Gone Batty

Illuminating the murky world of tropical bats

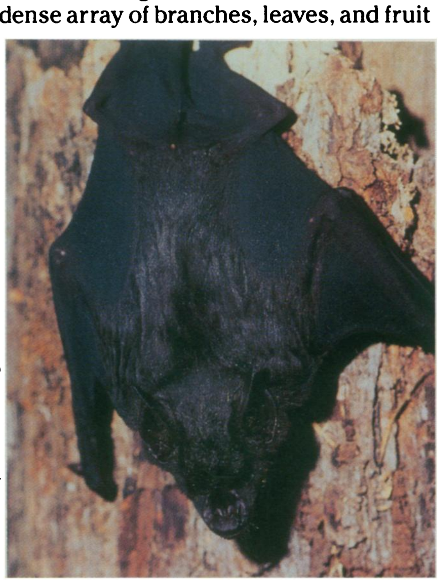
By ELIZABETH PENNISI

On Panama's Barro Colorado Island, Elisabeth K.V. Kalko works the night shift. Part of a scientific contingent studying this insular tropical forest preserve, she begins gathering up her equipment just as most of her colleagues are closing their notebooks for the night.

Come darkness, she motors away from the harbor lights in a small craft, disappearing into what feels like a great, black abyss. Her powerful halogen lamp barely reaches the vegetation along the island's edge as she turns into a channel toward a smaller island. As she nears the silhouette of a large tree that hangs out over the water, she cuts the motor and drifts.

Her companion for the evening, I immediately sense around me what we have come to find. Something – no, many things – flit by invisibly. I hear their wings flutter and feel brief rushes of warm air. In the tree, leaves rustle, sometimes gently, other times quite vigorously. We tie the boat to a small bush. Kalko hands me night-vision goggles. Then she climbs the steep slope, disappearing from sight two paces away, leaving me alone.

I wait, listen, and finally peek through these glasses, which look like high-tech binoculars. Through them I see a sight I will never forget: The tree resolves into a dense array of branches, leaves, and fruit set against a bright green background. Bats dart in and out, startling me with their swiftness. They barely slow down as they swerve past each other and the branches. One seems to pause in midair ever so briefly and plucks a fig, rustling the foliage. All this activity in the pitch black of a moonless night.



Photos: Kalko/Univ. of Tübingen

Phyllostomus hastatus, an omnivore.

I cannot help but marvel at how different their view of the world is from my own. By emitting high-pitched sounds that bounce back, the bats are able to chart the space through which they speed. Thanks to this ability to echolocate, they "see" in much finer detail the scene that the goggles present to me.

Kalko returns, a bat in hand. As part of her research at the Smithsonian Tropical Research Institute, she will catalog its sex and species for an ongoing study of these winged mammals and their relationship to the fig tree beside me. On fig trees that attract bats, the fruit ripens all at once. The fruit above my head was not ripe 3 days ago; 2 days from now, the figs will drop to the ground and rot. Tonight, hundreds of bats whiz by; tomorrow, these opportunists will find another tree, one whose fruit is ripening on a later schedule.

For this study, Kalko concentrates on learning what bat species consume these figs. But overall, she seeks to understand how so many kinds of bats can thrive in tropical ecosystems. About 120 species – many in large numbers – live in Panama. This variety accounts for much of the increase in the biological diversity of mammals in the tropics of the New World, she notes.

So many kinds of bats can exist because they have developed specialized roles in these forest communities, she adds. Bats thrive on insects, blood, small vertebrates, fruits, or nectar and pollen. She wants to know just how specialized each bat is for the part it plays here and how its food source, in this case the figs, influences that specialization.

Also, their large numbers give bats clout: They affect community structure – that is, what lives where, Kalko says. Their activity directly and indirectly influences the balance and distribution of the local plants and animals.

Temporary cages make it possible to study P. hastatus *as it uses sonar to find food.*

My guide holds the bat up so I can take a closer look. "She has such an incredibly full belly," Kalko marvels, while gently stroking the bat to calm it. "She looks pregnant, but she's just full of figs."

Each time a bat nabs a fig, it carries the fruit away from the tree to a "dining" roost. There, it bites off and chews the outer coat, presses that mashed tissue against the rigid part of its palate, then squeezes out and swallows the juice and seeds, spitting out what's left. Because most figs provide the bats with little else besides sugar water, they must eat and process quite a lot of fruit to meet their high demands for energy. Then, as they fly about, they defecate, dribbling sticky fig seeds everywhere.

"[Fig trees] profit from bats because the bat travels rather long distances," Kalko explains. Seeds wind up far from the mother tree.

The fig tree, too, may have its say about how bats behave. Some scientists argue that the structuring of a bat community happens by chance and leads to what ecologists call random assemblages of species. But others, Kalko among them, think that once biologists learn enough about these cryptic creatures, they will recognize that various factors cause certain bats to gravitate to particular parts of a habitat.

Physical limitations, such as the shape of the wing or the nature of echolocation signals, make each bat species well-suited just for the particular life it leads. For example, the ability to emit high-pitched sounds and listen for echoes as a means of finding food works well in the open air but not necessarily in cluttered spaces such as amidst the leaves and branches of fig trees, especially when the morsel sought is not moving. "This is quite a problem for the bats to solve," Kalko says.

Using multiple flashes and an open camera shutter, Kalko captures the maneuverings of a single bat in one image. By tracking echolocation signals at the same time, she has learned how this bat snares insects off the surface of the water.

Kalko became fascinated with this problem as a graduate student at the University of Tübingen in Germany during the early 1980s. There, Hans-Ulrich Schnitzler had developed several sophisticated recording systems that he used to study bats. He was looking for someone who could put what his group had discovered about echolocation and signal function into an ecological context.

"I was very much interested in this, but I thought, Wow, would I be able to get along with all this technology stuff?" Kalko recalls. "At some point, I reached a conclusion [that I could], and I have never regretted it."

Kalko now uses these systems in the field and in artificial situations that she creates for bats temporarily housed in a large cage.

One device consists of two cameras mounted on a tripod with up to a dozen flash units. With the camera shutters open, Kalko can record multiple images on the same frame by setting off one flash after another milliseconds apart. The film captures the bat's movements wing beat by wing beat. The two cameras then enable Kalko to make three-dimensional reconstructions of the bat's flight path.

Another device records the bat's ultrasonic utterances in sync with the picture taking. Kalko can then examine whether and how the bat alters its signals as it flies and closes in on a fig or other food source.

Already this high-tech equipment has taught her much about the specific hunting strategies of some bats. She and her colleagues find that through evolution, many bats have refined their emitted signals in order to detect targets efficiently in a given habitat and under particular conditions. The signals vary depending on how cluttered the air space is, how far away the target may be, and what that target is.

Moreover, data gathered these past 2 years in Panama indicate that in some cases, distantly related bats have evolved very similar signals because they forage for the same types of foods in similar habitats. At the same time, these studies also show that bats can evolve very different signal patterns to perform similar tasks.

"There's more than one solution to a given problem," says Kalko.

Working with Schnitzler and two other researchers, Kalko examined the hunting habits of the fisherman bat, *Noctilio leporinus,* which lives throughout South America. The bats emit one kind of signal pattern when they fly about 20 inches above the water seeking fish and a faster, more variable frequency pattern when they dip down to home in on the ripples they use to pick out surfacing fish.

Other times, they don't rely on echolocation at all but instead "rake" the surface by dragging their claws in the water to snare any fish available, Kalko and her colleagues will report later this year in BEHAVIORAL ECOLOGY AND SOCIOBIOLOGY.

More recently, she examined echolocation signals in six species of sheath-tailed bats, which scientists consider a primitive bat group. The similarities in size and shape of several species of these bats suggest that they use their environment similarly. But the interspecies variation in echolocation signals tells a different story, Kalko says.

Depending on the pattern and types of sounds, some hunt in the open, others dine at the edges of forests or in clearings, and still others track down insects by zooming between the trees. Moreover, Kalko's field observations supported her notion that because these bat species cannot vary their signals very much, they are unable to adapt to different environments the way some other bats can.

The bats here tonight are leaf-nosed bats, the largest and most diverse group of bats in the Americas. These fig-munching *Artibeus jamaicenses* never fine-tuned echolocation. Instead, they honed a sense of smell that lets them sniff out ripe fruit hidden beneath leaves, reserving echoes for helping them navigate in the dark.

"The evolutionary success of this group is presumably based on the fact that they can use other sensory cues," Kalko explains.

In contrast, a different bat, *Phyllostomus hastatus,* still relies only on echolocation as it seeks out its many types of food. And at least one food plant seems to know that. Unlike many tropical trees, *Gurania* dangles its fruit below its leaves and branches, says Marsha C. Condon, now at Hofstra University in Hempstead, N.Y. She and Kalko observed that this placement of fruit makes it easy for the bat to detect the morsel with its echoing signals. "How plants present their fruits to bats, that reflects the types of sensory modalities that the bats are using to find the fruit," Kalko concludes.

For the past 10 years, Smithsonian mammalogist Charles O. Handley has tagged and tracked *A. jamaicensis* and the six other fig-eating bat species living on Barro Colorado Island. Kalko and Handley plan to combine these data with information on the area's 20 fig species and with observations such as the ones made tonight. The analysis already shows that while larger bats tend to eat larger figs and smaller ones stick to smaller fruit, there is more overlap in diet than scientists expected.

As she is explaining all of this, Kalko stops midsentence. We both hear a loud ruckus from the direction of the net that she has set midway up the slope to snare bats. "I fear my mist net is full of bats; I must get back very quickly," she says. It seems that one animal's distressed squeals will attract others. So instead of one or two bats, a dozen or more can get hung up in her net at one time – requiring many minutes and much patience to free them.

But as she heads back into the darkness, she reminds me that the net-clearing task that awaits her is all part of a night's work, part of a career she cherishes. "The nice thing is [that] when you are looking at the interactions of bats and their environments, you're not specializing in just bats," she says. "You can do everything – you can venture into entomology, you can venture into botany.

"It's been fantastic." □