**////Title: Analysing Bones to Gain Insight into Mammalian Evolution**

**////Standfirst:** It may be surprising to know, that you – and all other mammals – are technically cynodonts. The first cynodonts appeared approximately 260 million years ago as small creatures about the size of a house cat. A particular group of cynodonts evolved to become more ‘mammal-like’, eventually evolving into the first true mammals. Dr Jennifer Botha from the National Museum, Bloemfontein in South Africa studies the anatomy and life history of specimens along the cynodont–mammalian transition, to gain key insights into the origins and evolution of mammals.

**////Main text:**

Scientists have long searched for cynodonts with mammal-like features. Studying fossils of such animals can offer clues about how mammals first evolved from pre-mammalian cynodonts.

In the mid-2000s, researchers discovered a group of cynodonts called ‘brasilodontids’, which they believe are the closest relatives to mammals. These rat-like animals were tiny insect-hunters, with a body length less than half that of mice.

Importantly, they had dental features similar to those of mammals that are not found in other cynodonts. Thus, they may represent the missing link in the transition from cynodont to mammal. These small animals also had a bony palate – allowing them to eat and breathe simultaneously. Other features, including the possible presence of hair, indicate a progressive increase in the acquisition of mammalian traits in brasilodontids.

In a 2018 study published in *PeerJ*, Dr Jennifer Botha and her colleagues from South Africa and Brazil assessed the life histories of several brasilodontid specimens. Their goal was to gain insight into the physical changes that occurred prior to and during the evolution of mammals. The researchers found that the tiny brasilodontids contained features from both cynodonts and mammals, hinting at the progression of evolution that led to modern mammals, such as humans.

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Specifically, they wanted to learn more about the growth patterns and growth rates in brasilodontids. To study growth patterns and other life history data, scientists typically analyse the microscopic structure of limb bones such as the femur – the longest bone in the leg.

Previously, it had been almost impossible to conduct these studies on brasilodontids, due to the delicate nature of the available specimens. However, the discovery of four well-preserved fossils in Brazil presented an amazing opportunity for Dr Botha and her colleagues – they now had the specimens they needed. Using anatomical techniques, the team compared the growth patterns of these brasilodontids with those of other cynodonts and mammals – filling a critical knowledge gap in the cynodont–mammal transition.

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Dr Botha and her colleagues analysed femoral samples from two brasilodontid fossils, alongside those from earlier cynodonts that lived around 233 million years ago. All of these specimens came from a site in northern Brazil.

The researchers made tiny cuts into the small femur bone in each fossil to create cross-sectional samples, in order to analyse the bone microstructure using powerful microscopes. They were able to distinguish between different types of bone and determine whether there had been dense networks of blood vessels. The level of vascularisation can offer clues about the growth rates of ancient animals.

They also assessed the microscopic structure of the femora to distinguish different bone tissue types. Woven bone, for example, is much less mature and can indicate a juvenile skeleton, or a skeleton of a fast-growing specimen. Woven bone is gradually replaced by more organised ‘lamellar’ bone in early adulthood. Thus, the ratio of woven bone to lamellar bone in a specimen gives researchers insights into an animal’s age and reproductive maturity.

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Dr Botha and her team’s analysis of the early cynodonts revealed a good example of the growth patterns that existed during the early evolution of this group of animals. The highly vascularised, rapidly deposited bone tissues suggested that the animals grew quickly during periods of favourable conditions, but growth slowed down during harsh, unfavourable periods as shown by growth rings (like those of a tree) indicating temporary slower growth. The researchers also determined that it likely took longer than one year for the animals to reach reproductive maturity.

The team found that the brasilodontid specimens had a mixture of woven and lamellar bone tissues, indicating that they grew quickly as juveniles, but also experienced some slowed growth into adulthood. Like the early cynodonts, certain bone features showed that brasilodontids took longer than one year to reach reproductive maturity. In contrast, similar-sized modern mammals, such as mice, reach reproductive maturity before one year of age.

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The researchers compared these bone tissues to those of early mammal specimens from a similar era. Unlike the brasilodontids and early cynodonts, the femora of these extinct mammals were composed entirely of poorly vascularised bone tissue, indicating slow growth over the course of a lifespan. However, they also had a mixture of woven and lamellar bone, meaning that their juvenile growth may have been similar to that of brasilodontids. The researchers deliberately compared the brasilodontids to mammals of a similar size, meaning that the differences in growth cannot be attributed to differences in body size.

The researchers also compared their early cynodont and brasilodontid femur samples to those of modern-day mammals. When compared with similar-sized mammals that exist today, brasilodontids may have actually grown more slowly up to adult size.

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Dr Botha and her team’s work suggests that brasilodontids may serve as a missing link between cynodonts and the first mammals. Their extended growth period yet rapid juvenile growth has provided clues about when, and under what ecological circumstances, certain mammalian traits began to evolve. Still – the researchers stress – more specimens from all groups would help us clarify how this phenomenon manifested for larger brasilodontids.

This SciPod is a summary of the paper ‘Osteohistology of Late Triassic prozostrodontian cynodonts from Brazil’, from *PeerJ.*

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