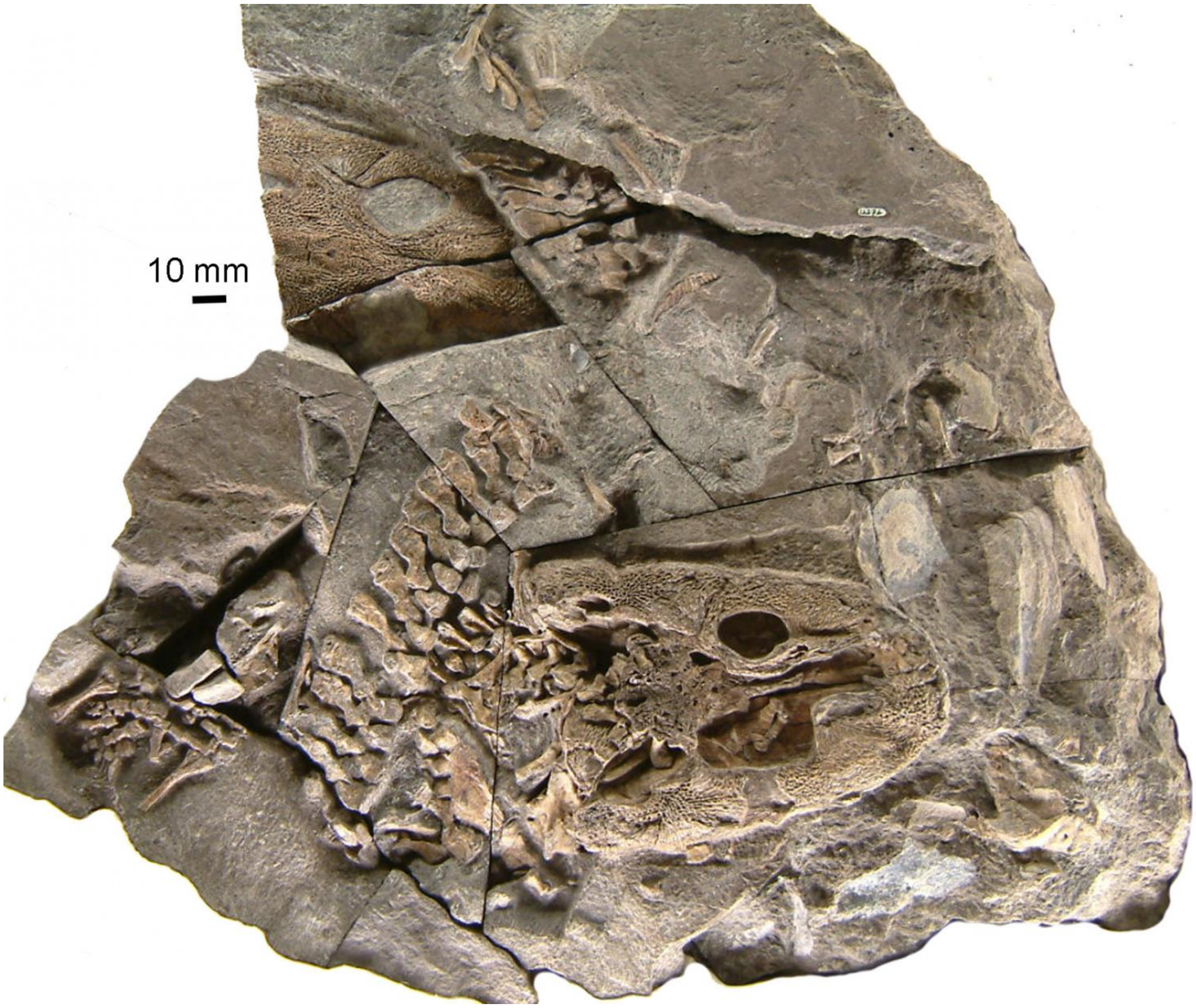
Life history of the 360-million-year-old tetrapod Acanthostega rewrites the tetrapod move on land

September 7 2016

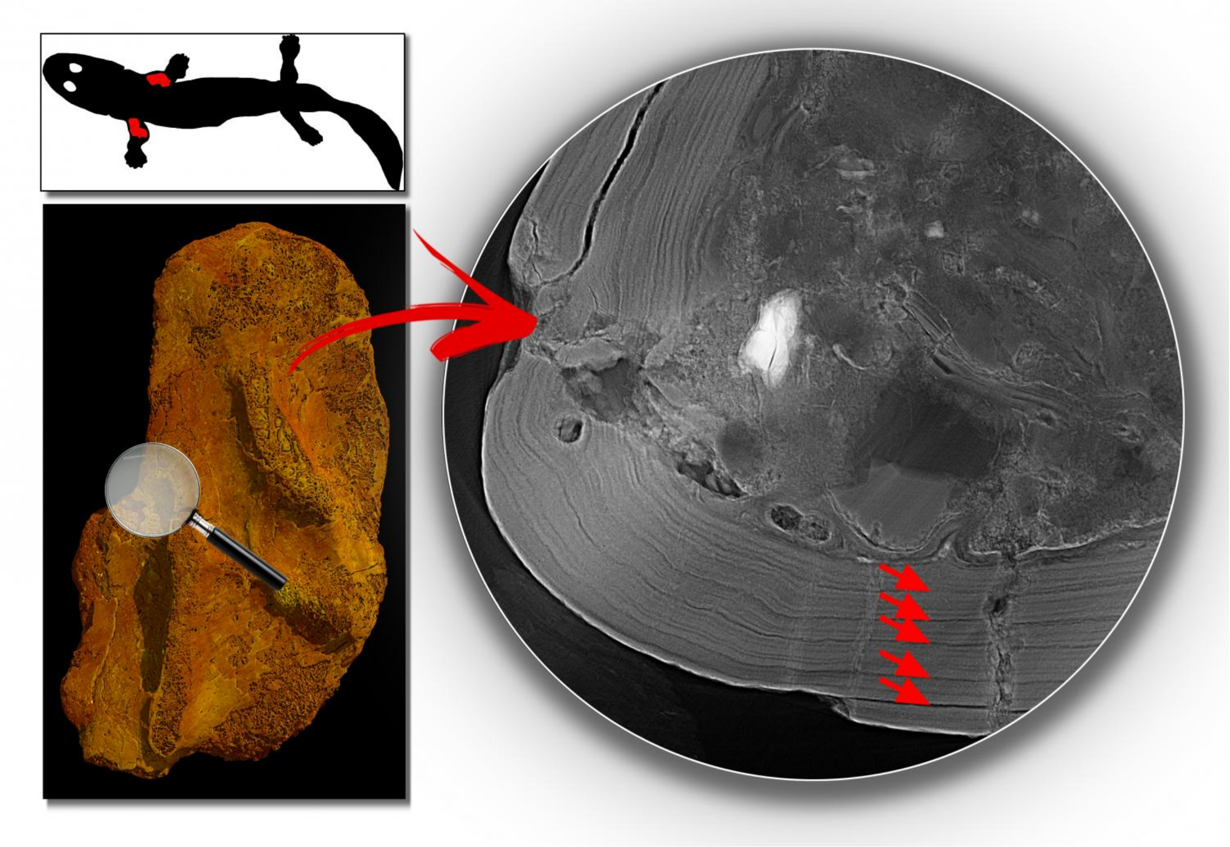


A picture of the *Acanthostega* fossil. Credit: Jennifer CLack

This week in the journal *Nature*, a team of researchers from Uppsala University in Sweden, the European Synchrotron Radiation Facility (ESRF) in France and the University of Cambridge in the United Kingdom shows that fossils of the 360 million-year-old tetrapod *Acanthostega*, one of the iconic transitional forms between fishes and land animals, are not adults but all juveniles. This conclusion, which is based on high-resolution synchrotron X-ray scans of fossil limb bones performed at the ESRF, sheds new light on the life cycle of Acanthostega and the so-called conquest of land by tetrapods.

The tetrapods are four-limbed vertebrates, which are today represented by amphibians, reptiles, birds and mammals. Early tetrapods of the Devonian period (419-359 million years ago) are of great interest to palaeontologists: they were the earliest vertebrate animals that ventured onto land, paving the way for all future vertebrate life on land. The move from water to land must have affected every aspect of the biology of these animals, but until now there has been no serious attempt to investigate their life histories - how long they lived or whether they had an aquatic juvenile stage, for example. Well-preserved skeletons are rare and it has simply been assumed that they represent adults.

The single richest locality for Devonian tetrapods is a so-called mass-death deposit of *Acanthostega*, discovered in 1987 in Greenland by Jennifer Clack, one of the authors of the study and leading teams from the Universities of Cambridge and Copenhagen, where dozens of skeletons lie packed together like sardines in a tin. It looks like the tetrapods all died together when a small stream within an "inland delta" (like the modern Okavango in Botswana) dried out. The team decided to look at the life history of these fossils by investigating the internal structure of their humeri (upper arm bones). "Using the tremendous power of synchrotron X-rays, we were able to access microscopic details in these dense specimens as on real histological slices, but without damaging these unique fossils" says Paul Tafforeau from the ESRF.



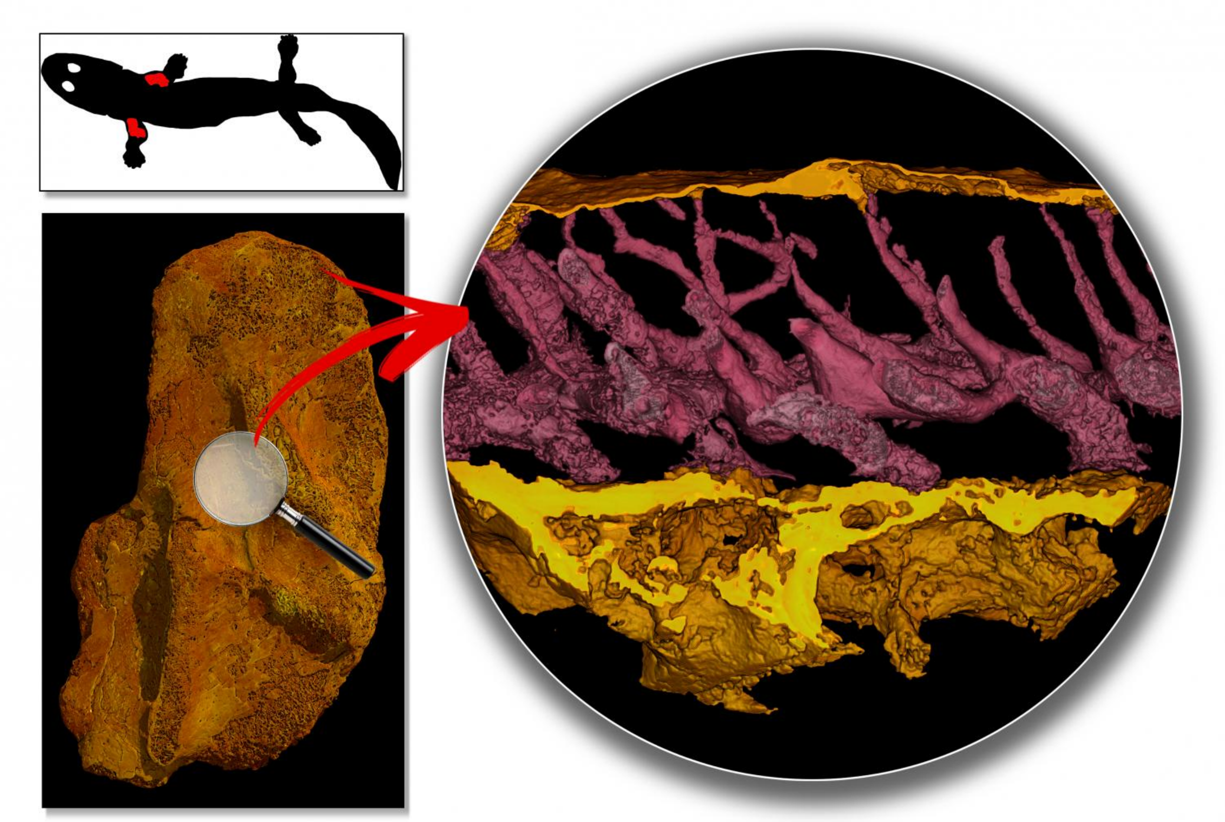
Top left: body outline of Acanthostega is in black, with the humeri (upper arm bones) represented in red. Bottom left: 3-D model of a humerus of Acanthostega, generated from a synchrotron scan, with magnifying glass indicating position of the high-resolution section shown on the right. Right: section through the bone showing annual growth rings (highlighted with red arrows) that allowed the researchers to assess the seasonal growth rhythms and individual age of this 360 million-year-old tetrapod. Credit: Sophie Sanchez, Uppsala University and ESRF

The microscopic structures in the bones of these fossil tetrapods are almost perfectly preserved. "Like a growing tree, a limb bone is marked by seasonal rhythms and lays down annual growth rings" says Sophie Sanchez, the lead author of the publication, working at Uppsala

University and the ESRF. "These growth rings, which can be seen in both fossil and living tetrapods, are informative about the development and age of the individual".

The powerful X-ray beam of the ESRF revealed that all studied fossils of *Acanthostega* were immature individuals, even though they were at least 6 years old and probably older. Their growth had not yet begun to slow down as it does at sexual maturity. In addition, the researchers showed that *Acanthostega*'s foreleg remained cartilaginous until late during its development.

In contrast to bone, cartilage is a non-mineralised tissue, elastic and far too weak to allow the forelegs to sustain the weight of the animal's body out of the water. "This suggests that the *Acanthostega* mass-death deposit represents a school of aquatic juveniles that included few or no adults" says Per Ahlberg from Uppsala University. So where were the adult *Acanthostega* living? Were there segregated distributions of juveniles and adults at least at certain times? This remains to be discovered. The scans done at ESRF ID19 beamline also show that the absolute size at which limb ossification began differs greatly between individuals, suggesting the possibility of sexual dimorphism, adaptive strategies or competition-related size variation.



Top left: body outline of Acanthostega is in black, with the humeri (upper arm bones) represented in red. Bottom left: 3-D model of a humerus of Acanthostega, generated from a synchrotron scan, with magnifying glass indicating position of the high-resolution section shown on the right. Right: 3-D transverse section model through the outer layer of the bone showing blood vessel cavities (in pink) that provide clues about the metabolism of this 360 million-year-old tetrapod. Credit: Sophie Sanchez, Uppsala University and ESRF.

The tetrapods' move onto land was arguably one of the most radical adaptive shifts in vertebrate evolutionary history. "Our study provides a first glimpse of the life-history traits of an early tetrapod. We plan to undertake a more complete survey of early-tetrapod life histories which should have a significant impact on theories depicted in all textbooks" concludes Sophie Sanchez.

More information: Sophie Sanchez et al, Life history of the stem tetrapod Acanthostega revealed by synchrotron microtomography, *Nature* (2016). DOI: 10.1038/nature19354

Provided by European Synchrotron Radiation Facility

Citation: Life history of the 360-million-year-old tetrapod Acanthostega rewrites the tetrapod move on land (2016, September 7) retrieved 29 June 2024 from https://phys.org/news/2016-09-life-history-million-year-old-tetrapod-acanthostega.html