

Study shows how biodiversity can protect against disease

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The richer the assortment of amphibian species living in a pond, the more protection that community of frogs, toads and salamanders has against a parasitic infection that can cause severe deformities, including the growth of extra legs, according to a new study by the University of Colorado Boulder.

The findings, published Feb. 14 in the journal *Nature*, support the idea that greater biodiversity in larger-scale ecosystems, such as forests or grasslands, may also provide greater protection against diseases, including those that attack humans. For example, a larger number of [mammal species](#) in an area may curb cases of [Lyme disease](#), while a larger number of [bird species](#) may slow the spread of West Nile virus.

"How biodiversity affects the risk of [infectious diseases](#), including those of humans and wildlife, has become an increasingly important question," said Pieter Johnson, an assistant professor in the Department of Ecology and [Evolutionary Biology](#) and lead author of the study. "But as it turns out, solidly testing these linkages with realistic experiments has proven very challenging in most systems."

Researchers have struggled to design comprehensive studies that could illuminate the possible connection between disease transmission and the number of species living in complex ecosystems. Part of the problem is simply the enormous number of organisms that may need to be sampled and the vast areas over which those organisms may roam.

The new CU-Boulder study overcomes that problem by studying smaller, easier-to-sample ecosystems. Johnson and his team visited hundreds of ponds in California, recording the types of amphibians living there as well as the number of [snails](#) infected by the pathogen *Ribeiroia ondatrae*. Snails are an intermediate host

used by the parasite during part of its life cycle.

"One of the great challenges in studying the diversity-disease link has been collecting data from enough replicate systems to differentiate the influence of diversity from background 'noise,'" Johnson said. "By collecting data from hundreds of ponds and thousands of amphibian hosts, our group was able to provide a rigorous test of this hypothesis, which has relevance to a wide range of disease systems."

Johnson's team buttressed its field observations both with laboratory tests designed to measure how prone to infection each amphibian species is and by creating pond replicas outside using large plastic tubs stocked with tadpoles that were exposed to a known number of parasites. All of the experiments told the same story, Johnson said. Greater biodiversity reduced the number of successful amphibian infections and the number of deformed frogs.

In all, the CU-Boulder researchers spent three years sampling 345 wetlands and recording malformations—which include missing, misshapen or extra sets of hind legs—caused by parasitic infections in 24,215 amphibians. They also cataloged 17,516 snails. The results showed that ponds with half a dozen amphibian species had a 78 percent reduction in parasite transmission compared to ponds with just one amphibian species. The research team also set up experiments in the lab and outdoors using 40 artificial ponds, each stocked with 60 amphibians and 5,000 parasites.

The reason for the decline in parasitic infections as biodiversity increases is likely related to the fact that ponds add [amphibian species](#) in a predictable pattern, with the first species to appear being the most prone to infection and the later species to appear being the least prone. For example, the research team found that in a pond with just one

type of amphibian, that amphibian was almost always the Pacific chorus frog, a creature that is able to rapidly reproduce and quickly colonize wetland habitats, but which is also especially vulnerable to infection and parasite-induced deformities.

On the other hand, the California tiger salamander was typically one of the last species to be added to a pond community and also one of the most resistant to parasitic infection. Therefore, in a pond with greater biodiversity, parasites have a higher chance of encountering an amphibian that is resistant to infection, lowering the overall success rate of transmission between infected snails and amphibians.

This same pattern—of less diverse communities being made up of species that are more susceptible to disease infection—may well play out in more complex ecosystems as well, Johnson said. That's because species that disperse quickly across ecosystems appear to trade off the ability to quickly reproduce with the ability to develop disease resistance.

"This research reaches the surprising conclusion that the entire set of species in a community affects the susceptibility to disease," said Doug Levey, program director in the National Science Foundation's Division of Environmental Biology, which helped fund the research. "Biodiversity matters."

The sheer magnitude of the recent study also reinforces the connection between deformed frogs and [parasitic infection](#), Johnson said. Beginning in the mid-1990s reports of frogs with extra, missing or misshapen legs skyrocketed, attracting widespread attention in the media and motivating scientists to try to figure out the cause. Johnson was among the researchers who found evidence of a link between infection with *Ribeiroia* and frog deformities, though the apparent rise in reports of deformations, and its underlying cause, remains controversial.

While the new study has implications beyond parasitic infections in amphibians, it does not mean that an increase in biodiversity always results in a

decrease in disease, Johnson cautioned. Other factors also affect rates of [disease transmission](#). For example, a large number of mosquitoes hatching in a particular year will increase the risk of contracting West Nile virus, even if there has been an increase in the biodiversity of the bird population. Birds act as "reservoir hosts" for [West Nile virus](#), harboring the pathogen indefinitely with no ill effects and passing the pathogen onto mosquitoes.

"Our results indicate that higher diversity reduces the success of pathogens in moving between hosts," Johnson said. "Nonetheless, if infection pressure is high, for instance in a year with high abundance of vectors, there will still be a significant risk of disease; biodiversity will simply function to dampen transmission success."

Provided by University of Colorado at Boulder

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