Fossilized bat skull adds vital piece to evolution puzzle

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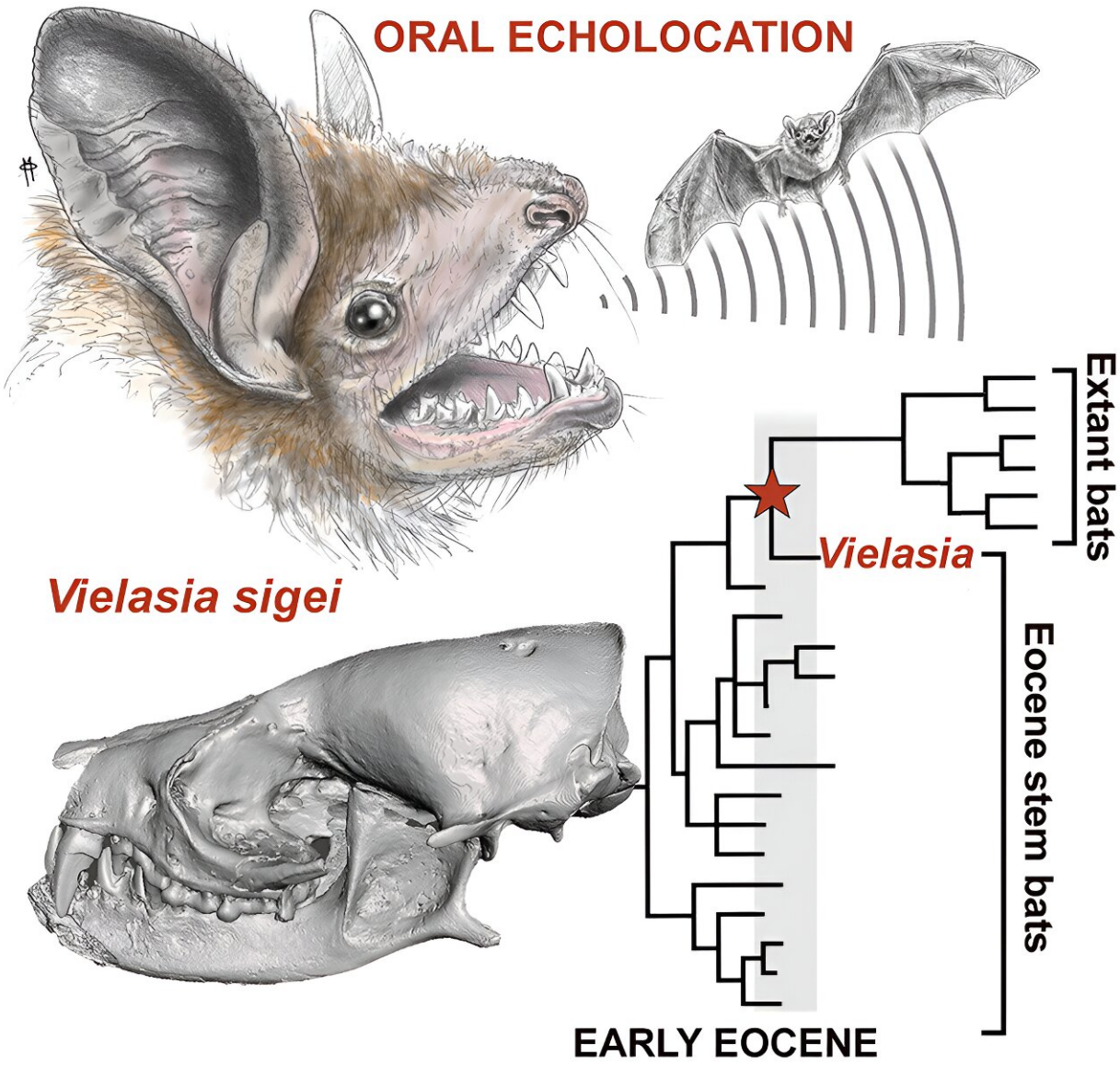

Graphical abstract. Credit: *Current Biology* (2023). DOI: 10.1016/j.cub.2023.09.043

Of all the mammals, bats have one of the poorest fossil records, with paleontologists estimating that about 80% of it is missing.

This has made it difficult to pinpoint exactly when they first began to fly, or began roosting in caves, or developed their unique way of 'seeing' their surroundings in the dark using sound—called echolocation.

But a near-perfectly preserved bat's skull discovered by French paleontologists in a cave that dates back about 50 million years has shed new light on what we thought we knew about this ancient, hypothetical creature.

Emeritus Professor Sue Hand from UNSW Sydney's School of Biological Earth and Environmental Sciences is a leading paleontologist with expertise in bat evolution. She led an analysis of the skull, published in the journal *Current Biology*, that involved Dr. Jacob Maugoust and Professor Maeva Orliac from University of Montpellier in France, and Professor Robin Beck from the University of Salford, UK.

Prof. Hand says prior to the discovery of this skull—which was among 23 separate fossilized individuals found in the cave belonging to the extinct species Vielasia sigei—only fragments or completely flattened skeletons of early bats had existed in the fossil record.

"We don't know very much about the beginnings of bats because we don't have the missing links like we do, say, between dinosaurs and modern birds," she says.

"The oldest bat fossil is about 57 million years old, and it's a single tooth from a site in Portugal—that's all we know about it. The first bats are all just known from fragmentary fossils, mostly teeth. When bats appear in the fossil record a little later, about 52 million years ago, some are wonderfully complete bats, but they're flattened."

While these flattened specimens are, in Prof. Hand's words, "beautifully preserved," the fact that they've been flattened by layers of rock deposited over millions of years makes it difficult to decide with conviction, the exact positioning of bones in their three-dimensional anatomy. And when it comes to determining whether a fossil is from a species of bat that is already using echolocation, detailed and precise anatomy of the skull is crucial.

"In modern bats, between the voice box and the ear, there are some bones called the hyoid bones. In all modern bats that echolocate, one of these bones directly contacts the middle ear bones and appears to be involved in transmitting high frequency sound.

"But in the flattened fossils, while we can see these various bones, there is a question about their precise relationships to each other. This has led to a lot of debate among scientists about whether or not a species used echolocation."

Uncrushed skull

But in the case of Vielasia sigei, not only is the skull almost entirely intact, but it has been preserved in limestone in its original three-dimensional shape which the scientists describe as "uncrushed."

"In this particular bat, we can see more directly what's going on deeper, in the inner ear," Prof. Hand says.

"We took fine measurements of that inner ear bone and compared it with that in the bats that do echolocate today and bats that don't, and it sits in the middle of the ones that echolocate."

Not all bats echolocate, Prof. Hand explains. Flying foxes regularly seen in the Sydney night sky around the Botanical Gardens, Centennial Park and the Royal National Park rely on their very good eyesight to navigate and find fruit, without echolocation. Meanwhile, Sydney microbats such as the Eastern Bentwing Bat, Gould's Wattled Bat and the Chocolate Wattled Bat, are well known for navigating and catching insects using feedback from the high frequency sound they emit.

While Prof. Hand stops short of concluding that Vielasia sigei used echolocation with 100% certainty, she says the new evidence is compelling.

"It's very convincing that the type of echolocation some of these early bats used was indistinguishable from what many echolocating bats use today, and at 50 million years ago, this is well ahead of whales developing this ability.

"Prior to this find, we were only really certain that echolocation developed in the modern families of bats."

Back to the bat cave

In all, there were 400 fossil bones and teeth discovered by the French team in the cave in south-western France, which represented 23 individuals. Vielasia—which is not a direct ancestor of today's bats but may have been closely related to it—was only a small bat, with the uncrushed skull measuring only 1.8 cm long.

"There were 23 of these wonderful little bats living in a cave, which also

makes it the oldest cave-dwelling bat in the world that we know of," says Prof. Hand.

"We didn't think that these early bats actually lived in caves. The information had been that they lived in trees around lakes and in forests which stretched right up to both poles because the Earth was very warm at this time."

But when these greenhouse conditions started to deteriorate later in the early Eocene period—around 50 million years ago and about the same time that this bat was living—there were much more wildly fluctuating changes in temperature.

"So it could be that this bat lived in a cave because this is much more stable environment."

Whether or not the analysis of the uncrushed Vielasia skull has settled the echolocation debate about early bats, Prof. Hand hopes that it will inspire further exploration of the fossil record.

"We think some of the characteristics of this bat would have also characterized the last common ancestor for modern bats. So it's exciting, and it is actually going to be an important specimen that people will get a lot of information from and use in their own analyses."

More information: Suzanne J. Hand et al, A 50-million-year-old, three-dimensionally preserved bat skull supports an early origin for modern echolocation, *Current Biology* (2023). DOI: 10.1016/j.cub.2023.09.043

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