Without helpful microbes, tadpoles can't stand the heat

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Tadpoles. Credit: Wikipedia/böhringer friedrich

In a warming world, animals could live or die by what's in their gut. That's one conclusion of a new study by Pitt biologists showing that tadpoles are less able to cope with hot temperatures without the help of

microbes. The results could spell a one-two punch for amphibians and other sensitive animals.

"As temperatures are warming, if animals are experiencing disruptions in their microbial communities—as we know can happen due to human-caused stress—then that could lead them to not survive as well," said lead author Samantha Fontaine, a Ph.D. student in the Kenneth P. Dietrich School of Arts and Sciences.

Amphibians are especially sensitive to their environments, and there's reason to believe that they'd be vulnerable to climate change, too. A shift of just a few degrees can make a big difference for animals like frogs and toads, which unlike mammals can't regulate their own internal temperatures.

Fontaine suspected that microbes—increasingly recognized to play an important role in health—might help amphibians handle heat and cold. So she raised tadpoles in water that ranged from 57 to 82 degrees Fahrenheit and split them into two groups raised in different kinds of water: Half in microbe-rich pond water, and half in pond water treated with heat and pressure to kill most microbes. That resulted in tadpoles with fewer kinds of microbes living in their guts.

In the short-term, the team found, tadpoles raised without microbes were able to tolerate temperatures about half a degree Fahrenheit less than those raised in pond water. When exposed to higher temperatures for longer periods of time, tadpoles with depleted microbiomes were five times more likely to die.

The team, including Assistant Professor Kevin Kohl in Pitt's Department of Biological Sciences and Patrick Mineo at Elmhurst University, published their research today in the journal *Nature Ecology and Evolution*.

"We definitely need more natural experiments to see how this would actually play out in the wild," Fontaine said. "But this is the first study to show that there's a connection between heat tolerance and the microbiome" in animals like amphibians.

Oddly enough, tadpoles with depleted microbiomes also grew far larger than their colonized counterparts—about half again as big on average. The effects of temperature still remained when the team controlled for the tadpole's size, however. And the team also took it a step farther by looking into several ways by which microbes could be helping tadpoles deal with heat.

Fontaine started with a list of traits that help tadpoles handle heat, then whittled them down to a few that she suspected could be influenced by the action of microbes. Tadpoles raised in sterilized water, the team found, had altered metabolisms and less activity in proteins that help turn food into energy. At high temperatures, they were even worse at swimming.

If you wouldn't expect that microbes could be linked to all these changes, you're not alone. "I am constantly surprised at where they are having an influence," Kohl said. "We've been doing research for decades not thinking about the microbiome as well as we should. A lot of those effects have been right under our noses, we just haven't looked for them yet."

What makes this discovery worrisome is that pollution and land-use change can harm the communities of microbes that live in nature, and climate change itself may damage them too. "When we raised tadpoles at the warm temperature, they lost a lot of diversity in their microbiome, regardless of the water treatment," Fontaine said.

Even as the climate puts amphibians under new stress, in other words, it

may make them less able to cope.

Along with showing the importance of reducing impacts on microbe communities in the wild, the research points to a potential way that conservationists could provide a buffer, especially for species they hope to reintroduce into the wild from captivity.

"The idea of probiotics is really big in the field: Are there microbes that are really important that we can supplement animals with?" she said. "If so, it's possible that can help them withstand changes in temperatures more robustly."

More information: Samantha Fontaine, Experimental manipulation of microbiota reduces host thermal tolerance and fitness under heat stress in a vertebrate ectotherm, *Nature Ecology & Evolution* (2022). DOI: 10.1038/s41559-022-01686-2.
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