Which came first, the moth or the cactus?

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It's not a good idea to put all your eggs in one basket… unless you're a senita moth.

Found in the parched Sonoran desert of southern Arizona and northern Mexico, the senita moth depends on a single plant species -- the senita cactus -- both for its food and for a place to lay eggs. The senita cactus is equally dependent upon the moth, the only species that pollinates its flowers. Senita cacti and senita moths have a rare, mutually dependent relationship, one of only three known dependencies in which an insect actively pollinates flowers for the purpose of assuring a food resource for its offspring.

"Mutualistic relationships like this present a problem for ecological theory," said Rice University ecologist Nat Holland, who co-discovered the senita moth-senita cactus mutualism in 1995 and has studied it ever since.

The problem is that the moths lay their eggs inside the cacti's flowers immediately after pollination, and when the eggs hatch the moth larvae eat the fruit, destroying the flowers' chances to produce seeds. Historic theory predicts extreme ecological instability for this relationship; as moth populations increase, more flowers are destroyed, fewer new cacti appear, and the spiral continues until both species disappear.

Yet that hasn't happened, and Holland, assistant professor of ecology and evolutionary biology, spends several months each year observing moths and cacti in the Mexican desert to document why.

Holland, whose lab is just a few steps down the hall from his Houston office, jokes that his "real" lab is 1,500 miles away. He's studied senita at several locations in the Sonoran Desert, including the Organ Pipe Cactus National Monument in southern Arizona. But his primary site for more than a decade is a desolate, 30-acre patch of desert straddling three ranches near Bahia de Kino on the Gulf of California. Holland said he and his students sometimes go weeks without seeing other people at the sites, with the exception of a cowboy on horseback here and there.

There isn't much to see on the long drives to and from Houston either, but Holland said hours of solitude provide a valuable time for thinking and synthesizing what he's learned in the desert. That's important because his ultimate goal reaches far beyond the Sonoran Desert to a fundamental rethinking of ecological theory for such mutualistic interactions.

"I develop theoretical models, equations that attempt to explain mutualistic relationships like the one between the moth and the cactus, and I take those models into the field and examine them empirically to find out how well they predict what really happens," Holland said.

Traditional theory of such mutualistic interactions leads to predictions of unbounded population growth or instability and eventual doom due to one species overexploiting another. These predictions clearly don't square with what Holland and his students see happening in the Sonoran Desert, where both species thrive. Holland's models differ from traditional theory, suggesting that one mutualist may exert some control over the other's population increases, such that neither unbounded growth nor overexploitation ensue.

"I have always been interested in the community ecology of mutualism -- the larger puzzle -- and this moth-cactus relationship is just one piece of that," Holland said. "When we discovered the relationship in 1995, I

immediately thought of using it to look at the bigger picture. But in aiming to do that, I wound up spending a decade working on the population ecology of mutualisms, a prerequisite for then understanding this larger puzzle."

Having made some progress on the population ecology of mutualism, some of Holland's current work, which is slated for publication later this year, returns to his earlier interests in community ecology. "We want to understand how the structure of mutualistic communities influences their stability and dynamics, both of individual species and of whole networks of species." The results suggest that the structures of mutualistic communities compliment those of predator-prey food webs, a finding that presents the tantalizing possibility of developing an overarching scheme that incorporates elements of both.

Source: Rice University