Fossil discovery suggests size poor predictor of maturity in ancient reptiles

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In this artist's rendering of the *Asilisaurus kongwe*, the animal is shown as it would walk and move about. The stripes are artistic license, although the animal's 'proto-feathers' are likely. 'We have good reason to think they probably had some sort of simple feather-like structures ... but we haven't found evidence of this yet," said Christopher Griffin, a geoscience graduate student at Virginia Tech. Credit: Painting by Andrey Atuchin

Paleontologists at Virginia Tech have found that muscle-scarred fossil leg bones of one of the closest cousins of dinosaurs that lived approximately 240 million years ago can shine new light on a large unknown: How early dinosaurs grew from hatchlings to adults.

Published this month in the *Journal of Vertebrate Paleontology*, the findings are surprising: dinosaurs and their close relatives had much more variation in growth patterns then ever expected, and this variation does not appear to be related to differences between males and females.

Lead author Christopher Griffin, a geosciences master's student in the College of Science, focused his study on muscle scars etched into the fossil bones of the Asilisaurus kongwe, a dinosaur cousin that lived roughly 10 million years earlier than the oldest known dinosaurs.

"Variation in muscle scars were thought to indicate sexual difference in early dinosaurs, but we know that in many modern animals these features are related to growth, not sex," said Griffin of Redding, California. "Because of this, we thought that similar variations that we saw in Asilisaurus would not turn out to split into two groups, which would be evidence for a sex difference, and instead be more on a spectrum. As we looked at more Asilisaurus fossils of different sizes, because we had such a great sample size, we found this to be supported: with a large sample size, they don't split into two clean groups."

Christopher Griffin, a geoscience master's student in the Virginia Tech College of Science, reconstructs a partial specimen of a Asilisaurus fossil. Pictured are the animals back legs and tail. Credit: Virginia Tech

Added Sterling Nesbitt, study co-author and an assistant professor with the Virginia Tech Department of Geosciences: "The earliest dinosaurs grew just like their closest relatives, and there are very few features that make dinosaurs unique from their closest relatives."

Asilisaurus lived during the Triassic Period, roughly 240 million years ago in present-day Africa. With four legs and a long tail, the animal was about the size of a Labrador retriever, and likely maxed at 65 pounds, according to previous studies of the animal. Its exterior skin appearance

remains unknown.

Fossils of Asilisaurus kongwe - a combination of Swahili and Greek works meaning "ancient ancestor reptile" - are vital because a large number of specimens were found, largely intact and varying in size and age. Such findings are so rare that paleontologists have struggled with understanding how the first dinosaurs grew, as most species of early dinosaur are known from only a handful of fossils.

The Asilisaurus fossils initially were discovered during a 2007 expedition in southern Tanzania, with additional field excursions taking place for the next eight years.

The length of the field excursions and the number of specimens of fossils resulted in several smaller individual specimens appearing to be more mature than larger finds, and individuals of the same size appeared to be at different stages of growth.

In studying the anatomy and bone tissue of Asilisaurus and how each changed during growth, Griffin and Nesbitt found the although these individual animals lived in roughly the same location at the same time, they grew differently. Griffin compared this finding to any modern family with siblings and cousins differing in height or body mass, for instance, one brother smallish, and another taller; one naturally muscular, another prone to thinness.

Griffin and Nesbitt studied bone scars on the Asilisaurus leg bones, focusing on spots where muscles and tendons attach to bone.

The more mature an individual was at death, the larger its bone scars appeared. As with any animal or person, an individual skeleton goes from possessing few scars to possessing many during life, with scars appearing in a particular order as the age of the individual increases.

Findings show that except for the smallest and largest individuals, which are the least and most mature, size is a poor predictor of skeletal maturity in Asilisaurus, and therefore likely in early dinosaurs as well.

Further, similar differences in early dinosaurs had been thought to represent a difference in sex, with more "mature" individuals representing one sex and more "immature" individuals representing another.

"Our study includes more individuals and more bone scars, and with this increase in sample size we found that individuals fall on a trajectory that is more similar to maturity difference than sexual difference," added Griffin. "This suggests that similar variation in bone scars in early dinosaurs is variation in growth, not male and female difference. Because this variation appears to be widespread among early dinosaurs and their closest relatives, it is likely that high variation in growth between individuals characterized the most recent common ancestor of Asilisaurus and all dinosaurs."

Griffin's initial work on Asilisaurus began when he was a Cedarville (Ohio) University undergraduate intern at the Field Museum of Natural History in Chicago. Although he did not participate in the 2007-2015 Tanzanian digs, Griffin, along with Nesbitt, studied fossils from those efforts. Nesbitt participated and led one of the field excursions in which Asilisaurus specimens were collected.

Asilisaurus is part of a group of reptiles, the silesaurids, that are close cousins of dinosaurs. Asilisaurus grew similarly to living crocodilians in that both possess differences between individuals in growth patterns.

Yet that growth was much faster in Asilisaurus, closer to the growth rate of birds, rather than living crocodiles. As with dinosaurs, living birds are considered a close living relative of Asilisaurus.

Griffin used a computer program to virtually reconstruct growth sequences derived from bone scar evidence, and then painstakingly sliced upper leg bone Asilisaurus fossil samples into cross-sections. He studied the microscope-thin slivers of bone tissue microstructures, determining each specimen's relative age and pace of its growth.

"I'm fascinated by how much we can learn about the past through animals that are so unlike anything that we have today, and how that can help us understand how today's world came to be the way it is," he said.

More information: C. T. Griffin et al. The femoral ontogeny and long bone histology of the Middle Triassic (?late Anisian) dinosauriform and implications for the growth of early dinosaurs , *Journal of Vertebrate Paleontology* (2016). DOI: 10.1080/02724634.2016.1111224

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