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The Red Queen rules: Team bolsters theory that sexual reproduction protects against threats

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Source: University of Iowa

Summary: What does the Red Queen in 'Alice in Wonderland' have to do with biology? 'It takes all the running you can do, to keep in the same place.' Sexual reproduction protects species by continuously shuffling their genes. A researcher team has now bolstered the theory by studying snails' resilience to parasitic worms.

FULL STORY

Leave it to evolutionary biologists to name a theory from a line in Alice in Wonderland.

In Lewis Carroll's book Through the Looking Glass, the Red Queen tells Alice, "It takes all the running you can do, to keep in the same place."

Evolutionary biologists have drawn from the phrase to hypothesize that organisms engage in sexual reproduction to keep pace with an ever-changing world. They contend that male-female mating--factored over generations--produces offspring with enough genetic diversity to resist varied, evolving threats -- from disease to changed climate.

A team of biologists led by the University of Iowa further scrutinized the hypothesis by testing whether female New Zealand freshwater snails that reproduce sexually would be more resilient to outside perils than females that produce offspring by themselves. The researchers documented the concentration of sexual females and asexual females at multiple sites in the same lake and compared how their populations were affected by a parasitic worm commonly associated with the snails.

The researchers found that in areas of the lake where the worm was prevalent, male snails were plentiful (indicating sexually reproducing female snails were present). They even found male snails roaming in areas where the parasite concentration was as low as four percent, as well as in higher numbers where parasite activity was heavier.

The results offered another encouraging sign that sexually produced offspring are getting a genetic boost from mommy and daddy. For instance, the offspring get two genetic blueprints (one from each parent), rather than just their mother's genome, which they would if they were born to an asexual female. Viewed over generations, sexual reproduction can produce new gene combinations that are needed to deal with changing environments.

"These results are consistent with the idea that there are advantages to sex related to the ability to produce diverse offspring," says Maurine Neiman, associate professor in biology at the UI and corresponding author on the paper published this week in the N*ew Zealand Journal of Ecology*. "Snails born with rare gene combinations would be harder to infect because the parasites have rarely, if ever, encountered those shuffled genetic combinations."

Neiman and others in her field have been studying the freshwater snails for years, in large part because some females can bear offspring without males. The snails also are vulnerable to a well-documented threat -- a parasitic worm (*Microphallus livelyi*) that lives within the snail as it awaits a chance to glom on to its final host: ducks that eat infected snails.

Previous studies have shown an association between parasite concentration and the number of sexual female snails. Where parasite activity is low, sexual females are few; where parasite activity is high, sexual females are abundant.

This study adds to other analyses linking parasite activity to sexual and asexual female populations within a small mountain lake, Lake Grasmere. This study is distinctive because the researchers found dramatic differences in the percentage of female sexual and asexual snails (using males' presence as a proxy) and parasite prevalence between sites as close as two football fields apart, "suggesting that these evolutionary links between sex and parasites can operate at a remarkably small scale," Neiman says.

Neiman and her colleagues think the parasitic worm invades the snail by tricking its immune system into believing it's not a threat. Some diseases do the same with humans, fooling our immune system just enough to lodge themselves within our bodies and make us ill. Yet, over time, humans have inherited and passed down new gene combinations that protect better against those diseases. That's genetic diversity and natural selection at work.

Like humans, the snails' best defense against the parasitic worm is to pass down gene combinations that are new to the parasite. That shuffling of genes is much more likely to occur through male-female mating than asexual reproduction, where the daughter inherits her mother's exact genetic makeup.

The team visited Lake Grasmere in January 2014. There, 25 undergraduates from Carleton College, in Minnesota, assisted Neiman and the paper's first author, Carleton College biologist Mark McKone, by collecting 1,800 snails at 18 sites, either on foot or by kayak, and examining each under a microscope to catalog sex and infection rates. Five Carleton undergraduates are included as authors on the paper.

"The students who took the lead on the project helped in all aspects of the research, including framing the experimental question, organizing data collection, analyzing the results, and ultimately submitting a manuscript for publication," McKone says. "It is rare for undergraduates to gain such broad exposure to the complete process of science."

Story Source:

Materials provided by **University of Iowa**. *Note: Content may be edited for style and length.*

Journal Reference:

1. Maurine Neiman et al. **Fine-scale association between parasites and sex in Potamopyrgus antipodarum within a New Zealand lake**. *New Zealand Journal of Ecology*, April 2016

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