The evolution of the mustards' spice

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The tangy taste a mustard plant develops to discourage insect predators can be the difference between life and death for the plants. A new study has used this trait and its regional variations to conquer the difficult task of measuring the evolution of complex traits in a natural environment.

There's a reason people don't put gobs of mustard on a hot dog. Mustard plants produce a spicy chemical intended to discourage insects from eating them lest they suffer a bad case of heartburn, and it has essentially the same effect on us.

Now, an interdisciplinary and international group of researchers based at Duke University has figured out why some of those wild mustard plants vary as much as they do in terms of that spice. The variation spells the difference between life and death for the plants in the mountainous Rockies where they live, a place where environmental conditions can change quite significantly over relatively short distances.

The study reported in the August 31 issue of the journal *Science* is one of very few to successfully follow the genes underlying variation of complex traits in a natural setting back to the evolutionary processes that influenced them.

"We were able to put this story together all the way from the plants in the dirt to the amino acids in the laboratory," said Tom Mitchell-Olds, a professor of biology and member of the Duke Institute for Genome Sciences & Policy. "That's where the challenge came in."

Mitchell-Olds' team studies the wild mustard Boechera stricta. Boechera is their organism of choice because its close relationship to the laboratory plant Arabidopsis offers them technical advantages and because the plants live in areas that have been untouched and unchanged for the last 3,000 years.

The researchers first identified a broad region in the plants' genome that was responsible for differences in their chemical defenses, vulnerability to insects and survival and reproduction in nature. "Technically, we had no idea what this would be," Mitchell-Olds said.

Ultimately, they traced those differences back to two amino acid changes in the enzyme controlling the plants' main spicy ingredient. With sophisticated biochemistry, the researchers discovered that this seemingly slight difference alters the spice-building pathway to produce a different defensive chemical—different in a way that apparently matters quite a lot to insects. When plants carrying the version of that enzyme normally found in Colorado were planted in Montana, they struggled to survive as insects took their toll. When Montana plants were established in Colorado, they too got hammered by bugs.

While the findings may have some agricultural applications, Mitchell-Olds says he is more interested in understanding natural variation and the evolutionary forces that have shaped that variation over thousands of years.

"We've been able to go to places where the environment is intact, where these genotypes have been sitting around for 3,000 years in the place where they evolved in the first place, and do science," Mitchell-Olds said. "This variation we see reflects history. We finally have the tools to find the genes and to understand their influence on physiology and fitness, and that's pretty cool."

More information: "A Gain of Function Polymorphism Controlling Complex Traits and Fitness in Nature," K Prasad, B-H Song et al. *Science*, Aug. 31, 2012. DOI: 10.1126/science.1221636

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