Researcher gauges species' evolutionary lag time in face of an altered climate

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Either change or disappear. A great many of Earth's creatures already have come to this crossroads, or soon will, driven by a rapidly shifting natural environment tied to global climate change. But how quickly can species evolve to cope with dire threats such as new pathogens, competing species and harsher climactic conditions?

A recent $150,000 grant from the National Science Foundation will enable scientists at the University of Kansas to better answer this question in hopes of guiding conservation efforts and shedding light on how organisms evolve.

"We would be interested in these questions no matter how we think the future climate might change," said Maria Orive, associate professor of ecology and evolutionary biology at KU. "We know that climate and environment are always changing, and so adapting to change is always something that species need to do. But many of the current climate models predict very rapid change, and that's especially interesting, because evolution and adaptation take time, and so the faster the environment changes, the faster a population needs to adapt."

Scientists already know that a key for rapid adaptation to the environment is generation time—the period it takes for an organism to go from one generation to the next.

"Generation times vary a great deal," Orive said. "A human generation time is about 20 years, the generation time for a fruit fly is about 10 days, and for a bacterial species, the generation time can be about 20 minutes. For the types of plants and marine invertebrates we are focusing on in this study, a generation time can be as long as 10 to 100 years. The longer the generation time, the slower the evolutionary rate."

But other factors influence the period it takes for species to adapt to the rigors of climate change: "A few important ones include the size of the population, the amount of genetic variability in the population, and the degree of environmental variability," Orive said.

When species can't develop new traits to keep pace with the demands of their environment, they suffer from "evolutionary lag," according to the KU researcher.

"'Evolutionary lag' most commonly refers to the difference between the optimum for a trait—the best possible version of that trait in a particular environment—and the average for that trait in the current population. It is a measure of how far from the optimum the population currently finds itself."

When an organism's physical or biochemical traits are ill suited to its environment the species is said to show "maladaptation"—a reduced ability to survive or reproduce, or both.

In addition to evolving in response to a changing environment, organisms with identical genetic codes could possess different sets of traits that emerge under different environmental conditions, a phenomenon dubbed "phenotypic plasticity."

"You might imagine two plants that have the same genetic makeup, so they have no genetic differences, but that are raised in two different environments, maybe low levels of light and high levels of light," said Orive. "If their final phenotype is different—the final height of the plant, or the distance between sets of leaves—the plants are showing phenotypic plasticity. This can be important, because it gives a population another way to respond to a changing environment."

Another way organisms might adjust to rapidly changing climactic conditions is by dispersal, or moving to a new location.

"You can imagine the dispersal of seeds from a plant, so that the offspring of the plant are found at some distance from the parent," Orive said. "If the population is able to disperse far enough so that the organisms are in a new environment, they can escape an environment that has changed for the worse in this way, rather than adapting to the changed environment."

Orive is especially interested in determining how sexual and asexual reproduction and "clonal lineages"—genetically identical organisms descended from one common ancestor—play a part in the speed of species' evolutionary speed.

"The types of organisms that my theoretical models are considering include some very ecologically important organisms, such as reef-building corals, many important marine invertebrates, and many important plant species, including tree species," said Orive. "All of these organisms show both sexual and clonal reproduction, yet we have very little understanding of how clonal reproduction may affect their ability to deal with changing environments."

Using mathematics, statistics and computer science in her research, Orive hopes to develop models that deepen our insight into the workings of evolution and extinction. Also, the work will educate graduate and undergraduate students at the boundary of biology and math, and involve traditionally underrepresented groups in these disciplines. Moreover, Orive will develop a video on the interface of biology and mathematics aimed at students.

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