Earliest example of a rapid-fire tongue found in 'weird and wonderful' extinct amphibians

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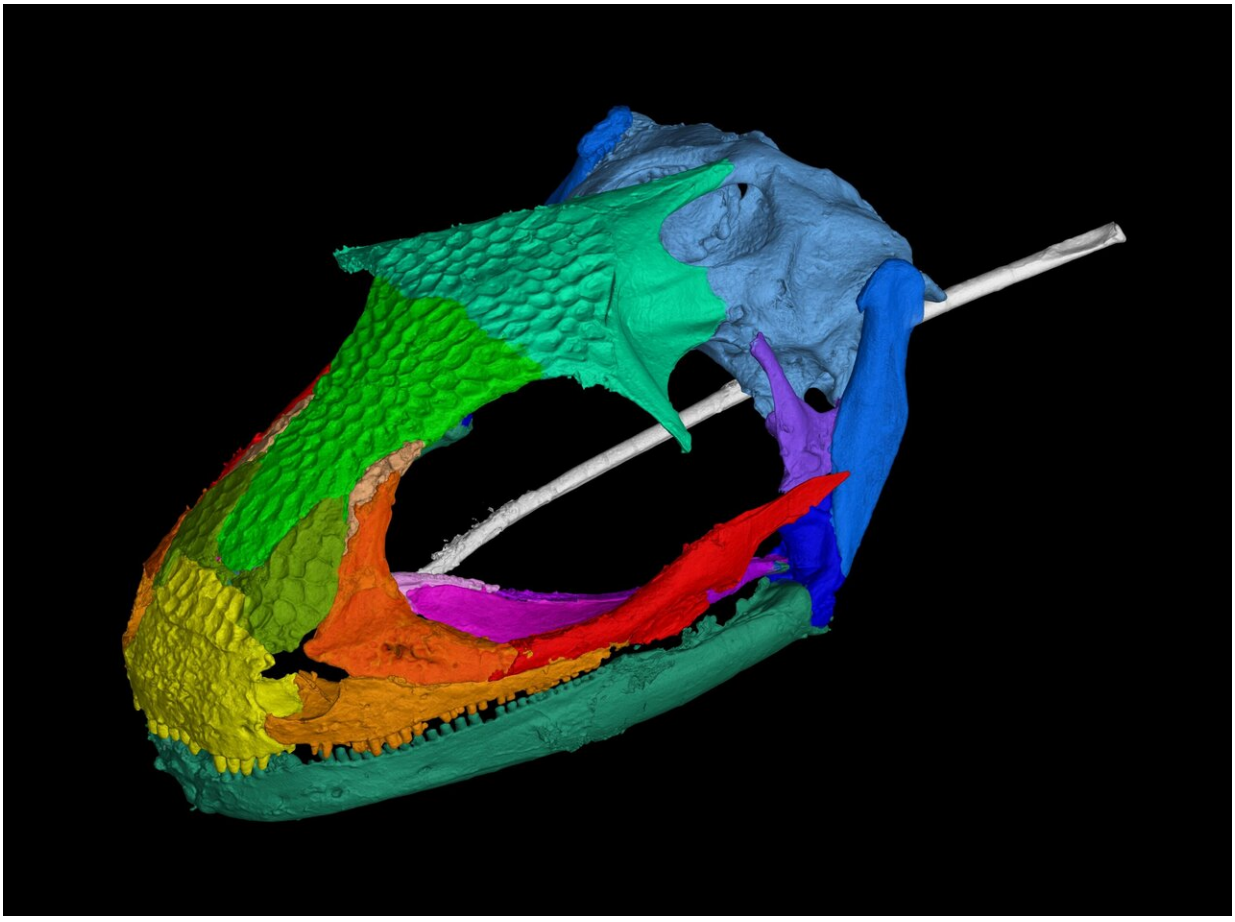


Most fossil albanerpetontids are crushed or in disarray. This CT image shows an exquisitely preserved adult albanerpetontid skull that is helping researchers re-envision these extinct amphibians. Credit: Edward Stanley/Florida Museum of Natural History/VGStudioMax3.4

Fossils of bizarre, armored amphibians known as albanerpetontids provide the oldest evidence of a slingshot-style tongue, a new Science study shows.

Despite having lizardlike claws, scales and tails, albanerpetontids—mercifully called "albies" for short—were amphibians, not reptiles. Their lineage was distinct from today's frogs, salamanders and caecilians and dates back at least 165 million years, dying out only about 2 million years ago.

Now, a set of 99-million-year-old fossils redefines these tiny animals as sit-and-wait predators that snatched prey with a projectile firing of their tongue—and not underground burrowers, as once thought. The fossils, one previously misidentified as an early chameleon, are the first albies discovered in modern-day Myanmar and the only known examples in amber.

They also represent a new genus and species: Yaksha perettii, named after treasure-guarding spirits known as yakshas in Hindu literature and Adolf Peretti, the discoverer of two of the fossils.

"This discovery adds a super-cool piece to the puzzle of this obscure group of weird little animals," said study co-author Edward Stanley, director of the Florida Museum of Natural History's Digital Discovery and Dissemination Laboratory. "Knowing they had this ballistic tongue gives us a whole new understanding of this entire lineage."

A fortunate mistake

The discovery began with a bumble.

In 2016, Stanley and Juan Diego Daza, lead author of the Science study and assistant professor of biological sciences at Sam Houston State

University, published a paper presenting a dozen rare amber fossil lizards—or so they thought. One juvenile specimen possessed a hodgepodge of bewildering characteristics, including a specialized tongue bone. After much debate and consultation with colleagues, the scientists finally labelled it an ancient chameleon, about 99 million years old, an estimate based on radiometric dating of crystals at the site where the fossil was found.

When she read the study, Susan Evans, professor of vertebrate morphology and paleontology at University College London and an albie expert, instantly recognized the puzzling specimen. It was no chameleon. She emailed Daza.

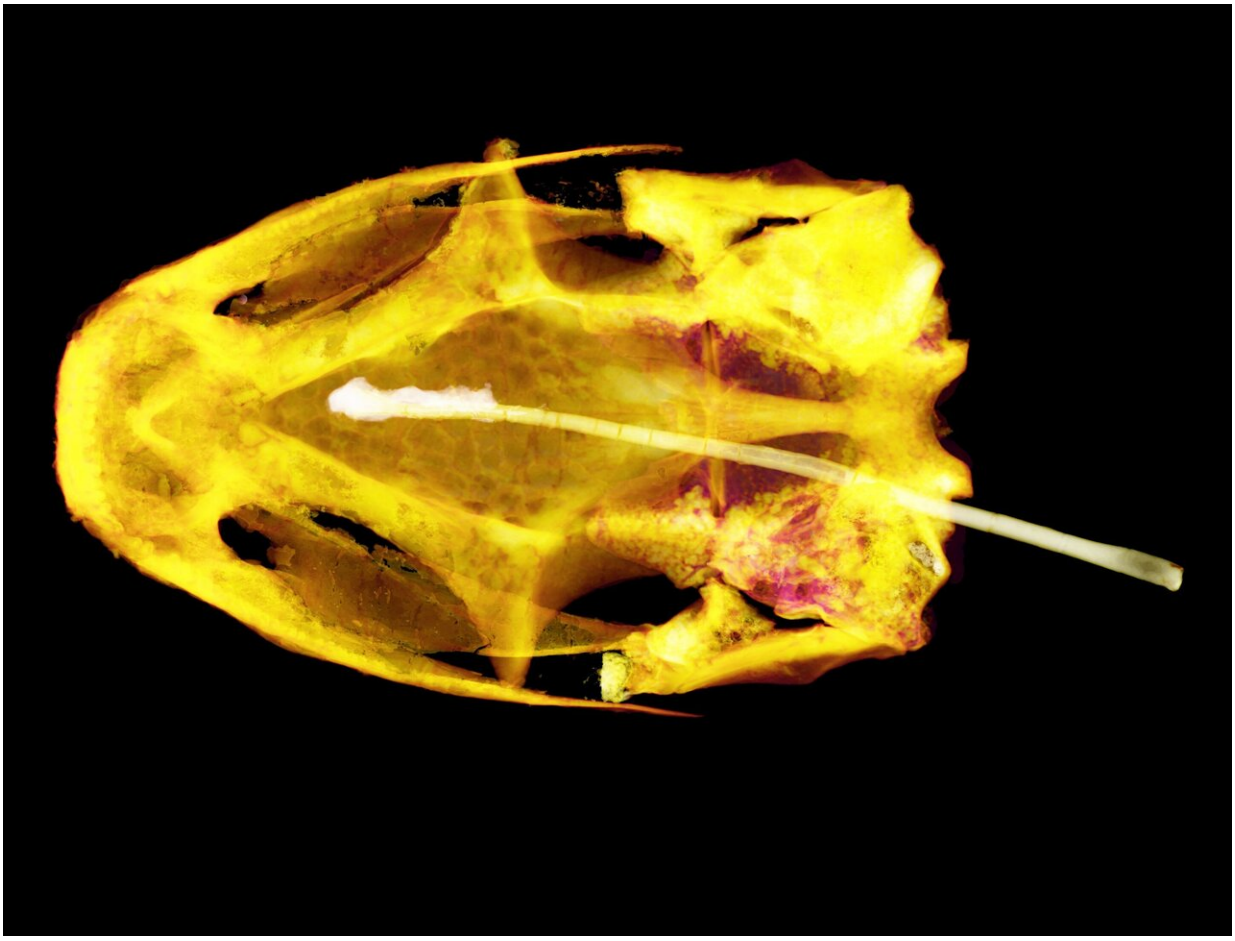
"I remember that as one of the worst days of my life," he said.

But the paper also attracted the attention of an unexpected collaborator: Peretti, a gemologist who contacted Daza about another collection of amber fossil lizards from the same region of Myanmar. (Note: The mining and sale of Burmese amber are often entangled with human rights abuses. Peretti acquired the fossils legally from companies that follow a strict ethical code. More details appear in an ethics statement at the end of this story).

Per Daza's recommendation, Peretti sent the collection to the University of Texas at Austin for CT scanning, a way of clarifying what lies inside. As Daza began cleaning up the scans, one fossil in particular caught his eye—the complete skull of an adult albie.

Most fossil albies are crushed flat or a jumble of bones in disarray. In 1995, Evans published the first description of a complete specimen, excavated in Spain, but "it was very much roadkill," she said. Even amber fossils suffer degradation, and soft tissues can mineralize, becoming difficult to work with.

This specimen, however, was not only three-dimensional, "it was in mint condition," Stanley said. "Everything was where it was supposed to be. There was even some soft tissue," including the tongue pad and parts of the jaw muscles and eyelids.



Albanerpetontids are the fourth main group of amphibians, joining frogs, salamanders and caecilians. But they vanished about 2 million years ago. New fossils, such as the skull shown in this X-ray image, suggest these animals were sit-and-wait predators, not burrowers as previously thought. Credit: Edward Stanley/Florida Museum of Natural History/VGStudioMax3.4

It was also the adult counterpart to the juvenile albie that had been mistaken for a chameleon.

When Daza sent the scan to Evans, she was dazzled by its rich detail.

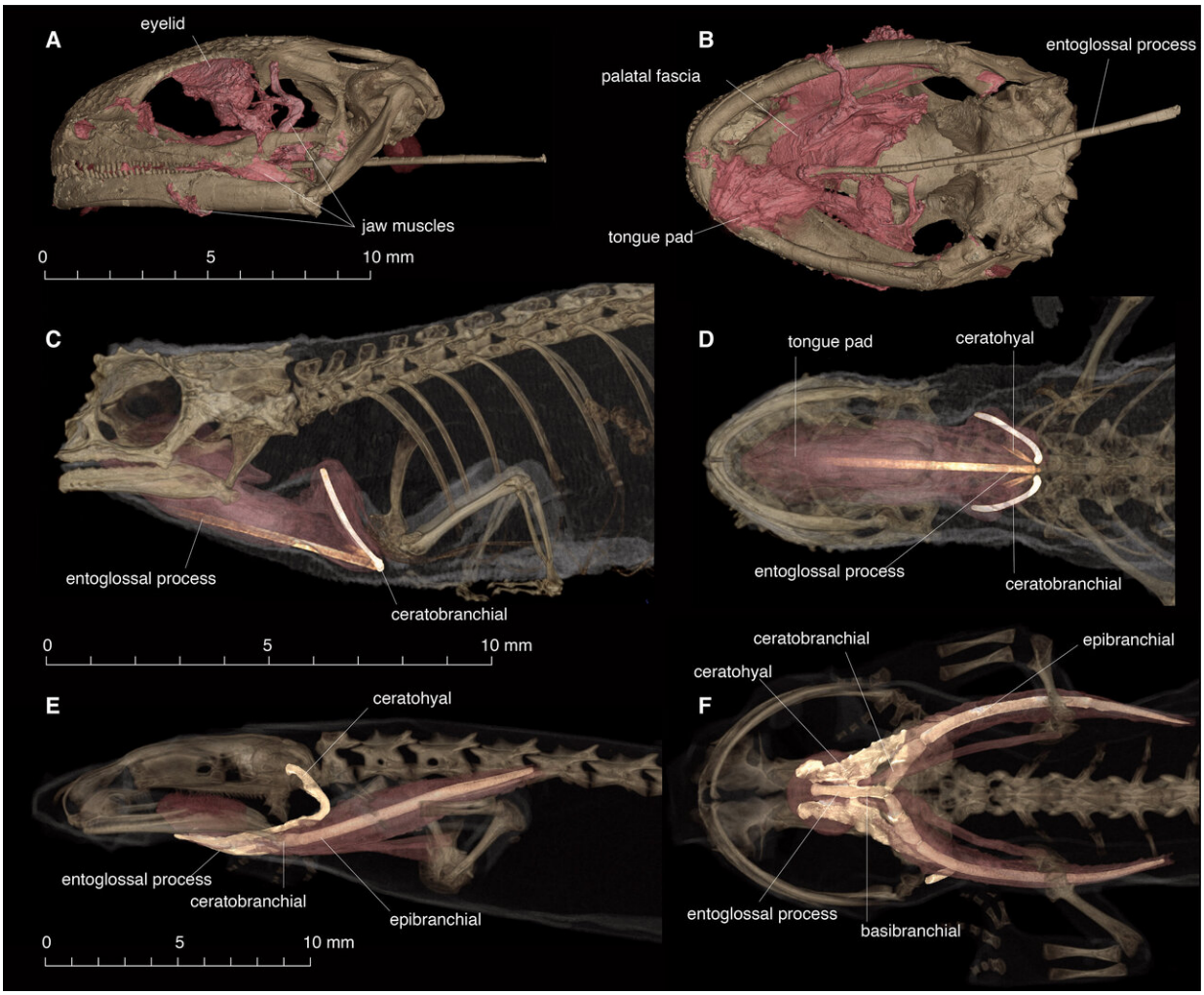
"All my Christmases have come at once!" she wrote back.

'Weird and wonderful'

Once classified as salamanders, albies' stippled, reinforced skulls led many scientists to hypothesize they were diggers. No one imagined them as having chameleonlike lifestyles, Stanley said. But, he added, "if you're going to misidentify an albie as any kind of lizard, a chameleon is absolutely what you would land on."

Even though one is an amphibian and the other a reptile, they share several features, including claws, scales, massive eye sockets and—we now know—a projectile feeding mechanism.

The chameleon tongue is one of the fastest muscles in the animal kingdom and can rocket from 0 to 60 mph in a hundredth of a second in some species. It gets its speed from a specialized accelerator muscle that stores energy by contracting and then launching the elastic tongue with a recoil effect. If the earliest albies also had ballistic tongues, the feature is much older than the first chameleons, which may have appeared 120 million years ago. Fossil evidence indicates albies are at least 165 million years old, though Evans said their lineage must be much more ancient, originating more than 250 million years ago.



Comparison of skeletal components in three tetrapods with ballistic tongues. Holotype of Yaksha perettii (GRS-Ref-060829) showing the preserved soft tissue (pink), including the tongue in lateral (A) and ventral (B) views. Diffusible iodine-based contrast-enhanced computer tomographies (DiceCT) of a leaf litter chameleon [Brookesia sp. UADBA:herps:15550 (31)] in lateral (C) and ventral (D) views. DiceCT of lungless salamander [Bolitoglossa porrasorum UF156522 (32)] in lateral (E) and ventral (F) views. Credit: Daza et al., Science (2020)

While armed with a rapid-fire tongue, Y. perettii was tiny: Based on the fossil skull, Daza estimates the adult was about 2 inches long, not

including the tail. The juvenile was a quarter that size.

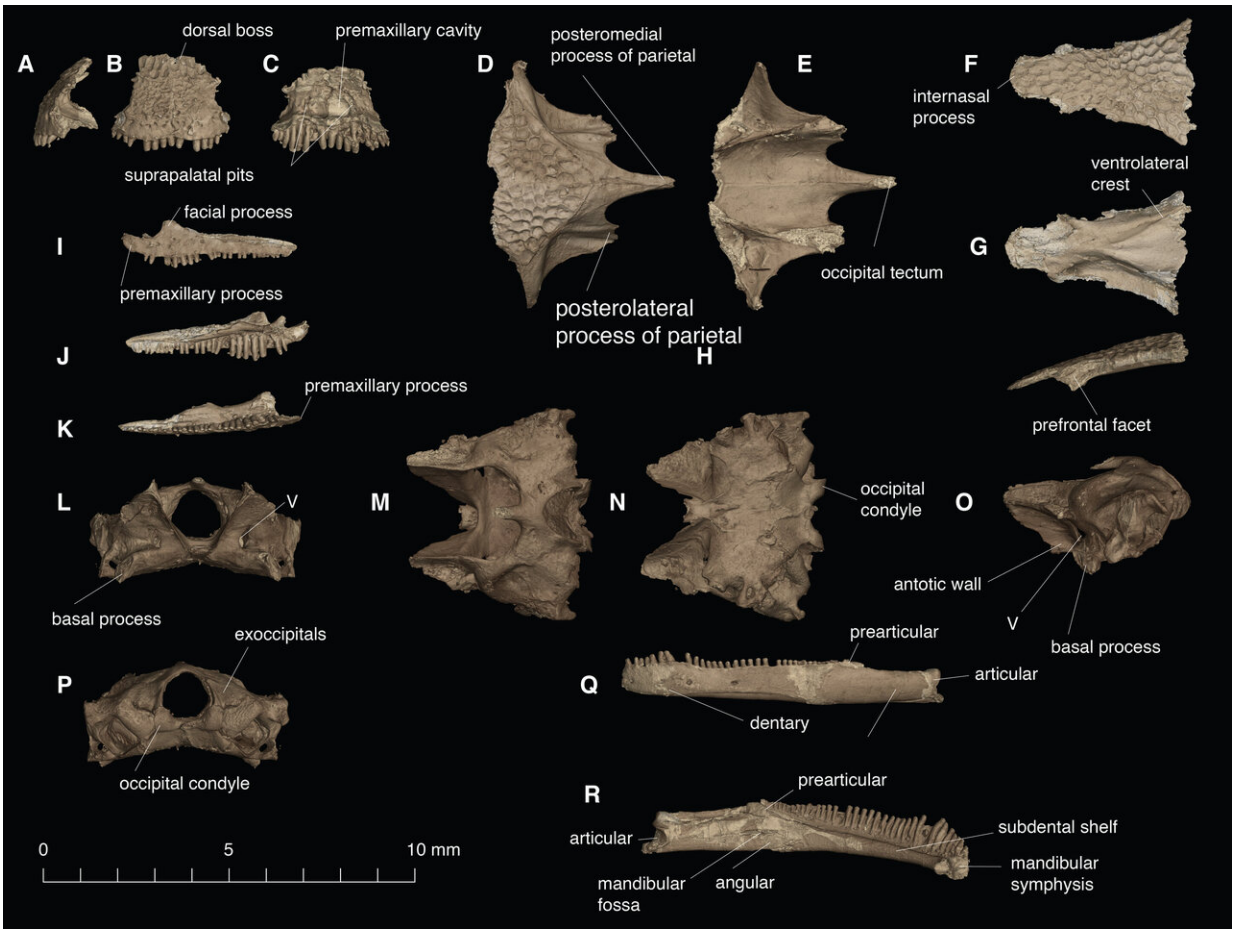
"We envision this as a stocky little thing scampering in the leaf litter, well hidden, but occasionally coming out for a fly, throwing out its tongue and grabbing it," Evans said.

The revelation that albies had projectile tongues helps explain some of their "weird and wonderful" features, such as unusual jaw and neck joints and large, forward-looking eyes, a common characteristic of predators, she said. They may also have breathed through their skin, as salamanders do.

Even though the specimens are remarkably preserved, Stanley said CT scanning was essential to the analysis, revealing fine-scale features obscured in the cloudy amber.

"They only come to life with CT scanning," he said. "Digital technology is really key with this amber material."

Digitization also enabled the researchers, scattered around the world and hunkered down during COVID-19 quarantines, to collaboratively analyze and describe the specimens—and then make the same material digitally available to others.



Isolated elements of the holotype skull of Yaksha perettii (GRS-Ref-060829). Fused (or tightly paired) premaxillae (A to C), parietal (D and E), frontal (F to H), left maxilla (I to K), basicranium (L to P), and left mandible (Q and R). Lateral [(A), (H), (I), (O), and (Q)], medial [(J) and (R)], anterior [(B) and (L)], posterior [(C) and (P)], dorsal [(D), (F), and (M)], and ventral [(E), (G), (K), and (N)] views. Credit: Daza et al., Science (2020)

How are albanerpetontids related to other amphibians?

Despite the level of preservation and completeness of the Y. perettii specimens, albies' exact place in the amphibian family tree remains a mystery. The researchers coded the specimens' physical characteristics

and ran them through four models of amphibian relationships with no clear results. The animals' unusual combination of features is likely to blame, Evans said.

"In theory, albies could give us a clue as to what the ancestors of modern amphibians looked like," she said. "Unfortunately, they're so specialized and so weird in their own way that they're not helping us all that much."

But Y. perettii does put albies on a new part of the map. Northwest Myanmar was likely an island 99 million years ago and possibly a remnant from Gondwana, the ancient southern continental landmass. With two exceptions in Morocco, all other fossil albies have been found in North America, Europe and East Asia, which formerly formed a northern continental landmass. Daza said Y. perettii may have rafted to the island from mainland Asia or could represent a new southern record for the group.

We just missed them

With such a wide distribution, why did albies vanish into extinction while frogs, salamanders and caecilians still exist today?

We don't know. Albies almost survived to the present, fading out about 2 million years ago, possibly late enough to have crossed paths with our earliest hominid relatives, Evans said.

"We only just missed them. I keep hoping they're still alive somewhere."

More information: J.D. Daza at Sam Houston State University in Huntsville, TX el al., "Enigmatic amphibians in mid-Cretaceous amber were chameleon-like and had ballistic feeding," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.abb6005

"A surprising fossil vertebrate," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.abe7826

3D digitized specimens are available online via MorphoSource. The adult skull is housed at the Peretti Museum Foundation in Switzerland, and the juvenile specimen is at the American Museum of Natural History.

Provided by Florida Museum of Natural History