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The mystery of an ancient reptile with a ridiculously long neck

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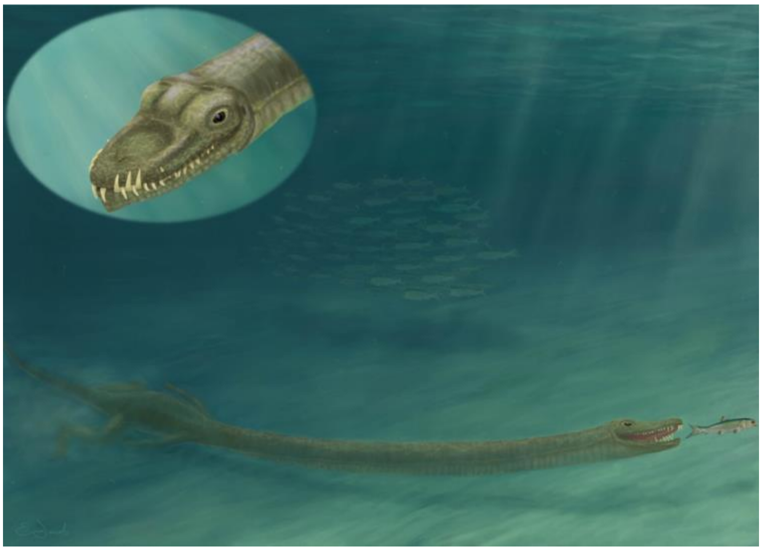
The absurdly long neck of the ancient reptile Tanystropheus represents a true evolutionary enigma. A new high-resolution 3D imaging of its skull suggests that two different, but closely related Tanystropheus species co-existed and that they had two very different approaches to life underwater with an extremely long neck.



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The Middle Triassic period, between 247 and 237 million years ago, was the age just before the rise of the dinosaurs and a time of great evolutionary innovation. The largest mass extinction event of all time, known as 'The Great Dying', destroyed almost all species only 5 million years earlier, and now life started to flourish into new forms completely unlike those alive today.

Of these forms *Tanystropheus*, a distant relative to crocodilians, dinosaurs, and birds, is arguably the most remarkable. From the shoulders down, *Tanystropheus* resembles a typical lizard, but its neck is three times longer than the torso, despite consisting of only 13 extremely elongated vertebrae. Thus, *Tanystropheus* could be summarized as a monitor lizard with a broomstick for a neck.

This seemingly absurd body shape makes reconstructing the lifestyle of *Tanystropheus* very challenging and it was unclear whether it lived mostly on land or in the water. To complicate things further, fossils of *Tanystropheus* come in a small and large type. Historically, they were considered as juveniles and adults of the same species, but some remarkable differences, particularly in the shape of their teeth, hint that more might be going on. Unfortunately, a comprehensive comparison between the two types of *Tanystropheus* was not possible because all known skulls were crushed during the fossilization process. Skulls are often the best way to distinguish extinct species because these complex structures possess many characteristic features.

To overcome this problem, we micro-CT scanned the most complete skull of the large type. Micro-CT scans create digital thin sections of an object in high resolution, which allowed us to observe inner structures of the skull like the braincase, as well as parts that were still covered by the sediment the skull was buried in. To our great delight, the scan revealed many three-dimensionally preserved bones that were previously hidden! Using the scan, we made digital models of all individual bones that allowed us to freely manipulate them. This way, we put the bones back into the position they had during life, creating a three-dimensional reconstruction of the skull.

The reconstructed skull showed us that the large type of *Tanystropheus* had clear adaptations for life underwater. The nostrils are located on the top of the snout as in crocodilians, and the teeth are long and curved, perfectly adapted for catching slippery fish and squid. However, the lack of swimming adaptations in the limbs and tail also means that *Tanystropheus* was not a fast swimmer. Instead, it likely stealthily approached its prey in murky water, using its small head and very long neck to remain hidden.

The new reconstruction of the large type *Tanystropheus* revealed many differences to the skull of the smaller type, suggesting that they actually represented different species. To provide definite proof of this, we needed evidence that the fossils of the small type represented fully grown individuals. To do this, we took small thin sections of leg bones of several individuals and observed these under the microscope to study their inner bone tissue. Like tree rings, many reptiles show rings in their bones that reflect the passing of years. Our samples contained many growth rings, with the rings at the outer edge of the bone being very closely packed together. This showed that these animals had lived for more than ten years and that growth had almost completely stopped in their final years, proving that they were basically fully grown when they died. Therefore, the small type must have represented a smaller species distinct from the large type.

In summary, two *Tanystropheus* species of very different sizes were living together in the same environment. The large species used its long and pointy teeth to catch fast-moving prey like fish and squid, whereas the small species had wider and three-pointed teeth, used to crush smaller soft-shelled invertebrates like shrimp. Both species likely used their small heads at the end of their long and stiff necks to remain hidden from their prey. The two species evolved from a common ancestor to feed on different prey. This way they avoided competition over food sources with each other in an evolutionary phenomenon called niche partitioning. The niche partitioning of *Tanystropheus* is particularly interesting, since it reveals that its remarkable and specialized neck was more adaptable than we thought, as is indicated by the different feeding strategies of the two species. This shows that body plans that seem implausible or even comical today were in fact perfectly adapted to the world these animals lived in.