BATTY ABILITY

Why one scientist is using 3-D scans of bats to improve drone technology

ALL EARS
Bats map their surroundings by listening to how their calls bounce off objects.

CRYING OUT
Bats emit high-pitched sounds that help them navigate and detect prey.

ESSENTIAL QUESTION: How do bats use sound to navigate? Are there any devices used by people that work in the same way?

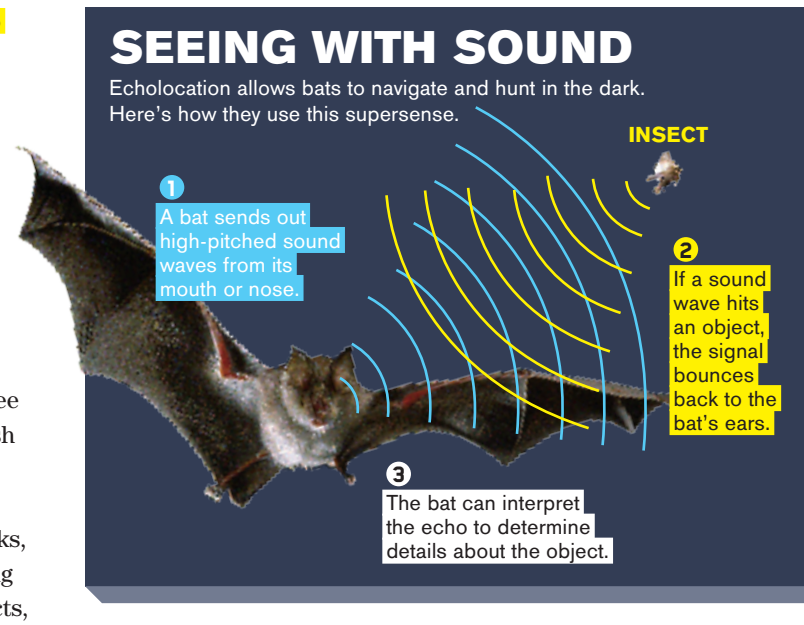
Dusk falls on a dense forest in China's Shandong province. As the sun dips below the horizon, hundreds of horseshoe bats swoop from the mouth of a cave. They dart across the dark sky, nabbing insect after insect. Before the sun rises the next morning, each bat will have eaten as many as 8,000 bugs—without bumping into a single tree or colliding with another bat. They accomplish this feat by using *echolocation*, a sixth sense that allows them to "see" using sound waves.

The bats navigate with high-pitched squeaks, many of which humans can't hear. By listening to how their calls *reflect*, or bounce, off objects, they can map their surroundings. It's an ability no human technology comes close to matching. But Rolf Mueller wants to change that.

Mueller is a mechanical engineering professor at Virginia Tech University in Blacksburg, Virginia. He's attempting to design high-tech navigation systems that mimic bats' amazing abilities. These systems could, for example, enable drones to maneuver in dark, cramped spaces like disaster zones more easily.

LISTENING IN

Bats emit chirps—some through their mouths and others through their noses—as many as 200 times per second. When the sound waves hit an object, like a tree or an insect, they reflect back to the bat's ears. The echo gives the bat information about the object's size and location, and whether it's moving and how fast (*see Seeing With Sound, above*).



A device called *sonar*, which is used in submarines, operates on the same principles as echolocation. But it requires large, cumbersome arrays of transmitters to produce sounds and microphones to detect their echoes. To Mueller, it seemed logical to turn to bats for inspiration to improve sonar technology. Nature, he says, has already designed echolocation—a more elegant and sophisticated version of sonar.

FREAKY FEATURES

Some bats have evolved unusual *adaptations* that improve their ability to echolocate. Species like horseshoe and leaf-nosed bats have nostrils

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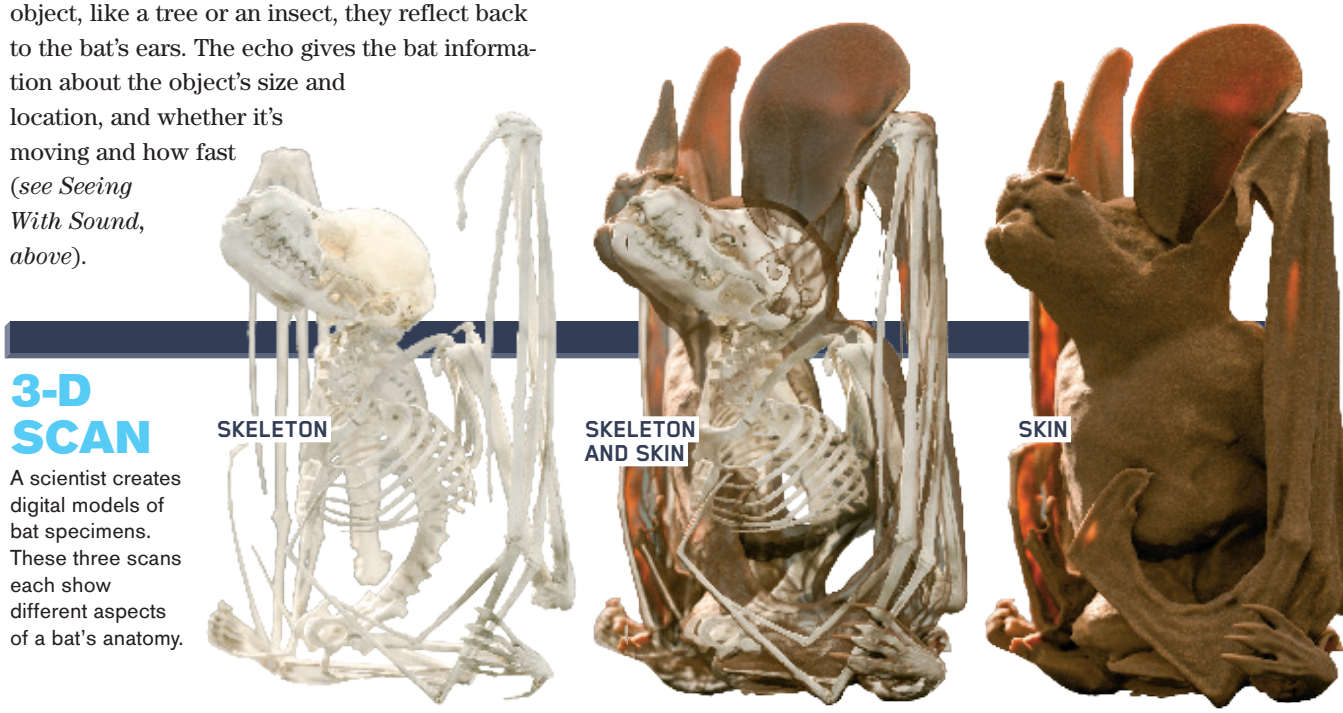
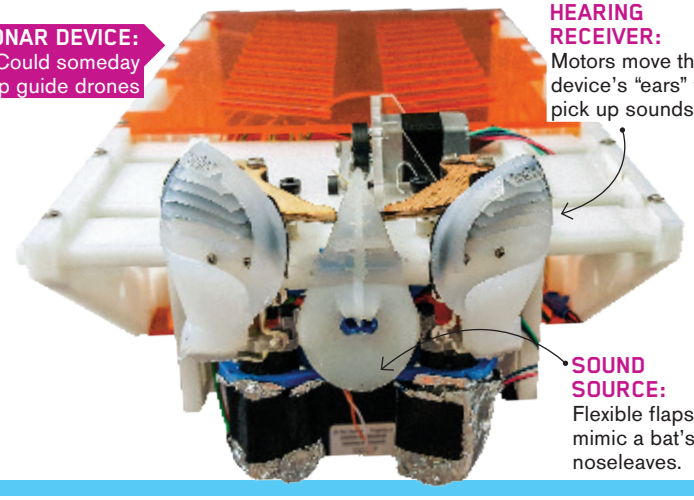


COPYING BATS

A scientist designs a sonar device based on bats' facial features.



covered in fleshy folds, called *noseleaves*, as well as enormous ears with ridges.

By moving their noseleaves, these bats can modify the echolocation signals they send out. Some horseshoe bats adjust their nostrils to direct outgoing sound waves over cavities in their noses. This amplifies the sound at a specific frequency so they can focus on it. The bats' oversized, wrinkly ears act like large antennas to pick up reflected sounds. By bending and twisting their ears, the bats can filter out some sounds while tuning in to others. That helps them evaluate different features in their surroundings.

Being able to fine-tune the sound waves they send and receive gives bats a more detailed picture of their environments. This, says Mueller, probably explains why bats in the world's thickest jungles have evolved the most extreme nose and ear shapes.

BAT SCANS

To learn more about how bats' noses and ears aid in echolocation, Mueller needed to examine these features up close. He began tracking down and capturing bats in the wild. But then he discovered an easier way to compare the anatomy of bats from around the world: Go to the Smithsonian Institution's National Museum of Natural History.

The museum, located in Washington, D.C., houses more than 125,000 preserved bat specimens. Mueller made molds of some of the bats' noses and ears. Then he switched to studying them using a *3-D scanner*. This device creates a digital copy of an object's shape (*see 3-D Scan, p. 21*). So far, Mueller has catalogued the ears and noses of more than 100 bat species.

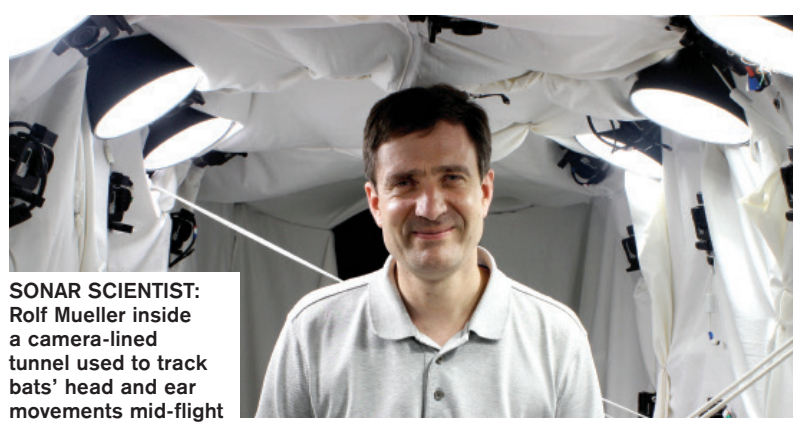
TRIAL RUN

Using that information, Mueller has created a bat-inspired sonar system (*see Copying Bats, above*). The device has a "nose" with rubber-like silicone flaps and a speaker that emits sound. The device also has "ears"—two microphones surrounded by silicone. Tiny motors move the flexible features to change their shape, just as bats do.

Mueller is testing the device in his lab in Blacksburg. He's also strapping it to a zip line and sending it zooming through the forest near Virginia Tech's laboratory in Shandong to see how well the system detects objects in its path. Once the device is perfected, Mueller plans to attach it to a small flying drone. It will whiz through the dark jungle alongside real bats. Someday, the sonar-guided drones could perform ground surveys, help farmers monitor their crops, and even deliver packages to homes.

"Having the drone is one thing—now what can you do with it?" says Mueller. "That is something that's going to keep us busy for years to come."

—Stephanie Warren Drimmer



SONAR SCIENTIST: Rolf Mueller inside a camera-lined tunnel used to track bats' head and ear movements mid-flight

CORE QUESTION

What characteristics did Mueller borrow from bats to create his bat-inspired sonar system? Why?

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