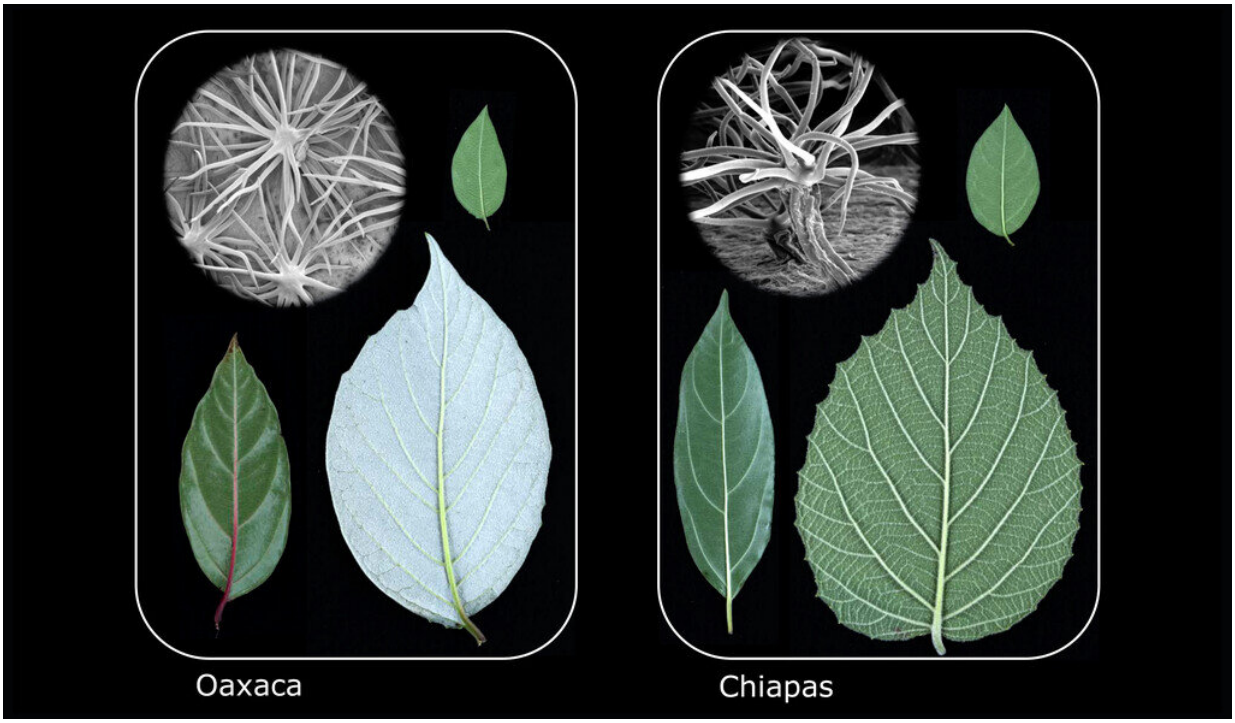
Plant study hints evolution may be predictable

July 18 2022, by Bill Hathaway



Similar leaf types evolved independently in three species of plants found in cloud forests of Oaxaca, Mexico and three species of plants in similar environment in Chiapas, Mexico. This example of parallel evolution is one of several found by Yale-led scientists and suggests that evolution may be predictable. Credit: Yale University

Evolution has long been viewed as a rather random process, with the traits of species shaped by chance mutations and environmental

events—and therefore largely unpredictable.

But an international team of scientists led by researchers from Yale University and Columbia University has found that a particular plant lineage independently evolved three similar leaf types over and over again in mountainous regions scattered throughout the neotropics.

The findings provided the first examples in plants of a phenomenon known as "replicated radiation," in which similar forms evolve repeatedly within different regions, suggesting that evolution is not always such a random process but can be predicted.

The study is published July 18 in the journal *Nature Ecology & Evolution*.

"The findings demonstrate how predictable evolution can actually be, with organismal development and natural selection combining to produce the same forms again and again under certain circumstances," said Yale's Michael Donoghue, Sterling Professor Emeritus of Ecology & Evolutionary Biology and co-corresponding author. "Maybe evolutionary biology can become much more of a predictive science than we ever imagined in the past."

For the study, the research team studied the genetics and morphology of the plant lineage Viburnum, a genus of flowering plants that began to spread south from Mexico into Central and South America some 10 million years ago. Donoghue studied this same plant group for his Ph.D. dissertation at Harvard 40 years ago. At the time, he argued in favor of an alternative theory in which large, hair-covered leaves and small smooth leaves evolved early in the evolution of the group and then both forms migrated separately, being dispersed by birds, through the various mountain ranges.

The new genetic analyses reported in the paper, however, show that the two different leaf types evolved independently, in parallel, in each of a number of mountain regions.

"I came to the wrong conclusion because I lacked the relevant genomic data back in the 1970s," Donoghue said.

The team found that a very similar set of leaf types evolved in 9 of 11 regions studied. However, the full array of leaf types may have yet to evolve in places where Viburnum has only more recently migrated. For instance, the mountains of Bolivia lack the large hairy leaf types found in other wetter areas with little sunshine in the cloud forest in Mexico, Central America, and northern South America.

"These plants arrived in Bolivia less than a million years ago, so we predict that the large, hairy leaf form will eventually evolve in Bolivia as well," Donoghue said.

Several examples of replicated radiation have been found in animals, such as Anolis lizards in the Caribbean. In that case, the same set of body forms, or "ectomorphs," evolved independently on several different islands. With a plant example now in hand, evolutionary biologists will try to discover the general circumstances under which solid predictions can be made about evolutionary trajectories.

"This collaborative work, spanning decades, has revealed a wonderful new system to study evolutionary adaptation," said Ericka Edwards, professor of ecology and evolutionary biology at Yale and co-corresponding author of the paper. "Now that we have established the pattern, our next challenges are to better understand the functional significance of these leaf types and the underlying genetic architecture that enables their repeated emergence."

Edwards and Deren Eaton of Columbia are co-corresponding authors of the paper.

More information: Michael J. Donoghue et al, Replicated radiation of a plant clade along a cloud forest archipelago, *Nature Ecology & Evolution* (2022). DOI: 10.1038/s41559-022-01823-x