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PLANT LITTER CAN BE IMPORTANT FOOD FOR STREAM BUGS

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YOUNG REVIEWERS:

VIKTOR
AGE: 15

VINCENT
AGE: 9

Plant parts from the land can be important energy sources and habitats for small plant-eating animals that live in water. Animals in forested streams depend on energy from plant parts because the shade limits the amount of light needed for photosynthesis. One group of animals that benefits from these resources are water critters called macroinvertebrates. Macroinvertebrates are small, but most of them are visible to the naked eye. Examples include insects and worms. Macroinvertebrates can influence the amounts of materials floating in streams by helping to break down plant litter that falls into the water. These tiny water critters play an important role in making energy available to stream animals like fish and shrimp.

ONE COMMUNITY'S LITTER IS ANOTHER'S DINNER

Many rivers and streams depend on nearby forests for energy [1]. For example, a small stream surrounded by forest may receive enough shade to block sunlight from reaching the stream bottom (Figure 1). This reduced sunlight limits the process of **photosynthesis**, which some stream plants and algae use to obtain energy and building blocks from sunlight. Forests can provide streams with lots of outside-the-stream, or "external" energy when they shed their dead leaves, branches, and other plant parts [2]. As these dead plant parts, called plant litter, fall to the stream bottom, they become **detritus**. Detritus in streams provides shelter for many small aquatic organisms. For example, insects hide in detritus to escape from predators like fish or shrimp, but these insects can also use detritus as food.

PHOTOSYNTHESIS

The process by which green plants and other organisms use sunlight to create food from carbon dioxide and water.

DETRITUS

Dead and decaying plant materials (plant litter), such as leaves, bark, needles, and twigs that have fallen to the ground or into the water.

Figure 1

A forested stream on the island of Puerto Rico (photo credit: Pablo E. Gutiérrez-Fonseca).

Figure 1

Detritus in a stream quickly becomes covered by **microorganisms**. Microorganisms, like bacteria and fungi, help break down detritus through the process of decomposition [3]. Bacteria and fungi remove nutrients from the detritus and, by hanging out on the plant materials, they make the detritus tastier to other organisms, like bugs. Scientists compare this to spreading peanut butter on a cracker. In other words, the microbes act like the peanut butter, or the tasty stuff, and the detritus acts like the cracker that simply holds the tasty stuff. Aquatic insects help break down detritus by eating it. However, because they are messy eaters, aquatic insects can break up larger pieces of detritus, turning them into smaller pieces that can be eaten by even smaller organisms, as these pieces sink to the bottom or float downstream.

MICROORGANISMS

Organisms that are of microscopic size or too small to see without using a microscope. Examples of microorganisms include bacteria and fungi.

HOW DO SCIENTISTS STUDY AQUATIC INSECTS AND THEIR DIETS?

Insects are the most diverse group of organisms on the planet. There are close to one million species of insects, which represents about 80% of all the species in the world. Many of these insects live in

rivers or streams when they are young. These immature forms are called **nymphs** or **larvae**. As aquatic insects mature and transform into adults, many transition to living on the nearby land. You have probably seen some of these insects—large swarms of mayflies coming out of streams, dragonflies and damselflies flying close to your home, or stoneflies and dobsonflies when you go fishing. In streams, you can find young aquatic insects living under rocks, amongst roots and leaves, or buried in the sand and mud.

Stream ecologists (scientists who study stream life) are often interested in discovering which species—and how many of them—live in streams or rivers. To collect aquatic insects, ecologists use nets or cores, depending on the type of stream (Figure 2). The insects collected in streams are then taken to the laboratory, where they are identified, counted, and measured with a microscope, a magnifying lens, or other tools.

NYMPHS

The immature forms of some invertebrates, particularly insects, which undergo gradual transformation before reaching its adult stage.

LARVAE

The juvenile form of many insects before undergoing the process of transformation into adults.

Figure 2

Two types of devices used for sampling **macroinvertebrates** in streams. A Surber sampler **(A)** uses a net fastened around a square frame which permits the user to isolate a known area of stream bed for sampling. A core sampler **(B)** is a cylindrical device used in shallow waters to collect sediments containing organisms (photo credits: Pablo E. Gutiérrez-Fonseca and Sean Kelly).

Researchers may also be interested in studying what the insects eat. This allows them to collect details on "who eats whom" in the stream, and tells them where the insects are getting the energy to grow. This information is used to build **food webs**, which help ecologists understand the feeding relationships of stream animals. To examine what insects are eating, researchers make small cuts to remove their stomachs. Then, the stomach contents are examined with a microscope to identify and count the various food particles found. This entire process is repeated until many organisms are obtained from each stream.

MACRO-INVERTEBRATES

Small animals without backbones that are large enough to be seen with the naked eye or without a microscope (like insects and worms).

FOOD WEB

A series of links describing "who eats whom" in an ecosystem.

In our study, we examined the stomach contents of aquatic insects from two streams on the island of Puerto Rico. We classified the food particles found in their stomachs as fungi, detritus, animals, or algae. We also measured the growth of insects over an entire year. We then

used this information to identify the major food sources that aquatic insects use in these tropical island streams.

WHAT WAS SEEN?

Similar to what happens to us when we are young and are growing really quickly, we found that small insects grow much faster than large ones of the same kind. While small insects use their energy to grow, larger insects use their energy to emerge from the streams as adults, to produce eggs, and to develop strategies that help them cope with life on land. Of all the insects we studied, we found that a group called the non-biting midges, which are flies commonly found in slow-moving waters, grew the fastest. Growing very quickly allows midges to have many offspring in a shorter time, which helps the survival of the species.

Although the diets of aquatic insects can be variable and are usually based on the availability of food in the stream, we found that most insects eat detritus in these forested island streams. In fact, dead plant materials accounted for about one-third of the insects' diets. Other food types such as algae, fungi, and animals were less common in the insect stomachs that we studied. Insect growth is the result of turning food items into body tissues or mass. We found that detritus contributed the most to the formation of insect mass in these streams (Figure 3).

WHY DOES IT MATTER?

Streams and the nearby land are closely connected by the exchange of materials and by the movement of insects. Forested streams have limited growth of algae, due to being shaded by surrounding trees, and most rely on outside sources of energy from the land. Therefore, learning more about what various types of aquatic animals eat (bark, leaves, wood, and algae) and why they eat it helps stream ecologists to understand the foundations of the food webs that keep streams (and their fish, birds, and other animals) healthy.

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Figure 3

A simplified food web of a forested stream on a tropical island. Aquatic insects include mayflies, midges, and caddisflies. Food items include terrestrial plant parts (e.g., leaves, stems) and animals (e.g., spiders and terrestrial insects) from the nearby land that fall in the stream, and fungi and algae from within the stream. The arrows indicate what is eaten by whom (image credit: José Sánchez-Ruiz).

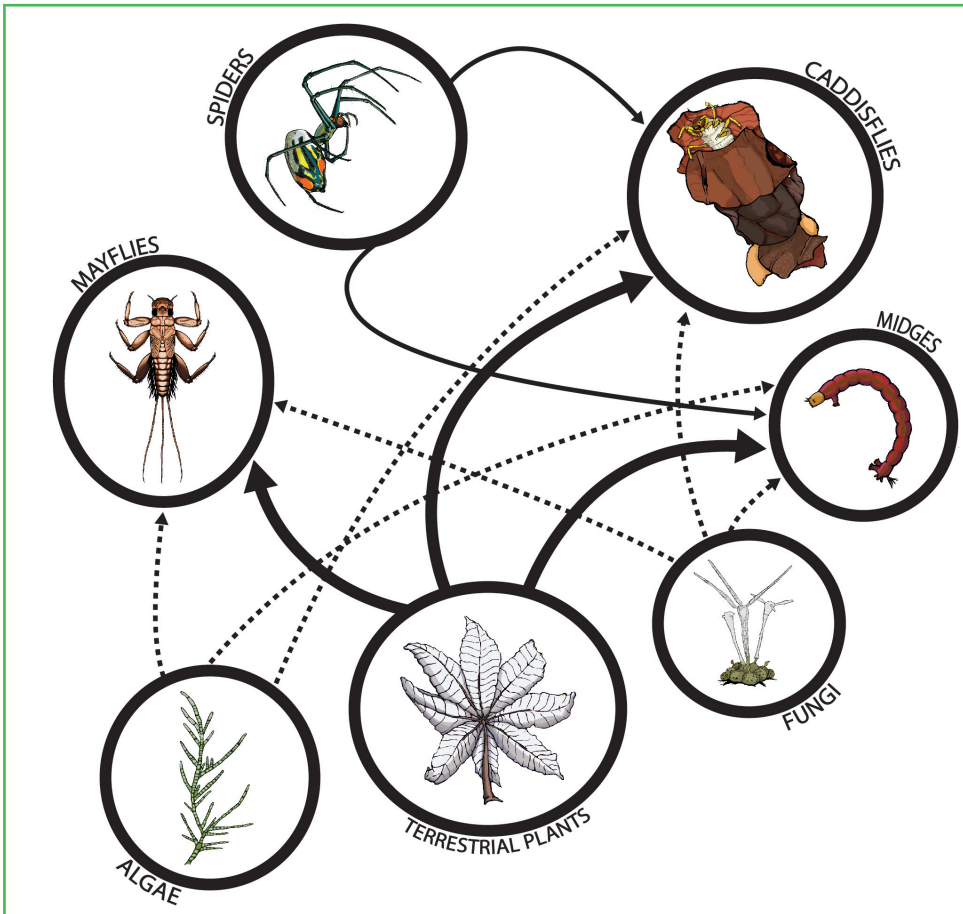

Figure 3

ORIGINAL SOURCE ARTICLE

Rosas, K. G., Colón-Gaud, C., and Ramirez, A. 2020. Trophic basis of production in tropical headwater streams, Puerto Rico: an assessment of the importance of allochthonous resources in fueling food webs. *Hydrobiologia* 847:1961–75. doi: 10.1007/s10750-020-04224-y

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CONFLICT OF INTEREST: The authors declare 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

VIKTOR, AGE: 15
I am 15 years old and love natural sciences, with a specific interest in ornithology. I am an avid birdwatcher, and in my spare time I like to look for new birds. I like traveling, and my interest has taken me all around the globe. I have seen all the continents except Antarctica, which I hope to visit soon.

VINCENT, AGE: 9
I am 9 years old and my favorite pokemon is Lucario. I love playing piano and my favorite piece is "Jingle Bells." I love playing football. I have traveled widely and my best memory is of Queensland, Australia. We were staying as a homestay guest and had set out in the night to see some flying squirrels. It was pitch dark and we saw a huge carpet python lying across the tarmac road. It was thrilling and scary at the same time.

AUTHORS

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Pablo E. Gutiérrez-Fonseca is an ecologist studying tropical stream ecosystems. He is a professor and researcher in Costa Rica, and he greatly enjoys sitting by the riverside and wondering about the creatures that live there.

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Alonso Ramírez is an ecologist studying stream ecosystems in tropical and urban environments. He is a professor in Raleigh, North Carolina, where he studies the effects of climate change on stream ecosystems, with a focus on macroinvertebrates.