These rapidly reproducing critters offer evolutionary insights

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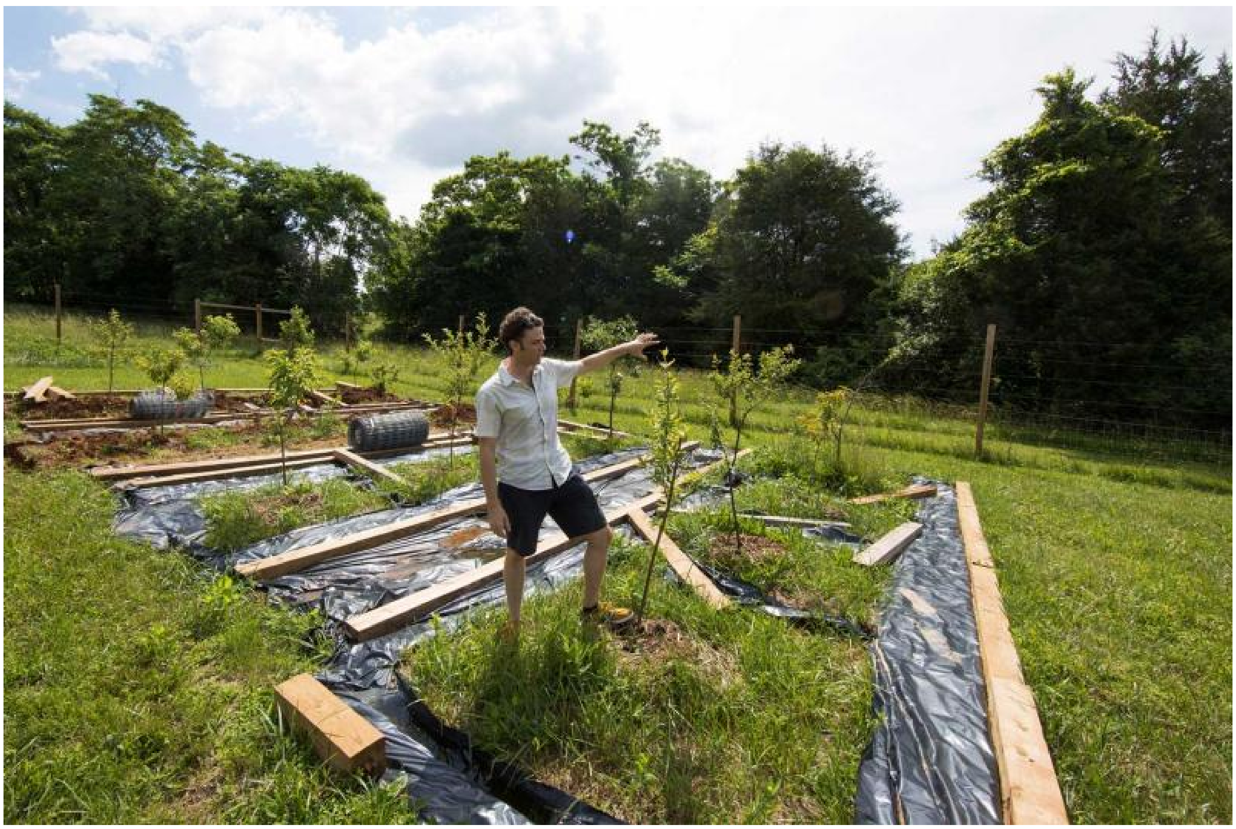

Bergland compares evolutionary changes in fruit flies found in the wild with those that occur in his lab. Credit: University of Virginia

It may not be obvious on casual glance, but bugs – flies, beetles, roaches – are constantly changing. In fact, they are masters of adaptation, always modifying their genes to adapt to the changes that occur to the environments in which they live.

Each individual of a species is affected by its constantly changing environment, and each succeeding generation of that species is affected in turn by the genetic adaptations that came before.

University of Virginia biologist Alan Bergland has long been fascinated by this evolutionary process of adaptation, particularly as it occurs among the "uncharismatic micro-fauna," as he calls them, the tiny organisms that play a big role in how the natural world goes about its business.

Using powerful new genomic analysis tools, Bergland is studying the micro-evolutionary changes that occur in lab populations of fruit flies and their wild counterparts in apple orchards. He's also studying adaptations in a nearly microscopic aquatic crustacean called a water flea . These species of flies and "fleas" are hatched, live, reproduce and die on short time scales (three to 10 days), making them ideal study subjects for understanding the rapid, if minute, adaptive changes that occur over generations in just a few seasons.

With species like these, the equivalent of "climate change" might be merely a particularly mild or short winter, or a particularly hot or mild summer. The critters are ever adapting to environmental change and passing on their resilience in their genes to their offspring and thereby future generations.

"Most species of any type are genetically variable, and some individuals perform better in some environments than others," Bergland said. "With the modern genomic tools now available to us, we have the ability to accurately describe genetic variation and test how variants contribute to adaptive evolution."

Bergland, who conducts his research on a grant from the National Institutes of Health, believes it may even become possible for biologists to forecast or predict the complexity of evolutionary changes across the genome of some species, providing new insights to how all species may evolve over time through the process of environmental adaptation, including in response to disease and predation.

Bergland is looking specifically at how fruit fly populations in an orchard on Carter Mountain outside of Charlottesville and at UVA's Morven Farm, adapt over tens of generations to the seasonal changes of a single year, and over multiple years. Prior to coming to UVA last fall from a postdoctoral fellowship at Stanford University, he studied flies in West Coast orchards and labs.

Credit: University of Virginia

"We know through several years of genomic analysis that hundreds of mutations occur with dramatic changes in frequency during the course of the four seasons," he said. "Some individuals have higher fitness – or better performance – in some seasons than others, and these differences are genetically based."

For instance, females that lay many eggs in the summer, an indication of fitness, have little body fat, which would be detrimental for survival in the winter. Conversely, individuals that store extra fat and can well survive the winter, lay fewer eggs. It seems to be a balancing act by the species to genetically find ways to survive cold winters and hot summers while also producing enough eggs for the species to proliferate through the seasons. And the variations to the climate – a colder winter here, a milder shorter winter there – cause adjustable adaptations to these fitness mechanisms.

Bergland also studies lab populations of fruit flies, where he can control light and temperature conditions to mimic the changing seasons, allowing him to compare wild populations to controlled ones.

"I'm working to link the genetic mutations we find to the traits that contribute to adaptations over seasonal time scales," he said.

Additionally, Bergland is conducting the same types of studies, asking the same questions, on water fleas, a very tiny, nearly transparent creature that lives in ponds, feeding on algae and being preyed upon by midges, a type of small aquatic insect.

Water fleas can grow a sharp spine on their neck as a means to ward off predators. In seasons when there are many predators, the spines grow larger. When there are few or no predators, such as when the species is isolated in water jars, succeeding generations develop much smaller spines.

But some water flea individuals do not grow larger spines even when in the presence of predators. This, Bergland says, is likely because a lot of energy is expended on growing large spines, a costly activity when energy is needed for reproduction. He is curious if these adaptations persist over long periods of time, or if they periodically arise in response to more immediate conditions in the environment.

He also has access to water fleas that were "resurrected" from dormant 700-year old eggs that had resided in pond sediment in England. With that he can trace the evolutionary history of predation-response genes over countless generations and predator cycles.

"We are working to identify the genes that give rise to larger spines, giving us a fuller understanding of adaptations over long spans of time," he said.

Provided by University of Virginia

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