Annual plants may cope with global warming better than long-living species

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Countering Charles Darwin's view that evolution occurs gradually, UC Irvine scientists have discovered that plants with short life cycles can evolutionally adapt in just a few years to climate change.

This finding suggests that quick-growing plants such as weeds may cope better with global warming than slower-growing plants such as Redwood trees -- a phenomenon that could lead to future changes in the Earth's plant life.

"Some species evolve fast enough to keep up with environmental change," said Arthur Weis, professor of ecology and evolutionary biology. "Global warming may increase the pace of this change so that certain species may have difficulty keeping up. Plants with longer life cycles will have fewer generations over which to evolve."

The study appears the week of Jan. 8 in the *Proceedings of the National Academy of Sciences*.

Weis and researchers Steven Franks and Sheina Sim studied field mustard, a weedy plant found throughout the Northern Hemisphere. In a greenhouse, they grew mustard plants at the same time from seeds collected near the UCI campus in the spring of 1997 -- two years before a five-year drought -- and seeds collected after the drought in the winter of 2004. Seeds can remain dormant but alive for years and be revived with a little water and light. The plants were divided into three groups, each receiving different amounts of water mimicking precipitation patterns ranging from drought to very wet conditions. In all cases, the post-drought generation flowered earlier, regardless of the watering scheme.

This shift in genetic timing was further confirmed with an experiment that crossed the ancestors and descendents. As predicted, the intergenerational hybrids had an intermediate flowering time.

"Early winter rainfall did not change much during the drought, but the late winters and springs were unusually dry. This precipitation pattern put a selective pressure on plants to flower earlier, especially annual plants like field mustard," Franks said. "During drought, early bloomers complete seed production before the soil dries out, whereas late bloomers wither before they can seed."

The technique of growing ancestors and descendents at the same time allowed the scientists to determine that the change in flower timing was in fact an evolutionary shift -- not a simple reaction to changing weather conditions. This method, pioneered by Albert Bennett, professor of ecology and evolutionary biology and acting dean of the School of Biological Sciences at UCI, has been used with bacteria, but this is the first study to make full use of it with a plant species. Bennett and his colleagues froze ancestral strains of E. coli so they could evaluate the bacterium's adaptive evolution after culturing it at elevated temperatures for thousands of generations.

Today, Weis is the organizing chairman of Project Baseline, a national effort to collect and preserve seeds from contemporary plant populations. Decades from now, plant biologists will be able to "resurrect" these ancestral generations and compare them to their descendents. By that time, advanced DNA technology may make it possible to sequence the entire genome of individual plants and at low cost. If so, biologists will be able to measure how much plants have evolved with climate change and pinpoint the evolution's underlying genetic basis.

Scientists expect global warming to alter air circulation patterns over the Pacific Ocean, and climate models predict frequent and extreme fluctuations in precipitation along the coast, which likely will affect plant life.

"If we go out today and collect a large number of seeds and freeze them, they will be a resource available to the next generation of scientists," Weis said. "Because of global warming, the evolution explosion is already under way. If we act now, we'll have the tools necessary to determine in the future how species respond to climate change."

Source: University of California - Irvine

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