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Bags of Bats, Fruits and Seeds
The long road to a book on Neotropical seed dispersers
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It's hard to imagine that this small cloth bag has anything to do with forest regeneration. It punches the damp night air as it dangles from a hook in our primitive shelter, little more than a roof and a floor tucked into the rainforest of French Guiana. The bag bumps others hanging from the same hook and soon they're all twitching. Despite appearances, this isn't some supernatural puppet show. It's bat research.

Inside each bag, a single fruit bat awaits its turn to be identified and measured. These bats, captured in mist nets set along trails and near fruiting trees, have only been in their bags for an hour or two. They are the focus of our multidisciplinary study, but the bags are crucial to linking these frugivores to the plants that depend on bats to disperse their seeds. Once a bat has been removed from its temporary cocoon, everything left in the bag is meticulously collected, especially the essence of rainforest regeneration â€“ seed-filled feces.

By comparing seeds left in bat bags with those taken directly from plant specimens, we can identify the plant species â€“ at least those with seeds small enough to be swallowed â€“ that have been visited by bats prior to capture. This form of seed transport is referred to as "endozoochory," meaning seeds are swallowed, carried within the animal and passed through its digestive tract prior to dispersal elsewhere. Seeds that can be swallowed by most Latin American fruit bats are no larger than peas. Many of these come from pioneer plants, such as Piper, Cecropia and Solanum, which are the first to colonize previously forested areas disturbed by large tree falls or by human activities. Unlike most birds, bats frequently defecate in flight and readily fly over large forest openings. This combination of behaviors makes fruit bats indispensible for rainforest regeneration.

At a table illuminated only by a candle and our headlamps, we begin the nightly tasks of our study â€“ quietly, so as not to awaken our expedition's botanists, who spent the day collecting plants. Cullen Geiselman identifies each bat and records its forearm measurement and weight. Tatyana Lobova examines the contents of the bat bag, using forceps to inspect each seed and place it in a labeled, glassine envelope. Using only a hand lens, she identifies most seeds to genus level and whispers her findings: "Piper amalago. Ficus." It is not uncommon to find seeds from several species in the same bag, indicating that the bat fed at multiple plants before becoming ensnared in our nets. One silky short-tailed fruit bat (Carollia brevicauda) left seeds from five species at once.

Seeds from plants with no edible fruit also turn up in our bags. These have not been eaten but instead caught a ride with fruit bats by adhering to their fur with barbs and hooks. This is referred to as "epizoochory," in which seeds attach themselves to the outside of the animal and are carried until they fall or are groomed off in another location. During our studies in French Guiana, seeds of one species in the amaranth family turned up multiple times in our bat bags, carried there by individuals of two species of yellow-shouldered bat (Sturnira lilium and S. tildae), the lesser spear-nosed bat (Phyllostomus elongatus) and the great stripe-faced bat (Vampyrodes caraccioli). Finding the seeds of these small shrubs in our bat bags tells us something about the bats' foraging behavior: they must have been

flying within a meter of the ground to pick up these hitchhikers.

Sometimes Lobova will open a bag only to find a mess of seedless pulp. This is all that remains of a large-seeded fruit eaten by the bat prior to capture. Though many bat-dispersed plants are small-seeded, some have large seeds surrounded by fruit pulp or a fleshy appendage called an aril. Bats pluck these fruits (or their seeds in the case of those with arils) and carry them to feeding roosts, where they chew off the edible parts. They drop the remaining seeds at the roost or in flight. This form of seed transport is "stomatochory," meaning seeds are carried in the mouth of the animal and dropped after the fleshy reward has been eaten from around the seed.

Studying this mode of dispersal proved difficult since pulp has fewer identifiable characteristics than seeds. Identifying large-seeded fruits in bat diets requires catching the bat with the fruit in its mouth or, more likely, collecting the seeds from beneath a feeding roost. For example, large fruit bats in the genus Artibeus are known to feed on the 2.4- by 1.5-inch (6- by 4-centimeter) fruits of the tonka bean (Dipteryx odorata). These bats are responsible for carrying large seeds of primary forest plants into secondary forests, an essential step in regenerating the high species diversity of the original forest.

Our approach to investigating bats' roles as seed dispersers is hardly new. Thousands of bats throughout the American tropics have been captured and delicately placed in bat bags that danced in the night. Over the last 40 years, researchers have painstakingly studied the seeds left in their bat bags, sometimes even planting them in hopes of identifying seedlings. Since they usually had no guides, each bat researcher had to learn to identify area plants and build a reference collection of fruits and seeds for comparison with those gathered from captured bats. This was no easy task, especially given the small size of many bat-dispersed seeds and the great many fruiting species in tropical forests. Wouldn't a botanist make an ideal collaborator for such a project?

This is exactly what passed through Scott Mori's mind when he met BCI Founder and President Merlin Tuttle for the first time in 1986. Mori and John D. Mitchell, honorary curator at the New York Botanical Garden (NYBG) and current chair of BCI Board of Trustees, invited Tuttle to join them on a field expedition to central French Guiana, where the two botanists were inventorying vascular plants. That marked the beginning of a 22-year collaboration between BCI and NYBG â€“ a combined effort to uncover the important role bats play as seed dispersers in the Neotropics. Since that time, the two organizations have sponsored various research projects in which botanists and bat researchers work together to identify plants dispersed by bats, especially in French Guiana.

The years of collaboration have culminated in a 465-page book entitled Seed Dispersal by Bats in the Neotropics, published this year by NYBG Press. This book is not only a guide for identifying seeds, but also a summary of current knowledge of bat-dispersed plants and the diets and behaviors of frugivorous bats. We list a total of 549 plant species in 191 genera from 62 families as dispersed by bats in the New World tropics. We delve deeper into the subject by focusing specifically on the flora of central French Guiana, home to over 1,900 flowering plant species and 50 species of potential seed-dispersing bats. We discovered that 15 percent of the native flowering plant species and 29 percent of those bearing fleshy fruits may rely on bats to disperse their seeds. Many of these are essential for forest regeneration or have major economic value. And that doesn't even consider bats' critical role as pollinators of many important plants.

Our goal in compiling and analyzing the data gathered over the past 40 years is to stimulate

future research in the many areas that remain unstudied. In addition, we intend for this guide to provide bat conservationists in Latin America with a much-needed tool for detailing the role frugivorous bats play in reseeding tropical forests.

A single bat bag remains on the hook near our table. Inside is a male Peters' spear-nosed bat (Phylloderma stenops). He is docile and does not resist being measured. Geiselman stands to release him at the edge of our shelter. From her opened palm, the bat surveys his surroundings, gives a strong pump of his wings and is gone into the dark forest. Lobova peers into the bat bag. "Passiflora!" she exclaims as she smiles down at the passionflower seeds in the bag. And a new species is added to our ever-growing list of bat-dispersed plants â€“ proof yet again that botanists make some of the best bat researchers.

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