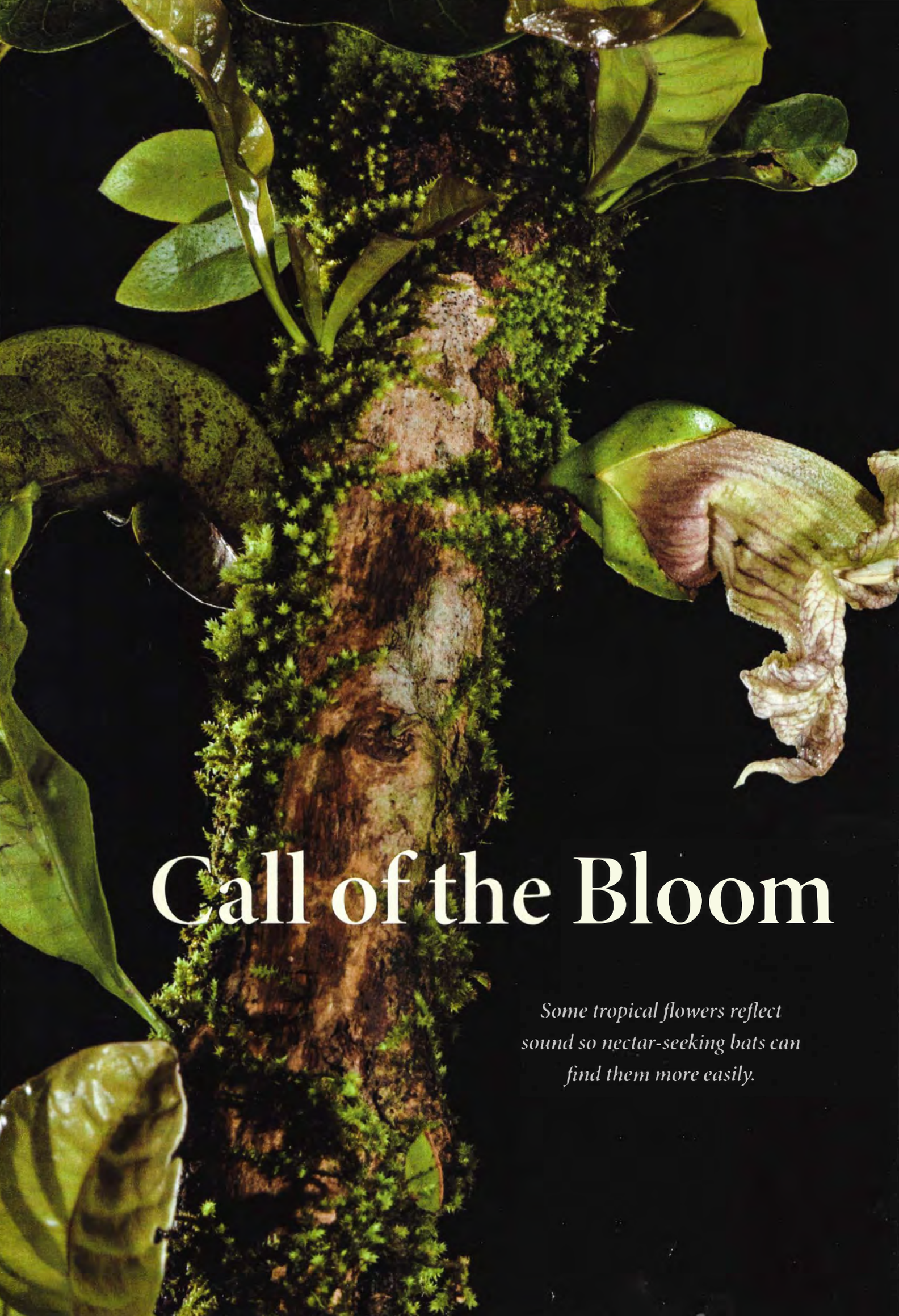


Call of the Bloom

Some tropical flowers reflect sound so nectar-seeking bats can find them more easily.

This flower's shape and exposed position cater to a bat's ears.

PLANT *CRESCENTIA CUJETE*
BAT *GLOSSOPHAGA COMMISSARISI*

WERAUHIA GLADIOLIFLORA RANGE
ALL MAP DATA: TROPICOS

Merlin Tuttle filleted this flower to document the bat's tongue siphoning nectar as the flower's anthers stamp its forehead with pollen. He photographed wild bats in temporary cages.

PLANT *WERAUHIA GLADIOLIFLORA*
BAT *LONCHOPHYLLA ROBUSTA*

By Susan McGrath
Photographs by Merlin D. Tuttle

Nature's inventiveness knows no bounds.

Consider the case of the nectar-drinking bat and the night-flowering vine whose lives intertwine in the lowland tropical forests of Central America.

Glossophaga commissarisi, a tiny, winged mammal with a body no bigger than your thumb, flits among the flowers of *Mucuna holtonii,* lapping nectar, much as hummingbirds and bumblebees do. In exchange it pollinates the plant. In daylight flowers can flaunt their wares with bright colors such as scarlet and fuchsia, but at night, when even the brightest hues pale to a moonlit silver, *Mucuna* flowers resort to sound to catch the ear of nectar bats.

At La Selva Biological Station in northern Costa Rica a vigorous old *Mucuna* has woven a leafy ceiling above a forest clearing and lowered dozens of flowers into the opening on long, green stalks. The flowers dangle at staggered heights in the vaulted clearing like chandeliers in a shadowy ballroom, each palm-size inflorescence a whorl of pale yellow, pea-pod-shaped buds on arched stems.

At dusk the vine's buds ready themselves for bats. First the topmost, greenish petal that caps a bud slowly opens vertically, to stand atop the blossom as a glossy beacon. Below the beacon petal, two tiny side petals wing apart, revealing a crack at the top of the pea pod. From this slit wafts a faint, come-hither scent of garlic, a long-distance signal that draws the *Mucuna*'s winged servants into earshot.

Bats use high-frequency sound as a tool. With their vocal cords, they bang out short, swift bursts through their nostrils or mouths, molding airwaves and interpreting the pattern changes that ricochet back to their sensitive ears. The incoming information is processed fast and continually, allowing bats to adjust their course in mid-flight as they streak through the air after a mosquito or race among flowering trees.

Most bats feed on insects, and they often use powerful, long-range calls, pumped out with every upstroke of their wings. Nectar bats send gentle but very sophisticated calls, which scientists refer to as frequency modulated. These calls trade distance for detail. Most effective within 12 feet, they reflect back pictures that convey precise information about a target's size, shape, position, texture, angle, depth, and other qualities only a nectar bat can interpret.

In the darkened *Mucuna* ballroom at La Selva a beacon petal's cupped shape acts as a mirror, fielding bat calls and bouncing information back hard and clear. With eyes and ears and nose leaf trained straight on the beacon, a bat snaps onto the blossom in a high-speed embrace.

The fit is exact. The bat crams its head into the cupped opening, hooks thumbs onto the beacon's base, tucks its tail, whips its hind feet up. Braced high on the pea pod, it thrusts its snout into the garlicky opening. The bat's long tongue springs a hidden switch, exploding the pea-pod keel. As it laps deep in the flower's nectary, spring-loaded anthers burst from the keel and gild the bat's tiny rump with a spray of golden pollen.

Bang! Bang! Bang! Bang! Ten blossoms detonated and licked dry, and the bats are gone. Their high-octane metabolism and meager sugar-water diet don't allow for lingering. Each bat makes several hundred flower visits every night. *Mucuna holtonii,* with their exploding mechanism and generous snort of nectar, are among the rare flowers that warrant actual landings. (Nectar bats can empty the flowers of less lavish species in a hover lasting a mere fifth of a second.)

Susan McGrath wrote about polar bears in the July 2011 issue. Merlin Tuttle is the founder and former director of Bat Conservation International.

Echoes from this waxy, bell-shaped flower draw a pollen-dappled bat straight up from below.

THE 40 OR SO SPECIES of the subfamily Glossophaginae are the aerial elite of nectar-drinking bats. They belong to the family of New World leaf-nosed bats, native to the tropics and subtropics of the Western Hemisphere. Their fleshy nose embellishments—the eponymous nose leaves—fine-tune the bats' virtuoso echolocation calls.

Nectar bats evolved in fruitful partnership with specific families of flowering plants, a relationship biologists call chiropterophily—from Chiroptera, the mammalian order of bats, and phily, from *philia,* Greek for "love." But this is no love story. The driving force behind the bat-flower partnership is not romance but the primary business of life: survival and reproduction.

Trading nectar for pollination is a delicate transaction, one that presents plants with a quandary. It behooves night-flowering plants to be thrifty with their nectar, because well-fed bats will visit fewer flowers. But if a plant is too stingy, a bat will take its services elsewhere. Over millennia, bat-pollinated plants have evolved a neat solution: They sidestep the problem of nectar quantity (as well as quality) by investing instead in maximizing the bats' foraging efficiency.

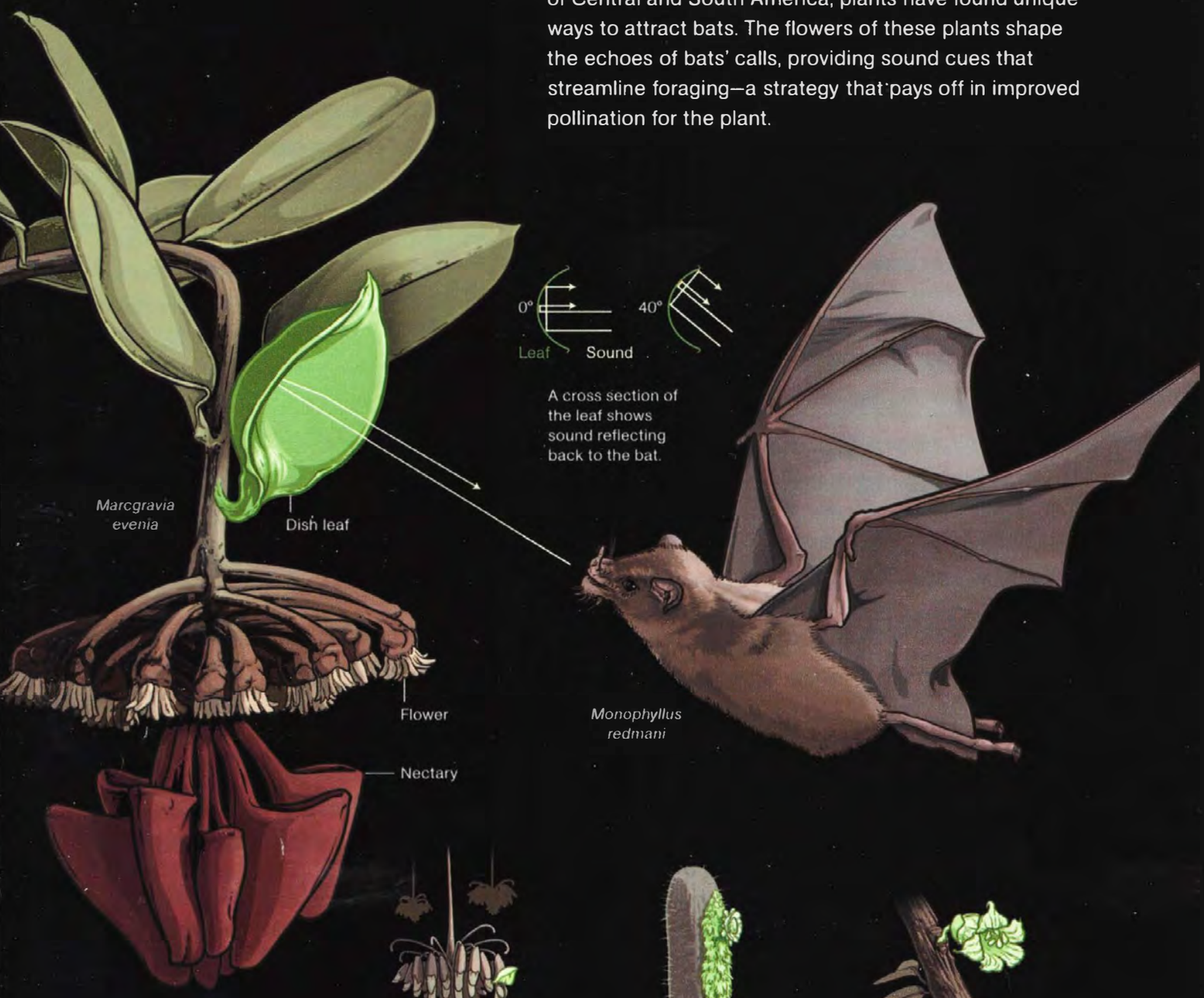
So plants that flower at night proffer their wares in exposed, fly-through positions—easy for bats to find and drink from and removed from cover for arboreal predators such as tree snakes and opossums. They spike their flowers' scent with sulfur compounds—long-distance signals irresistible to nectar bats. (But not to humans: Bat-flower perfume has been variously described as nasty; somewhat reminiscent of cabbage, kohlrabi, and garlic; and like damp, decaying leaves, sour milk, rotten urine, opossum, skunk, carcass, and corpse.) The *Mucuna* vine and certain other plants go one step further. They shape their flowers to catch a bat's ear.

UNTIL 1999 no one had any inkling that plants use shapes that reflect sound to streamline bat foraging. That year biologists Dagmar and Otto von Helversen, of the University of Erlangen in

PLANT: *MERINTHOPODIUM NEURANTHUM.* BAT: *HYLONYCTERIS UNDERWOODI*

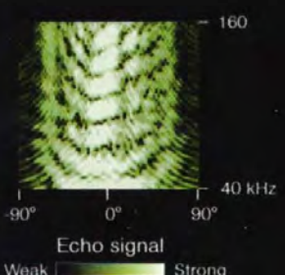
Form feeds function

Nectar bats make several hundred flower visits nightly to fuel their roaring metabolism. In the tropical forests of Central and South America, plants have found unique ways to attract bats. The flowers of these plants shape the echoes of bats' calls, providing sound cues that streamline foraging—a strategy that pays off in improved pollination for the plant.

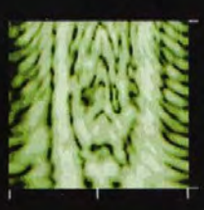


Shaping Echoes

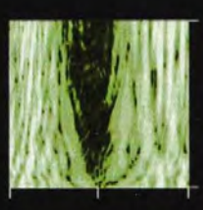
Leaf shape
Marcgravia evenia's dish-like leaves (top) return conspicuous echoes from longer distances and across wider angles.



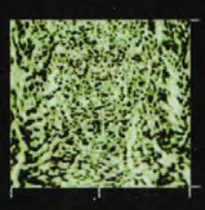
Isolation from foliage
Mucuna holtonii dangles accessibly below the forest canopy. Echoes from a concave petal on each bloom convey precise cues.



Sound dampening
Espostoa frutescens brightens its flowers' echoes by muffling the background with a strip of sound-absorbent "fur."



Sound enhancing
Blooming on the stem (cauliflory) and waxy petals help *Crescentia cujete* stand out acoustically.



MATTHEW TWOMBLY, NGM STAFF; MESA SCHUMACHER

SOURCES: RALPH SIMON, DEPARTMENT OF SENSOR TECHNOLOGY, UNIVERSITY OF ERLANGEN; MERLIN D. TUTTLE, DEPARTMENT OF INTEGRATIVE BIOLOGY, UNIVERSITY OF TEXAS; NATHAN MUCHHALA, UNIVERSITY OF MISSOURI–ST. LOUIS

Germany, were studying acoustics in bats at La Selva. It occurred to Dagmar that *Mucuna*'s beacon petal bore a striking resemblance to a sound beacon—a conspicuous acoustic signal, the aural equivalent of a lighthouse's beam. Field tests with modified *Mucuna* beacons clinched the theory.

The von Helversens followed their observation with a broader investigation into flower echoes, using a colony of captive bats at their lab in Erlangen. Under their supervision, Ralph Simon, an undergraduate research assistant, trained bats to drink from randomly placed nectar feeders flagged with various shapes. Rounded hollow forms proved easiest for bats to find.

Simon subsequently found such forms on flowers in nature, including one with a dish-shaped beacon he first spotted in a photo in a nature magazine. (The plump, red, nectar-containing structures on the flower had caused the editors to misidentify it as a fruit.) Intrigued, he traveled to Cuba, where the flower had been photographed. Crouched in a forest alone at night, the elated scientist watched bats drink nectar as the flower dusted them with its golden pollen, confirming his supposition.

Does a dish-shaped leaf really help bats locate a flower more easily? Back in the lab, Simon found that a replica of a dish-shaped leaf atop the feeder halved the bats' search time; a flat, unmodified leaf replica barely improved search time over an unmarked feeder.

"A normal, flat leaf just twinkles once as a pulse bounces off it," Simon explains, "but the dish-shaped leaf sends echoes back strongly, multiple times, from a pretty wide angle as the bat approaches. It's like a real beacon, because it has an echo with a unique timbre, which stands out like a colored flower in green vegetation."

By now a graduate student, Simon next built a mobile robotic bat head. He mounted a small ultrasonic speaker and two receivers in the triangle formed by a bat's nose and ears. He fired complex, frequency-modulated sounds—like those of a nectar bat—through the robotic nose at flowers attached to a rotating stand and recorded their echoes in the electronic bat ears. He thus collected the echo-acoustic "signatures" of flowers from 65 species of bat-pollinated flowering plants. Every flower Simon tested had a unique and conspicuous acoustic fingerprint.

Overall, Simon found that bat flowers share several general sound adaptations. They all have waxy surfaces that are highly sound reflective, and their sizes and shapes are remarkably consistent from specimen to specimen. Using echo fingerprints of 36 bat flowers from 12 species as a basis for comparison, Simon (Dr. Simon, by this time) wrote a program that classified 130 new flowers to species level based on sound alone. The program confirmed what the bats have long known: Some flowers speak their language.

WHY DO PLANTS INVEST so much in attracting and rewarding bats? "It's because bats are most effective pollinators," Simon says. "They're worth it."

A 2010 study by evolutionary ecologist Nathan Muchhala, of the University of Missouri–St. Louis, comparing hummingbirds and nectar bats in Ecuador found that on average bats deliver ten times the number of pollen grains their avian counterparts do. And bats carry pollen long distances too. Hummingbirds are thought to deliver pollen within a radius of about 700 feet. The longest-haul trucker among nectar bats, *Leptonycteris curasoae,* forages as far as 30 miles from its roost. For tropical forest plants, which are often widely dispersed at low densities, the bats' range confers a big advantage. This long-range pollinating is ever more important as forests become increasingly fragmented through deforestation.

It was in the 1790s that the Italian biologist Lazzaro Spallanzani was ridiculed for suggesting that bats use their ears to see in the dark. A century and a half later, in the late 1930s, scientists discovered how bats do it. Now, 75 years along, we know that in step with bats' ability to "see" with sound, plants themselves have shaped their flowers to be heard, becoming as brilliant to the bat's ear as their brightly colored daytime counterparts are to the eyes of their pollinators. In such intricate interactions, nature reveals its most profound magic. □

BLUE MAHOE TREE RANGE

A pollen-gilded bat emerging from a flower of the blue mahoe tree demonstrates the carrying capacity of fur. This bat lives in eastern Cuba in a colony more than one million strong—a pollinating powerhouse.

PLANT: *TALIPARITI ELATUM*
BAT: *PHYLLONYCTERIS POEYI*

A sound-deadening backdrop heightens this flower's echoes. As wildlands fall and plants become more isolated, nectar bats show their value: Some carry pollen 30 miles nightly.

PLANT: *ESPOSTOA FRUTESCENS*
BAT: *ANOURA GEOFFROYI*

OLD MAN CACTUS FLOWER RANGE