOOL, AGES: 11–13

These 6th graders live along the foothills of the Cascade Mountains of Central Oregon, and in the Deschutes River watershed. This is traditional homelands to the Tenino, Warm Springs, Wasco, Klamath, Paiute, Molalla, and Yahooskin Tribes. Typical to contemporary times in Central Oregon, these Young Minds reviewers enjoy many outdoor activities including running around playing with friends or while playing organized after-school sports, keeping up with their friends on social media apps, and staying busy with their families on weekends.

AUTHORS

TREY SIMMONS

Trey Simmons is an aquatic ecologist working in the Central Alaska Network Inventory and Monitoring Program for the National Park Service. His job is to characterize river and stream ecosystems in three large wilderness parks in Alaska and to determine how these ecosystems are changing over time. Altogether the parks where he works cover 22 million acres, which is bigger than the state of South Carolina. Because there are very few roads in these giant parks, Trey uses helicopters and airplanes to get to most of the streams where he works. When he was not working, Trey loves skiing and hiking and playing with his dog Regan. *trey_simmons@nps.gov

ERIC C. DINGER

Eric C. Dinger is an aquatic ecologist for the National Park Service Klamath Inventory and Monitoring Network, conducting monitoring and assessment of streams, lakes, and intertidal zones in national parks in Southern Oregon and Northern California. He grew up backpacking in the mountains and enjoying his time visiting wilderness streams and lakes. During university studies, he fell in love with aquatic invertebrates and what they can teach us about our ecosystems. Since then, he has been active in monitoring and assessing ecosystems for the past 25 years. When not working, Eric keeps visiting the mountains and coasts with his family, sometimes rock climbing or running as well.

E. WILLIAM SCHWEIGER

E. Willian Schweiger is the principal ecologist for the National Park Service Rocky Mountain Inventory and Monitoring Network. He is the lead for developing and implementing multiple long-term ecological monitoring protocols in six national parks in the northern and southern Rocky Mountains. He also collaborates with other scientists to support long-term goals to keep these parks healthy. When not doing science, he likes to race cars, play Ultimate Frisbee, and get lost in the wilderness.