Research shows that weakness can be an advantage in surviving deadly parasites

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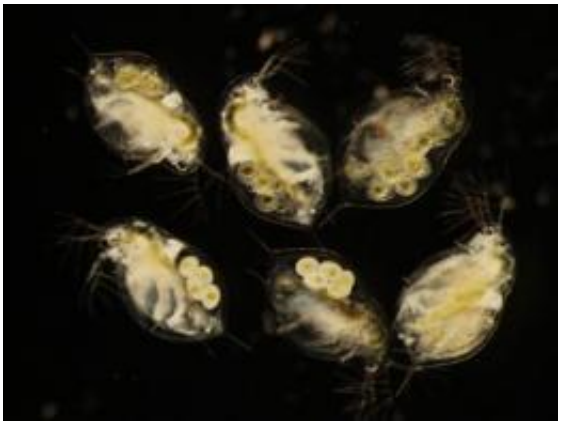


A new study led by Georgia Tech found that a lake's ecological characteristics influence how *Daphnia dentifera* quickly evolve to survive epidemics of a virulent yeast parasite *Metschnikowia bicuspidata*. The *Daphnia dentifera* individuals on the top right and bottom middle of this image are uninfected; the other four *Daphnia* are infected with *Metschnikowia*. Credit: Georgia Tech/Meghan Duffy

When battling an epidemic of a deadly parasite, less resistance can sometimes be better than more, a new study suggests.

A freshwater zooplankton species known as *Daphnia dentifera* endures periodic epidemics of a virulent yeast parasite that can infect more than 60 percent of the Daphnia population. During these epidemics, the *Daphnia* population evolves quickly, balancing infection resistance and

reproduction.

A new study led by Georgia Institute of Technology researchers reveals that the number of vertebrate predators in the water and the amount of food available for *Daphnia* to eat influence the size of the epidemics and how these "water fleas" evolve during epidemics to survive.

The study shows that lakes with high nutrient concentrations and lower predation levels exhibit large epidemics and *Daphnia* that become more resistant to infection by the yeast *Metschnikowia bicuspidata*. However, in lakes with fewer resources and high predation, epidemics remain small and *Daphnia* evolve increased susceptibility to the parasite.

Downing Lake, shown here, was one of seven Indiana lakes researchers monitored during a four-month period to assess how the *Daphnia dentifera* population quickly evolved to survive epidemics of a virulent yeast parasite *Metschnikowia bicuspidata*. Credit: Indiana University/David Civitello

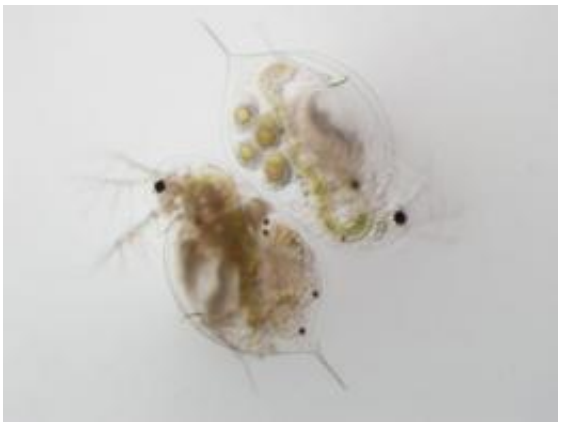
"It's counterintuitive to think that hosts would ever evolve greater susceptibility to virulent parasites during an epidemic, but we found that ecological factors determine whether it is better for them to evolve

enhanced resistance or susceptibility to infection," said the study's lead author Meghan Duffy, an assistant professor in the School of Biology at Georgia Tech. "There is a trade-off between resistance and reproduction because any resources an animal devotes to defense are not available for reproduction. When ecological factors favor small epidemics, it is better for hosts to invest in reproduction rather than defense."

This study was published in the March 30, 2012 issue of the journal *Science*. The research was supported by the National Science Foundation and the James S. McDonnell Foundation.

In addition to Duffy, also contributing to this study were Indiana University Department of Biology associate professor Spencer Hall and graduate student David Civitello; Christopher Klausmeier, an associate professor in the Department of Plant Biology and W.K. Kellogg Biological Station at Michigan State University; and Georgia Tech research technician Jessica Housley Ochs and graduate student Rachel Penczykowski.

For the study, the researchers monitored the levels of nutritional resources, predation and parasitic infection in seven Indiana lakes on a weekly basis for a period of four months. They calculated infection prevalence visually on live hosts using established survey methods, estimated resources by measuring the levels of phosphorus and nitrogen in the water, and assessed predation by measuring the size of uninfected adult *Daphnia*.



A new study suggests that when battling an epidemic of a deadly parasite, less resistance can sometimes be better than more. This image shows a *Daphnia dentifera* infected with the virulent yeast pathogen *Metschnikowia bicuspidata* (lower left) and an uninfected *Daphnia* (top right). The parasite fills the body, making the infected *Daphnia* appear darker brown in the image. Credit: Georgia Tech/Meghan Duffy

The researchers also conducted infection assays in the laboratory on *Daphnia* collected from each of the seven lake populations at two time points: in late July before epidemics began and in mid-November as epidemics waned. The assays measured the zooplankton's uptake of *Metschnikowia bicuspidata* and infectivity of the yeast once consumed.

The infection assays showed a significant evolutionary response of *Daphnia* to epidemics in six of the seven lake populations. The *Daphnia* population became significantly more resistant to infection in three lakes and significantly more susceptible to infection in three other lakes. The hosts in the seventh lake did not show a significant change in susceptibility, but trended toward increased resistance. In the six lake populations that showed a significant evolutionary response, epidemics were larger when lakes had lower predation and higher levels of total nitrogen.

"*Daphnia* became more susceptible to the yeast in lakes with fewer resources and higher vertebrate predation, but evolved toward increased resistance in lakes with increased resources and lower predation," noted Duffy.

The study's combination of observations, experiments and mathematical modeling support the researchers' theoretical prediction that when hosts face a resistance-reproduction tradeoff, they evolve increased resistance to infection during larger epidemics and increased susceptibility during smaller ones. Ultimately, ecological gradients, through their effects on epidemic size, influence evolutionary outcomes of hosts during epidemics.

"While the occurrence and magnitude of disease outbreaks can strongly influence host evolution, this study suggests that altering predation pressure on hosts and productivity of ecosystems may also influence this evolution," added Duffy.

The team plans to repeat the study this summer in the same Indiana lakes to examine whether the relationships between ecological factors, epidemic size and host evolution they found in this study can be corroborated.

Provided by Georgia Institute of Technology