Headwater stream nutrient enrichment disrupts food web

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Human activity is increasing the supply of nutrients, such as nitrogen and phosphorus, to stream systems all over the world. The conventional wisdom -- bolstered by earlier research -- has held that these additional nutrients cause an increase in production all along the food chain, from the tiniest organisms up to the largest predators. A long-term, ecosystem-scale study by a team of University of Georgia researchers, however, has thrown this assumption into question.

The researchers—a team from the UGA Odum School of Ecology and department of entomology in the College of Agricultural and Environmental Sciences—found , unexpectedly, that while nutrient enrichment did indeed cause a steady increase in the production of organisms lower on the food chain, organisms at the top of the food chain did not benefit.

Their study, "Long-term nutrient enrichment decouples predator and prey production," published this week in the early edition of Proceedings of the National Academy of Sciences, was funded by the National Science Foundation. It documents the effects of long-term nutrient enrichment of a headwater stream in a forested area at the Coweeta Hydrologic Laboratory in North Carolina. For the first two years of the study, the results were as expected: the production of both prey (the organisms low on the food chain) and predators (in this case salamanders and macroinvertebrates) increased. But with continued addition of nutrients, things began to change. While the prey continued to increase at the same rate, the production of predators leveled off, signifying a 'decoupling' of the typical relationship between predators and prey.

Maintaining patterns of energy flow between predators and prey is a critical aspect of healthy ecosystems. "What we found was a dead end in the food chain," said Amy Rosemond, assistant professor at the Odum School, and one of the lead researchers. "This is the first time we've seen this kind of trophic decoupling, or break in the food chain, between the levels of prey and predator on this scale. This kind of disruption of the food web wasn't on anyone's radar screen before now."

In this instance, Rosemond explained, the break was driven by the traits of the various prey species that inhabit the stream system. Some of these species were better able to take advantage of the extra nutrition than were others. After the first two years, the nutrient enrichment began to favor the growth of large-bodied prey, such as the caddisfly, Pycnopsyche spp., over smaller organisms. These large-bodied prey were simply too big for the stream's predators to consume; hence, they were unable to capitalize on the increase in available food.

John Davis, who conducted the research as part of his Ph.D. dissertation, said that the work has global implications. "Nutrient enrichment is a global threat to the health of freshwater ecosystems," he explained. "However, our understanding of its effects is limited. Our experimental results varied substantially from the few other large-scale experiments, which suggests that ecosystem-level responses to nutrient enrichment are largely context-dependent. This is important because humans are increasing nutrient loading rates to a diversity of ecosystems, but our understanding of their effects is based on only a small number of ecosystem types."

Rosemond said that their results point to the need for more research, especially large-scale, long-term studies in a variety of ecosystems. Davis agrees. "It took over four years for nutrient enrichment to decouple predator and prey production within these headwater streams," he said. "But most ecological experiments are limited to time scales of weeks to months."

And the need to understand the effects of nutrient enrichment continues to grow more important.

According the Environmental Protection Agency, the health of 47 percent of lakes and 45 percent of streams in the U.S. is impaired, with excessive nutrients a significant source of that impairment. Nutrient inputs to lakes and streams are likely to continue to increase globally from fertilized agricultural and suburban lands and from human and animal wastes that enter aquatic systems from treated sewage, septic tanks, or run-off from land. Furthermore, headwater streams, like the study stream in Coweeta, may account for as much as 73% of all stream miles. These headwater streams are the 'feeders' of larger rivers, so their response to nutrient enrichment likely affects downstream systems as well. But long-term effects of nutrients have not been previously tested in these systems.

"Without more accurately assessing the long-term effects of nutrients on a diversity of ecosystem types," Davis concluded, "we won't be able to adequately predict how global ecosystems are going to respond to chronic nutrient enrichment."

Provided by University of Georgia

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