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The Ties that Bind Bats & Plants
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Over eons, certain plants and pollinators can become so tightly dependent on one another that the loss of one can be fatal to the other – a fact that has tremendous impact on conservation. My research in Ecuador, supported by BCI Graduate Research Scholarships, explores this symbiotic relationship between the far-flung bellflower family of Latin American plants and a group of nectar-eating bats. Along the way to documenting that evolutionary bond, I also described a previously unknown bat species.

For my Ph.D. research at the University of Miami (Florida), I came to the high-country cloud forests of Ecuador. Expanding agriculture and livestock grazing, as well as the introduction of non-native commercial plants, are disrupting pollination systems in the cloud forests and dramatically increasing the need to understand and preserve the relationships between pollinators and plants.

By conducting field research in a number of forest reserves throughout the Andes, I have worked with many people, including local residents, reserve staff, tourists and students. Misconceptions about bats are incredible in Ecuador. As I described my research, I often had to first explain that not all bats suck blood and that bats do not begin life as rats and then sprout wings.

Simply talking about what I was learning about bat pollination raised the awareness of many Ecuadorians about the essential role of bats in their environment. I distributed lists of local bat species to the owners of all six of the reserves where I have worked, giving them another tool in advertising for tourists. Several reserves even began sending tourist groups to join us on our nightly mist-netting forays.

In addition to educating the public, I trained 11 field assistants (undergraduates from three Ecuadorian universities) in bat-research techniques, which should increase the amount and quality of bat research in Ecuador. Two of these students are completing their thesis work with me, one on seed dispersal by bats and the other on bat reproductive cycles.

I studied the pollination of flowering *Burmeistera* (bellflower) plants. The 102 species of this genus are found from Guatemala south to Peru, mostly at elevations between 5,250 and 8,500 feet (1,600-2,600 meters). Previous research suggested that both bats and hummingbirds pollinate these plants.

For 90 nights, we captured bats in mist nets, recorded 285 hours of video of *Burmeistera* flowers and measured the pollen left on the flowers during the day (when hummingbirds visit) and at night (when bats are on the wing). Pollen samples were also collected from captured bats and microscopically identified.

The video demonstrated that both hummingbirds and bats – Geoffroy's long-nosed bats (*Anoura geoffroyi*) and tailed tailless bats (*Anoura caudifera*) – visited 10 of the 11 *Burmeistera* species with roughly the same frequency. The eleventh species, *Burmeistera rubrosepala*, was visited only by hummingbirds and apparently pollinated only by them.

We caught 44 *Anoura* bats in mist nets that we placed across trails near *Burmeistera* or other bat-pollinated plants. Pollen samples were collected from each bat's fur (using small cubes of gelatin) and mounted on microscope slides for identification.

In addition to 18 tailed tailless bats and 18 Geof-froy's bats, we also captured eight individuals of a new species, *Anoura fistulata*. This species, described in the *Journal of Mammalogy* (by myself, Patricio Mena V. and Luis Albuja V.), was never found with *Burmeistera* pollen. *A. fistulata* is characterized by a long, tube-like lower lip and an extremely long tongue.

To measure pollen deposition, I placed small squares of double-sided tape on reproductive parts (anther and stigma) of the flowers. The tape was collected and replaced at dusk and dawn to determine the relative contribution of bats and/or hawkmoths (at night) versus bees and/or hummingbirds (during the day).

The video showed that nine moths visited the flowers we were filming, but they are totally ineffective pollinators since they do not touch anthers or stigma. We recorded 85 bat visits that lasted an average of 0.56 second and 81 hummingbird visits averaging 0.9 seconds. Analysis of pollen deposition demonstrates that nearly all pollen transfer occurs at night. Nocturnal pollination by bats was 30 times more effective than daytime pollination by hummingbirds.

Burmeistera rubrosepala is the exception. For this species, pollen was only deposited during the day; we recorded no pollen transfer at night. As one might guess given its bright red and yellow flowers, this species is adapted entirely for hummingbird pollination.

For the other 10 species, while flowers attract both bats and hummingbirds, only the bats effectively distribute pollen. My research strongly suggests that *Burmeistera* species evolve to require pollination by either bats or hummingbirds, but not both.

The fact that hummingbirds visit bat-adapted flowers implies that this specialization does not result from difficulty in attracting various pollinators. I believe flower morphology is the key: To ensure a bat's head will be dusted with pollen, a flower must be wide enough to accommodate the bat's snout. But a wide flower also lets a hummingbird slip in for a taste of nectar without touching the pollen.

To be hummingbird-adapted, therefore, flowers must be narrow enough to ensure contact with the anthers and stigmas. To test this hypothesis, I am conducting flight-cage experiments with bats and hummingbirds and artificial flowers of varying shapes.

Clearly, the *Burmeistera* flowers are intensely dependent on the bats for survival. But my results also suggest that that specificity is not shared by the bats, which are sometimes found in areas without *Burmeistera* plants. They can forage on other flowers and will even learn to take honey-water from artificial flowers. The flowers, in other words, need the bats much more than bats need the flowers.

Nathan Muchhala, a graduate student at the University of Miami is in the fifth year of his Ph.D. research into various aspects of bat pollination in Ecuador, where he has been living for the past two years. He first came to

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