When the bat sings

The trills and chirps of bats can be as complex and meaningful as bird song—and may be a closer analog for human speech

By Virginia Morell

Archaeologists aren’t sure how the Governor’s Palace, a cream-and-white limestone structure at Uxmal, Mexico, figured in Maya religious ceremonies. Its walls of carefully chiseled blocks are now crumbling; the chants of priests no longer echo in its halls. Yet if you’re quiet and observant, you’ll hear the songs of the current residents of the palace: bats.

“Do you hear them?” asks Kirsten Bohn, a behavioral ecologist and bat expert at Florida International University in Miami. “It’s like the walls are singing.”

It takes a moment to tune my ear to the right pitch, but once I do, I realize the air is filled with the bats’ soft, birdlike twitters, chirps, and trills. And this is not during the deep of the night, but in the middle of the day. So if you know where to look, you can see the bats, too.

“Well, hello there, boo-boo,” Bohn says, peering into a long, narrow fissure that time and erosion have opened up between the wall’s stones. She presses her face close to the crack, squinting to get a better look at the mouse-sized bats sandwiched inside. I do the same, and once my eyes adjust to the dark of the crevice, I’m eye to eye with a brown-eyed Nyctinomops laticaudatus, the broad-eared bat. He scuttles back into his rocky lair, but I can still see his chattering jaws: “Zzzzzzz.”

“That’s an aggressive warning call,” Bohn explains. “He’s telling us to back off. He doesn’t want to bother with us; he wants to do what’s important—[which is] to sing.”

Bohn has traveled to Uxmal to capture the songs of this and dozens of other broad-eared bats scrunched inside the ruin’s walls in order to study the evolution and function of bat song. Biologists commonly use the word “song” to describe any acoustic displays by males, including the simple calls of frogs, insects, and many other creatures. Bohn, however, reserves “song” for something as complex as bird song—calls “composed of multiple syllables combined in a specific way, and which have repeatable patterns and rhythm.” By this reckoning, many birds, some cetaceans, and humans sing. So, it turns out, do some bats.

That bats emit any kind of song comes as a surprise to most people, partly because we tend to think chiefly of their echo-location calls, ultrasonic sounds beyond
our hearing, or their short, sharp social calls. It’s also a surprise because it is so rare for a mammal to sing like a songbird. “So why do bats?” Bohn asks. “What are the social and environmental pressures that have led them to evolve this ability, which is so mentally demanding?”

To find out, researchers are seeking out bat troubadours from New Zealand to Africa. Already, studies by Bohn, her collaborator Michael Smotherman, a neurophysiologist at Texas A&M University, College Station, and others have shown that like many songbirds, most bat songsters are male, live in polygynous societies where males mate with more than one female, and tend to sing during the mating season to court females and defend territories. Their complex songs are probably not innate, and so require vocal learning, as bird song and human speech do. At least one species of bat appears to have a specialized neural loop in its forebrain, analogous to the circuit in songbirds that underlies vocal learning. Geneticists have added another parallel: The FOXP2 gene, which is tied to vocal learning in humans and birds, has also been under intense selection in bats.

“There’s much left to discover,” says Mirjam Knörnschild, a behavioral ecologist and bat song expert at the University of Ulm in Germany. But already, the bat song enthusiasts are wondering if these winged mammals can help explain the evolution of complex vocal abilities overall—including that of their fellow mammals, human speech.

**SCIENTISTS HAVE KNOWN** that bats sing since at least 1974, when Jack Bradbury, a behavioral ecologist and now a professor emeritus at Cornell University, and zoologist Louise Emmons of the Smithsonian Institution reported recordings of greater sac-winged bats, *Saccopteryx bilineata*, from Trinidad. “I used a shotgun mic and reel-to-reel recording gear,” Bradbury recalls. “The bats would land on their roosts at dawn and sing like birds, and in a low enough register that I could hear them.”

The study of bat song didn’t take off until this century, however, when recording equipment became more portable, making it easier to work in the wild. By now, song has been documented in 20 of the 1116 known species of bats, although scientists suspect that many more are talented songsters. Some, such as the parti-colored bat (*Vespertilio murinus*), the broad-eared bat (*Nyctinomops laticaudatus*), and the heart-nosed bat (*Cardioderma cor*),

New Zealand’s *Mystacina tuberculata*, hung in a cleft of a tree or similar grotto to belt out their tunes. Others, such as the European *Vespertilio murinus*, sing both from roosts and on the wing, erupting into song at the end of autumn when females may be seeking a mate to spend the winter with. Male Brazilian (also known as Mexican) free-tailed bats, *Tadarida brasiliensis*, the species that Bohn and Smotherman have studied the most, sing year-round, but especially during mating season.

To study the details of bat song, Smotherman and others have started captive colonies—captive bats won’t sing alone, underscoring the social nature of bat song. But researchers also venture to caves, trees, parking garages, and ruins, studying known songster species and searching for new ones. “You have to know which ones sing and which ones don’t to fully understand song in bats,” Bradbury says.

Answering that question is one reason why Bohn traveled to Uxmal. “Do all the Molossidae species—there are at least 100—and their related genera sing?” she asks. “If they don’t, why not? I’m trying to figure out how and why this complex form of communication came about.”

In spite of our presence, the broad-eared bats are still twittering to each other. Close to the wall, I catch a whiff of a strong, pungent odor. “They sure smell like males,” Bohn says, taking another peek at the bats. “Yuck. It’s got to be a bachelors’ pad.”

In the related Brazilian free-tailed bat that Bohn studies back home in the United States, each male stakes out a territory within the larger mixed roost and sings both to lure females in for mating and to keep other males out. The broad-eared bat may have similar arrangements, but no one knows; Bohn is only now exploring its habits. “They’re peeing on everything, marking every bit of their territories,” she observes. “And just singing their hearts out.”

So far, scientists have found few similarities in the notes or syllables used by the various species of bats, or in the structure of their tunes. But in three major papers, one published just last year in *Animal Behaviour*, Smotherman and Bohn traced striking similarities between the tunes of the Brazilian free-tailed bats and those of songbirds. The bat song is as complex and structured—as “songlike”—as that of songbirds, they reported. Both are hierarchically structured, composed of multiple syllables and phrases; among the bats they include chirps, trills, and buzzes.

Bat song even has syntax, or rules for constructing a tune. For instance, in the songs of the free-tailed bat only chirp syllables can be included in chirp phrases, and buzz syllables belong in buzz phrases. Yet there is also room for flexibility, so that each male’s song is unique—rather like a jazz player riffing on a tune. “Their songs aren’t just honk-honk-honk or eee-eee-eee,” Bohn says. “They’re polysyllabic; they
have sequences, temporal structures, and a timed rhythm.”

Perhaps most surprising, Bohn and her colleagues discovered that these bats can also quickly vary the syntax of their songs in response to social circumstances, again as songbirds do. This type of audio-vocal plasticity is rare in mammals, aside from humans. For instance, Brazilian free-tailed bats can instantly (in less than 100 milliseconds) switch from belting out a courtship song to singing a territorial tune, if another male echolocates nearby. “It means they can adjust their output—their songs—based on what they hear,” says Cynthia Moss, a neuroethologist and bat echolocation expert at the University of Maryland, College Park. “It’s a very exciting discovery, as is all the work on bat acoustic communication, because it shows that bats have the same degree of vocal flexibility as songbirds, and it gets at bats’ social behaviors,” which are as yet not well understood.

Bohn is full of unanswered questions about bats’ social life and songs. But after enumerating them she pauses, her blue eyes twinkling. “Actually, there’s an even bigger question. Why don’t we use bats to study the evolution of human speech?”

**IT’S A QUESTION** that many bat researchers raise. For more than 50 years, songbirds have been the animal model of choice for investigating the roots of human speech. That’s because of the many parallels—developmental, behavioral, neural, and genetic—between how human children learn to speak and how young songbirds, such as zebra finches, learn to sing, explains Richard Mooney, a neuroscientist who studies bird song at Duke University in Durham, North Carolina.

But songbirds are not mammals. “They don’t have a mammal’s neural architecture,” Smotherman says. “So working out how bats use song and how bats’ brains produce song may give us a better idea of the changes and adaptations that had to occur for human speech to evolve.” Mice that sing ultrasonic tunes have been suggested as a model, but questions remain about their abilities, whereas “bats’ vocal production is fertile ground,” Mooney says.

The bat researchers have already found that certain bats use songs in a slightly more complicated way than do some songbirds. Many songbirds use a single “dual-function” song to both attract mates and defend territories. But both greater sac-winged and Brazilian free-tailed bats have distinct songs for courtship and territorial defense. And male free-tailed bats sing even when it’s not the mating season, a time when they’re in an all-male roost with a million other guys. “They may be using their songs for other social purposes,” depending on the situation, Smotherman says.

Bird song researchers are miles ahead, Smotherman concedes. They know the regions in a bird’s brain that produce song, and the selective pressures, such as female choice and male-male competition, that caused song to evolve. More than 100 labs worldwide, many with steady
funding, explore bird song from all angles; there are dedicated conferences and a supportive website, http://songbirdscience.com.

Although bird song researchers would welcome a comparative mammalian model, the nascent study of bat song has nothing to compare with this. Bat song researchers are still identifying which species sing and in what social situations. “There’s such variation in the songs and their functions,” Knörnschild says. Some sound deceptively simple. The male Seba’s short-tailed bat (Carollia perspicillata) from Central and South America rhythmically repeats one variable note over and over, much like a frog calling, Knörnschild says. Within that simple tune, however, there is an “individual vocal signature,” a sound that identifies the caller and may help a female find her chosen mate, Knörnschild and her colleagues reported in April in Behaviour.

The crooning of other bats is more baroque. A team of researchers from the Czech Republic has decoded much of the courtship song of male European Pipistrellus nathusii, a migratory species that sings both on the wing and from a roost. The scientists analyzed nearly 3000 recordings they had gathered at 33 roosts in southern Bohemia, and reported in Acta Chiropterologica in 2008 that these songs are semantically structured. The rhythmic tunes begin with a phrase (which the scientists designated as motif A) announcing the bat’s species, including an individual vocal signature (motifs B and C), information about the bat’s population (motif D), and a signal about where to land (motif E). “Hence, translated into human words, the message ABCED could be approximately: (A) ‘Pay attention: I am a P. nathusii, (B, C) specifically male 17b, (E) land here, (D) we share a common social identity and common communication pool,’ ” the researchers wrote in their paper.

Even more complicated are the courtship songs of the greater sac-winged bats, Knörnschild says. “When you look at their sonograms, they are as complex as [those depicting] the melodies of nightingales. They have motifs within motifs.” A male sac-winged bat roosts during the day in a tree hollow or grotto with a harem of females. He uses a song with soft tones to lure the ladies, and a harsher tune to compete with other males in countersinging bouts. They air these latter territorial tunes at dawn and early in the evening when females are most likely to be early. The song lasts a mere 1.6 seconds, yet contains some 20 syllables and ends with loud, low-frequency buzzes that are individually distinct and advertise the male’s strength. And there’s a big payoff for a song well sung: Male sac-winged bats that sing the most territorial songs at the lowest frequency father more offspring. Knörnschild is investigating the possibility that this species has culturally transmitted dialects, as humans and some birds do.

Young sac-winged bats (and likely those of other species) must learn these complex songs from their parents. Knörnschild and her colleagues found that male and female sac-winged bat pups learn songs by babbling and imitating, as do human infants and the chicks of many bird species. (Although the females don’t sing as adults, they need to know the songs in order to choose a mate.) Some bat species may even be able to imitate new songs throughout their lives, Knörnschild, Bohn, and Smotherman think. Only some songbirds possess such “vocal plasticity”; most songbird chicks have only a short developmental period during which they’re able to learn songs. To clinch the case for bats, these scientists say, someone needs to show an adult bat imitating another adult bat’s song. “That would be the ultimate proof,” Smotherman says, and could help push bats up to the level of birds in studies about the origin of speech.

That’s why Bohn carted both recording and broadcasting equipment to the palace’s wall at Uxmal. She and her graduate student assistant Fernando Montiel run cables from their laptops over the ancient stones to a pair of microphones and a single speaker on a long bar atop a tripod. Montiel raises the array and points the speaker and microphones at the wall’s fissures, where the small bats lurk and sing. By now, our ears are tuned to their tiny melodies, and I, too, can tell the difference between an aggressive call and a rhythmic ditty.

Earlier, Bohn and Montiel had recorded some of the bats’ songs, and, using special-