Like products, plants wait for optimal configuration before market success

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Botanists had long thought that new species proliferate soon after plants developed a new physical trait. Stephen Smith and colleagues have shown that plants may bide their time for undergoing major speciation. Credit: Mike Cohea, Brown University

Just as a company creates new, better versions of a product to increase market share and pad its bottom line, an international team of researchers led by Brown University has found that plants tinker with their design and performance before flooding the environment with new, improved versions of themselves.

The issue: When does a grouping of plants with the same ancestor, called a clade, begin to spin off new species? Biologists have long assumed that rapid speciation occurred when a clade first developed a new physical trait or mechanism and had begun its own genetic branch. But the team, led by Brown postdoctoral research associate Stephen Smith, discovered that major lineages of flowering plants did not begin the rapid spawning of new species until they had reached a point of development at which speciation success and rate would be maximized. The results are published in the American Journal of Botany.

"Evolution is not what we previously thought," said Smith, who works in the laboratory of Brown biologist Casey Dunn. "It's not as if you get a flower, and speciation (rapidly) occurs. There is a lag. Something else is happening. There is a phase of product development, so to speak."

To tease out the latent speciation rate, Smith and colleagues from Yale University and the Heidelberg Institute for Theoretical Studies in Germany compiled the largest plant phylogeny to date, involving 55,473 species of angiosperms (flowering plants), the genealogical line that represents roughly 90 percent of all plants worldwide. The group looked at the genetic profiles for six major angiosperm clades, including grasses (Poaceae), orchids (Orchidaceae), sunflowers (Asteraceae), beans (Fabaceae), eudicots (Eudicotyledoneae), and monocots (Monocottyledoneae). Together, these branches make up 99 percent of flowering plants on Earth.

The common ancestor for the branches is Mesangiospermae, a clade that emerged more than 125 millions years ago. Yet with Mesangiospermae and the clades that spun off it, the researchers were surprised to learn that the boom in speciation did not occur around the ancestral root; instead, the diversification happened some time later, although a precise time remains elusive.

"During the early evolution of these groups," Smith said, "there is the development of features that we often recognize to identify these groups visually, but they don't begin to speciate rapidly until after the development of the features."

"These findings are consistent with the view that radiations tend to be lit by a long 'fuse,' and also with the idea that an initial innovation enables subsequent experimentation and, eventually, the evolution of a combination of characteristics that drives a major radiation," the authors write.

Smith believes some triggers for the speciation

explosion could have been internal, such as building a better flower or learning how to grow faster and thus outcompete other plants. The winning edge could also have come from the arrival of pollinating insects or changes in climate. The team plans to investigate these questions.

To compile the phylogenetic tree, the group combined data gathered from an exhaustive survey of the peer-reviewed literature with a gene-wide classification of species thanks to data gathered by GenBank, a genetic sequence database run by the U.S. National Institutes of Health.

"This is a nice example of how computer science and cyberinfrastructure initiatives can help to extend the limits of biological explorations," said Alexandros Stamatakis, group leader of the scientific computing group at the Heidelberg Institute.

Provided by Brown University