Richer parasite diversity leads to healthier frogs: study

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Increases in the diversity of parasites that attack amphibians cause a decrease in the infection success rate of virulent parasites, including one that causes malformed limbs and premature death, says a new University of Colorado Boulder study.

According to CU-Boulder Assistant Professor Pieter Johnson, scientists are concerned about how changes in biodiversity affect the risk of infectious diseases in humans and wildlife. Charting the relationships between parasites and amphibians is important since few studies have examined the influence of parasite diversity on disease, and the fact that amphibians are declining faster than any group of animals on the planet due to human activities like habitat loss, pollution and emerging diseases, Johnson said.

In the new study, the team sampled 134 California ponds for the parasites, known as trematodes, comparing their abundance and distribution with the health of more than 2,000 Pacific chorus frogs. The CU team combined the field studies with extensive lab experiments that charted the health of the frogs in the presence of different combinations of the six most common amphibian parasites, including the Ribeiroia group whose larvae burrow into tadpole limb regions and form cysts that disrupt normal frog and toad leg development, causing extra or missing limbs.

The new study showed when the chorus frogs were exposed to all six trematode types simultaneously, the infection success rate was 42

percent lower than for frogs exposed to only a single species of parasite. "Our results show increases in parasite diversity consistently cause a decrease in infection success by the most virulent parasite," said Johnson of the ecology and evolutionary biology department.

A paper by Johnson and co-author Jason Hoverman, a CU-Boulder postdoctoral researcher, appears in this week's issue of the Proceedings of the National Academy of Sciences. The project was funded by grants from the National Science Foundation and a David and Lucile Packard Foundation fellowship awarded to Johnson in 2008.

While the six parasites used in the study are responsible for about 95 percent of trematode infections in the wild, most of the world's parasites cause limited damage to host individuals, said Johnson. In the PNAS study, only two parasites, *Ribeiroia* and a parasite group called *Echinostoma* -- which can trigger amphibian mortality -- were known to be particularly dangerous to their host species.

The primary study results support the idea that higher biodiversity can help protect against certain diseases, but few previous studies had considered the diversity of the parasites themselves. Because many parasites compete with each other, ecological systems richer in parasites can act as a buffer against virulent pathogens. Johnson said the combination of extensive field and lab work helped strengthen the study results.

One surprising study finding was that under certain conditions, increases in parasite diversity could increase or decrease host disease. In that aspect of the study, the infection rates were dependent on the order in which the six parasite species were added to the habitats of the frogs, and whether newly added parasite species replaced other parasites or were added alongside them, he said.

If a dangerous parasite is first on the scene, it tends to be replaced when less dangerous species are added, decreasing the odds of host disease. But if a dangerous parasite species is added to an environment already harboring parasites, the study showed either a neutral effect or an increase in disease, Johnson said.

"Collectively, our findings illustrate the importance of considering the hidden role of parasite diversity in affecting disease risk," said Johnson. "While our study was on amphibian diseases, there is ample evidence to suggest similar processes can be occurring in humans and other groups of animals."

Recent studies also have shown similar relationships between host diversity and the risk of disease in some plants, mammals, birds and coral. A decrease in vertebrate host species for ticks carrying Lyme disease, for example, can increase the risk of Lyme disease in humans, said Johnson.

"It could be that the most dangerous parasites occur in greater numbers in disturbed environments," said Hoverman, who recently accepted a position as assistant professor at Purdue University's forestry and natural resources department. "If we are trying to minimize disease risk in humans or in threatened groups of animals like amphibians, studies like this will be able to tell us which scenarios are most likely to occur."

The new study has implications for declining biodiversity being seen across the planet as a result of human activities, including amphibians, said Johnson. Roughly 40 percent of amphibian species around the world are in decline, and more than 200 have gone extinct since the 1970s, some as a result of the often-fatal chytrid fungus that infects amphibian skin. Some scientists argue that rapid global amphibian decline seen today is driving the next great mass extinction event, he said.

Trematodes have a complex life cycle that involve snails, amphibians and predators. Host snails release parasite larvae in the water, infecting amphibians and causing deformities that include extra or missing legs. Deformed frogs and toads rarely survive long because of their susceptibility to predators like wading birds, which ingest them and later release trematodes that infect other snails, completing the life cycle.

Deformed frogs first gained attention in the mid-1990s when a group of Minnesota schoolchildren discovered a pond where more than half of the leopard frogs had missing or extra limbs, said Johnson. Since then reports of deformed amphibians have been widespread in the United States, leading to speculation they were being caused by factors like pollution, increased ultraviolet radiation or parasitic infection.

A 2008 study by Johnson showed American toads who pal around with gray tree frogs reduce their chances of parasitic infections known to cause limb malformations because trematode larva that infect tree frog tadpoles are killed by the tadpoles' immune systems. In 2007, Johnson led a study showing high levels of nutrients like nitrogen and phosphorus used in North American farming and ranching activities fuel trematode infections by elevating the abundance and reproduction of snail species that host the parasites.

Provided by University of Colorado at Boulder