Ancient shark fossil reveals new insights into jaw evolution

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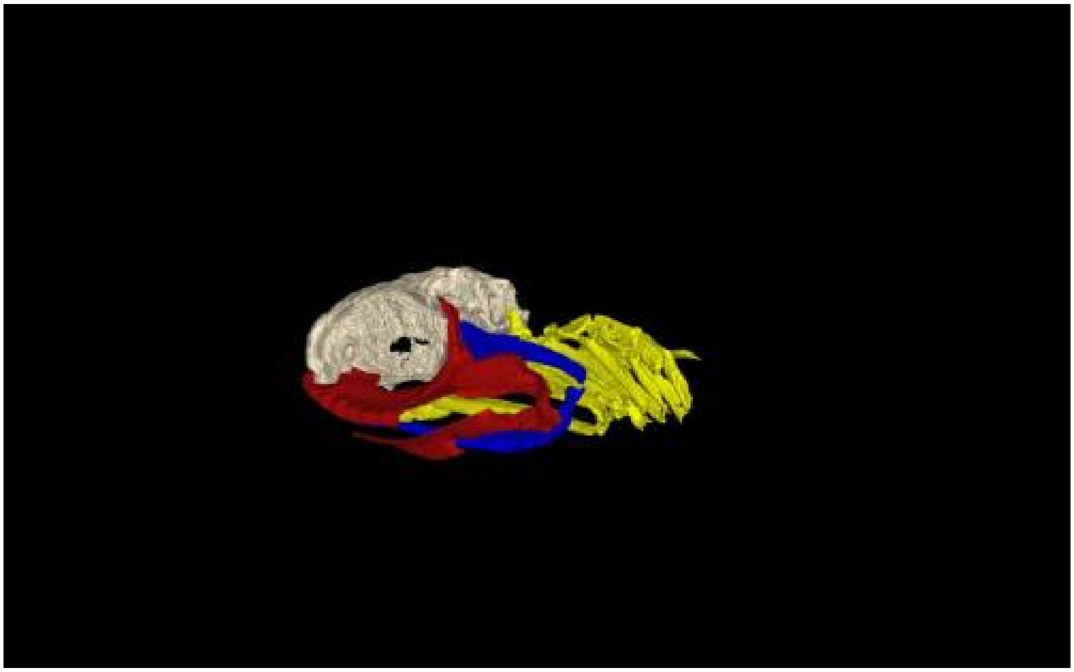
This photo shows the exceptionally well-preserved fossil of *Ozarcus mapesae* from two different lateral views. The scale bar is 10 millimeters. Credit: AMNH/F. Ippolito

The skull of a newly discovered 325-million-year-old shark-like species suggests that early cartilaginous and bony fishes have more to tell us about the early evolution of jawed vertebrates—including humans—than do modern sharks, as was previously thought. The new study, led by scientists at the American Museum of Natural History, shows that living sharks are actually quite advanced in evolutionary terms, despite having retained their basic "sharkiness" over millions of years. The research is published today in the journal *Nature*.

"Sharks are traditionally thought to be one of the most primitive surviving jawed vertebrates. And most textbooks in schools today say that the internal jaw structures of modern sharks should look very similar to those in primitive shark-like fishes," said Alan Pradel, a postdoctoral researcher at the Museum and the lead author of the study. "But we've found that's not the case. The modern shark condition is very specialized, very derived, and not primitive."

The new study is based on an extremely well-preserved shark fossil collected by Ohio University professors Royal Mapes and Gene Mapes in Arkansas, where an ocean basin once was home to a diverse marine ecosystem. The fossilized skull of the new species, named *Ozarcus mapesae*, along with similar specimens from the same location, were part of a recent donation of 540,000 fossils from Ohio University to the Museum.

The heads of all fishes—sharks included—are segmented into the jaws and a series of arches that support the jaw and the gills. These arches are thought to have given rise to jaws early in the tree of life.



This image shows a 3-D reconstruction of the skull of *Ozarcus mapesae*. The braincase is shown in light gray, the jaw is shown in red, the hyoid arch is shown in blue, and the gill arches are shown in yellow. Credit: AMNH/A. Pradel

Because shark skeletons are made of cartilage, not bone, their fossils are very fragile and are usually found in flattened fragments, making it impossible to study the shape of these internal structures. But the *Ozarcus mapesae* specimen was preserved in a nearly three-dimensional state, giving researchers a rare glimpse at the organization of the arches in a prehistoric animal.

"This beautiful fossil offers one of the first complete looks at all of the gill arches and associated structures in an early shark. There are other shark fossils like this in existence, but this is the oldest one in which you can see everything," said John Maisey, a curator in the Museum's Division of Paleontology and one of the authors on the study. "There's enough depth in this fossil to allow us to scan it and digitally dissect out the cartilage skeleton."

Working with scientists at the European Synchrotron, the ESRF, Pradel imaged the specimen with high-resolution x-rays to get a detailed view of each individual arch shape and organization. "We discovered that the arrangement of the arches is not like anything you'd see in a modern shark or shark-like fish," said Pradel. "Instead, the arrangement is fundamentally the same as bony fishes."

The authors say it's not unexpected that sharks—which have existed for about 420 million years—would undergo evolution of these structures. But the new work, especially when considered alongside other recent developments about early jawed vertebrates, has significant implications for the future of evolutionary studies of this group. "Bony fishes might have more to tell us about our first jawed ancestors than do living sharks," Maisey said.

More information: A Palaeozoic shark with osteichthyan-like branchial arches, *Nature*, dx.doi.org/10.1038/nature13195

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