Tadpoles in Trouble

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PITT RESEARCH SHOWS THAT LOW CONCENTRATIONS OF COMMON INSECTICIDE CAN DECIMATE TADPOLE POPULATIONS THROUGH THE FOOD CHAIN

Insecticide malathion initiates chain reaction that deprives tadpoles of food source, indirectly killing them at doses too small to kill them directly

PITTSBURGH The latest findings of a University of Pittsburgh-based project to determine the environmental impact of routine pesticide use suggests that malathion the most popular insecticide in the United States can decimate tadpole populations by altering their food chain, according to research published in the Oct. 1 edition of Ecological Applications.

Gradual amounts of malathion that were too small to directly kill developing Leopard Frog tadpoles instead sparked a biological chain of events that deprived them of their primary food source. As a result, nearly half the tadpoles in the experiment did not reach maturity and would have died in nature. The research was funded by a National Science Foundation grant.

The results build on a nine-year effort by study author Rick Relyea, an associate professor of biological sciences in Pitt s School of Arts and Sciences, to investigate whether there is a link between pesticides and the global decline in amphibians, which are considered an environmental indicator species because of their sensitivity to pollutants. Their deaths may foreshadow the poisoning of other, less environmentally sensitive species including humans. Relyea published papers in 2005 in Ecological Applications suggesting that the popular weed-killer Roundup® is "extremely lethal" to amphibians in concentrations found in the environment.

For his current research, Relyea and the study's coauthor, Pitt alumnus Nicole Diecks (CGS 2005), created simulated ponds from 300-gallon outdoor tanks containing Wood Frog and Leopard Frog tadpoles. They exposed the ponds to no malathion, moderate concentrations in a single dose, or low concentrations in weekly doses that mirror the levels tadpoles experience in nature. Malathion is commonly used worldwide to thwart crop pests and control mosquitoes that carry malaria and West Nile virus. It has been detected in the wetlands where frogs and other amphibians live.

The doses of malathion in the simulated ponds were too low to directly kill the amphibians, but instead wiped out tiny animals known as zooplankton that eat algae that float in the water. With few zooplankton remaining, the algae, known as phytoplankton, grew rapidly and prevented sunlight from reaching the bottom-dwelling algae, or periphyton, which tadpoles eat. This chain of events occurred over a period of several weeks. The Wood Frog tadpoles, which mature quickly, were largely unaffected.

Leopard Frog tadpoles, on the other hand, require more time to develop into frogs and experienced slower growth as a result of the reduced amount of periphyton. Ultimately, 43 percent of the Leopard Frog tadpoles did not mature as a result of the repeated application of malathion at very low concentrations. Relyea reported that the multiple low doses were a greater detriment than the single dose, which had a concentration 25-times higher than the multiple applications combined. The single doses also wiped out the zooplankton, but they eventually recovered and the pond reverted back to its original state. The repeated doses prevented the zooplankton from recovering.

"The chain of events caused by malathion deprived a large fraction of the leopard frog tadpoles of the nutrients they needed to metamorphose into adult frogs," Relyea said. "Repeated applications sustained that disruption of the tadpoles' food supply. So, even concentrations that cannot directly kill tadpoles can indirectly kill them in large numbers."

The research results should apply to several other insecticides that are highly lethal to zooplankton, including carbaryl, diazinon, endosulfan, esfenvalerate, and pyridaben, Relyea said. All of these chemicals are toxic to humans as well and are commonly used in the United States, although some are banned in other countries. The effect of insecticides and other pesticides on amphibians are not widely known because current regulations from the U.S. Environmental Protection Agency do not require amphibian testing. The EPA also relies on single-species tests to assess a pesticide s risk and does not account for potential indirect repercussions.

"The indirect impacts on the amphibians observed in this study could not be observed in traditional, single-species tests," Relyea said. "These results demonstrate that we need to take a much broader view of the consequences pesticides might have in our world."

Leopard and Wood Frogs naturally range across North America, including Pennsylvania and the Northeastern United States. Once plentiful, leopard frogs have declined in recent years.

The journal Ecological Applications is available online at

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Contact for this release:

Morgan Kelly
412-624-4356 (office)
412-897-1400 (cell)
mekelly@pitt.edu