Penis bones, echolocation calls, and genes reveal new kinds of bats

August 27 2020

A banana bat found to represent a new genus, Afronycteris. Credit: Bruce Patterson, Field Museum

If you've ever seen a bat flying around at sunset, chances are good it was a vesper bat. They're the biggest bat family, made up of 500 species, found on every continent except Antarctica. And most of them look a lot alike—they're little, with fuzzy grayish-brown fur, sort of the sparrows of the bat world. That can make it hard to tell the different species apart. But scientists just discovered three new species and two new genera of vesper bats in Africa by comparing the bats' genes, their teeth and skulls, the high-frequency calls they make when echolocating, and the tiny bones in their penises.

"We didn't realize we had two new genera of bats until the genetics told us, in no uncertain terms, that we had four very discrete groups and only two of them were named. It was then a matter of characterizing each of those groups based on their other characteristics," says Bruce Patterson, the MacArthur curator of mammals at Chicago's Field Museum and senior author of the paper describing the new species and genera in the *Zoological Journal of the Linnean Society*. "Sure enough, their penis bones are as different as night and day."

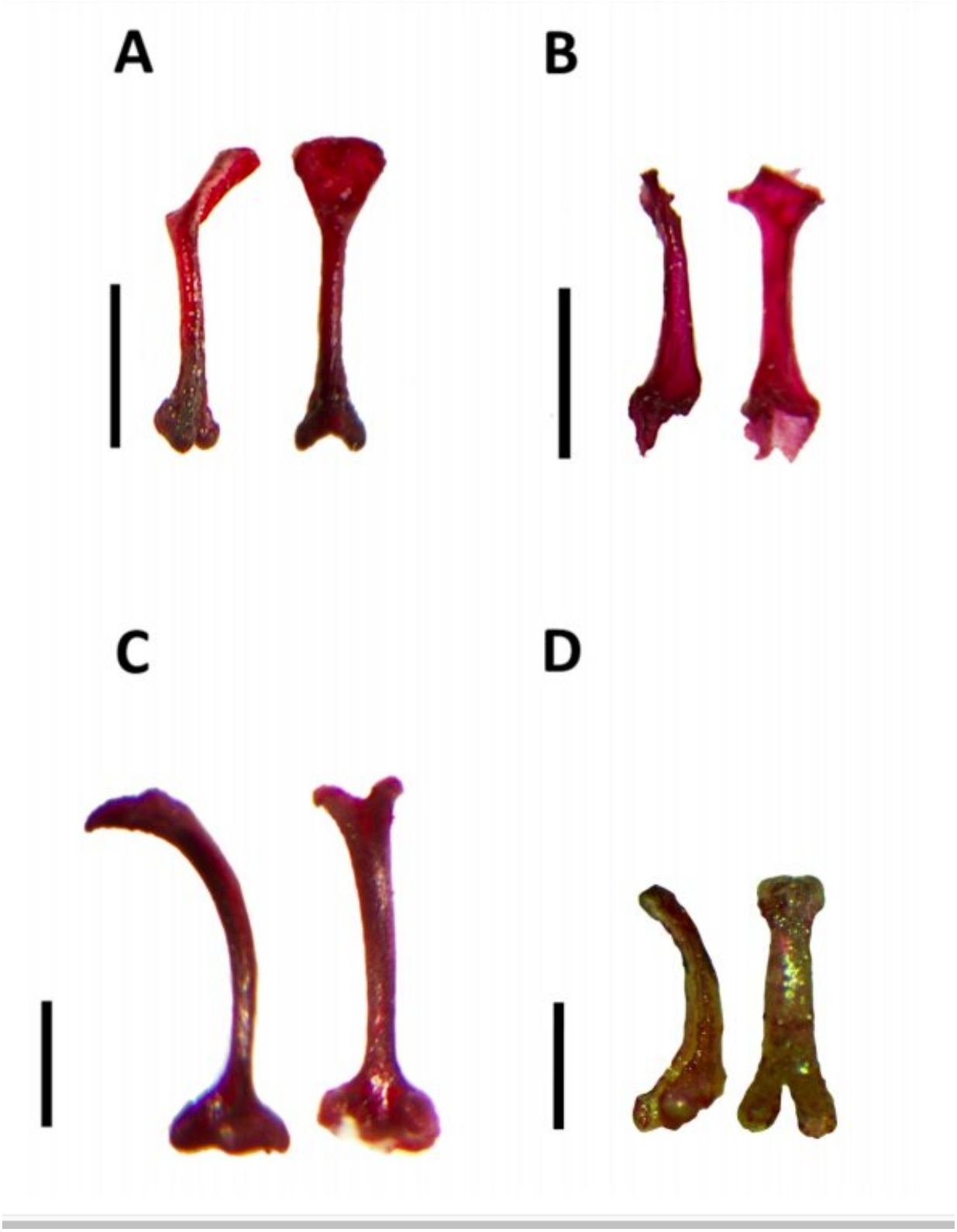
"We have discovered three new species of vesper bats to science, but perhaps more importantly, we have also resolved the taxonomic relationships between the large number of species in this family, which resulted in us describing two new genera of African bats," says Professor Ara Monadjem of the University of Eswatini and the paper's lead author.

"After almost a decade on this project, our sweat and efforts have been rewarded with the discovery of new species or range extensions for others," says coauthor Paul Webala, a senior lecturer of wildlife biology at Kenya's Maasai Mara University. "Finding a new species is always exciting, but finding one hidden in plain sight is truly beautifully inspiring and shows how fascinating the natural world is. The discovery lends credence to long-held beliefs by biologists that only a tiny fraction of biodiversity is known to science."

The bats in question live in Kenya and Uganda, and to study them, the researchers headed out in a van they refer to as "the Batmobile" and went in search of bats.

"Bats are hard to find. They are small, some weigh less than 5 grams, they fly by night and hide during the day, but perhaps the most challenging part is that there are fewer of them than there used to be," says Webala. "When we started the 'Bats of Kenya' project in 2011, it was an arduous but exciting exploratory journey into the known and unknown. We scoured every nook and cranny, often camping and working in the remotest parts. We descended or hiked into bat caves, mines, volcanic tunnels or caverns, sometimes crawling on our bellies. We were filthy and tired but excited about our find in such perfect bat hideouts."

They caught the bats in nets and examined them, taking measurements and tissue samples. They also recorded the bats' calls.



The bacula, or penis bones, of the bats described in this paper. The tiny bones

have been dyed red so that they're easier to isolate. Credit: (c) Ara Monadjem

Many bats use echolocation to communicate, navigate, and find their insect prey: they emit high-pitched calls, and when the sound bounces off insect prey or their surroundings, the bats triangulate their locations. The researchers built a portable flight cage and set the bats loose inside it, recording the bats' efforts to find a way out.

Back in the lab, scientists extracted DNA from the tissue samples, sequenced it, and compared it to known bat genetic sequences in the database GenBank. Some of the sequences didn't match up and together they formed recognizably different groupings.

With the bats' DNA suggesting new species and genera, the researchers examined the physical characteristics of the specimens they collected in the field. They found crucial differences in the bats' skulls and teeth—and penis bones.

Penis bones, or bacula, are found in several groups of mammals—scientists remember them with the mnemonic PRICC (Primates, but not humans; Rodents; Insectivores, like hedgehogs; Carnivores, like dogs and seals; and Chiroptera, bats).

"The baculum is so variable. This is a bone that's not found in all mammal species, and yet its variability exceeds any other bone in the vertebrate body, throughout all the vertebrates," says Patterson. Since bacula come in all shapes and sizes, even among closely-related species, those different shapes might help keep animals from hybridizing with other species. "How that happens remains a mystery—certainly if you're thinking about the baculum like a key that fits a specific lock, it seems like many, many keys could fit a given lock. Still, reproduction is a really

complicated interaction of neurology, physiology, and behavior and we don't understand the effects of all those variations in bacular structure."

The bacula of the bats in this study are absurdly small, about 2 millimeters long. That's barely longer than a hyphen.

"They're so tiny that you're afraid you're going to lose them when you're studying them," says Patterson. "We stained them with a brilliant reddish-purple dye so it was easier to find them, and then store them in separate little gelatin pill capsules."

A white-winged bat from the newly named genus Pseudoromicia. Credit: (c) Bruce Patterson, Field Museum

In addition to examining the bats' bodies, the researchers analyzed the bats' calls that they recorded back in the "wedding dress." Different species call at different frequencies to communicate with each other, explains Patterson: "Bats divide up call frequencies for the same reason that radio stations divide up the airwaves, to avoid interfering with one another."

The researchers found that the bats' calls, all higher than the highest-pitched squeak a human can hear, distinguished them from other bats in the area. The final verdict was that there were three species new to science, and two new genera among the vesper bats they studied.

According to Patterson, the success of the research group was largely due to its international makeup: "I think that the real secret ingredient for our success was that we had scientists who have worked extensively in different parts of Africa and each had a regional understanding of the areas we studied. And by working together, we had enough of the puzzle in hand that we could resolve the rest of it." Both Monadjem and Webala made multiple study trips to Chicago hosted by the Field Museum during the course of this work.

"I love working in African rainforests where the chances of encountering an undescribed species are particularly high," says Monadjem. "Our new taxonomic arrangement of the species-rich vesper bats is based on a consensus of genetic and morphological characters that is likely to become the standard reference for this traditionally difficult-to-identify group."

"The discovery of new species is important as it helps to protect them and their ecosystems, mainly from the direct role that humans play in their decline via environmental change, deforestation, and agriculture intensification," says Webala. "Each of these bat species, known and as-yet-unknown, is a wonder unto itself, but may also hold the key to

ground-breaking innovations in science or society."

Patterson notes that the study has real-world implications, since bats play a major role in humans' lives, even if we don't realize it. "Vesper bats eat an extraordinary number of disease-spreading insects and crop-destroying bugs," says Patterson. "Studying these bats matters—there is no way to document their roles in nature if we can't even tell them apart."

Provided by Field Museum