



The golden age of the cynodonts

Species first discovered in Africa, and now in Brazil, lived during the peak of diversity of mammal precursors

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Triassic landscape:
By the water, the cynodont *Menadon besairiei* with offspring, followed by a band of *Santacruzodon hopsoni*.
At left, *Dagasuchus santacruzensis*, a carnivorous reptile like the *Chanaresuchus bonapartei* (behind the tree)



Tens of millions of years before dinosaurs ruled the Earth, a peculiar kind of animal reigned on land. A large, diverse group with a striking similarity to present-day mammals. These primitive animals were the cynodonts. The cynodonts had begun to develop the characteristics that today are exclusive to mammals: they were warm-blooded and had hairy bodies and various types of teeth. In Latin, cynodont means “dog teeth”.

For a long time, all the continents were inhabited by carnivorous and herbivorous cynodonts, such as *Menadon besairiei*, pictured watching over its young in the illustration above. Today, we know that *Menadon* also lived in what is now southern Brazil. *Menadon*, which was about one meter in length—the size of a large dog—may have looked like a descendant of an impossible cross between an alligator and a capybara, a large rodent. It belonged to the lineage of transversodontids, the most diverse of the cynodonts, which is now extinct. There were many other lineages,

and one of them, the mammaliamorphs, gave rise to the mammals.

Paleontologists Tomaz Melo and Marina Soares of the Federal University of Rio Grande do Sul (UFRGS), working with Argentine paleontologist Fernando Abdala of the University of the Witwatersrand, South Africa, discovered that *Menadon besairiei*, the first fossil of which was found in rocks on the island of Madagascar (off the eastern coast of Africa), also lived during that same period, 230 million years ago, in an area that is now the interior of the Brazilian state of Rio Grande do Sul. Therefore, *Menadon* lived in the middle of the Triassic period—250 million to 200 million years ago—when South America, Africa (including Madagascar) and the other continents were all part of a single supercontinent known as Pangaea.

The study, published online in September 2015 in the *Journal of Vertebrate Paleontology*, confirms that transversodontids such as *Menadon* populated Pangaea end to end.



A *Menadon besairiei* skull found in Rio Grande do Sul state: the animal was about one meter in length and belonged to the transversodontid lineage

age, between 232 million and 228 million years old—the only sedimentary rocks of that age preserved in South America and Africa. “Each new finding enables us to strengthen the temporal correlations between rock layers in different parts of the world.”

There are gaps in the Triassic history of every continent. In southern Africa, for example, paleontologists have now identified sedimentary rocks that were formed from mud or sand at the beginning and the end of the Triassic, but there are no preserved rocks from the middle of the Triassic, as occur in Argentina and Brazil.

Melo explains that researchers are rarely able to date the age of sedimentary rocks from the Triassic with absolute certainty. Some layers in Argentina, for example, have been dated by means of radioactive isotope decay in volcanic ash. “But generally speaking, we depend on comparison of fossils found in different layers to find out whether they are the same age,” Melo says.

To determine the relative ages of rock layers, researchers generally use comparisons between microscopic fossils

“Most of the transversodontid fossils have been found in South America and southern Africa, but there are also records in North America and Europe,” explains Soares, who advised Melo for his Master’s research on *Menadon* at UFRGS. “Since there weren’t any big geographic barriers to fauna on Pangaea, the transversodontids and other animal groups at the time had a cosmopolitan distribution.”

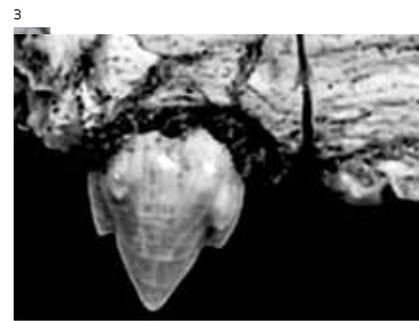
FROM SANTA CRUZ TO MADAGASCAR

Abdala, regarded as one of the world’s leading cynodont experts, had previously (in 2001) noted a similarity between the fossilized fauna in a layer of rocks that form a sandstone outcropping in the municipality of Santa Cruz do Sul, Rio Grande do Sul, and the fossil fauna found in a rocky layer of the Isalo II Formation, found in Madagascar and described by American paleontologists in 2000. One of the transversodontids discovered in Isalo II, *Dadadon isaloii*, looked very much like *Santacruzodon hopsoni*, found in Santa Cruz do Sul (shown behind *Menadon* in the illustration on pages 64 and 65). Likewise, the skull of *Menadon besairiei* exhibited similarities with the skull of a species that had been found in Santa Cruz but not yet identified.

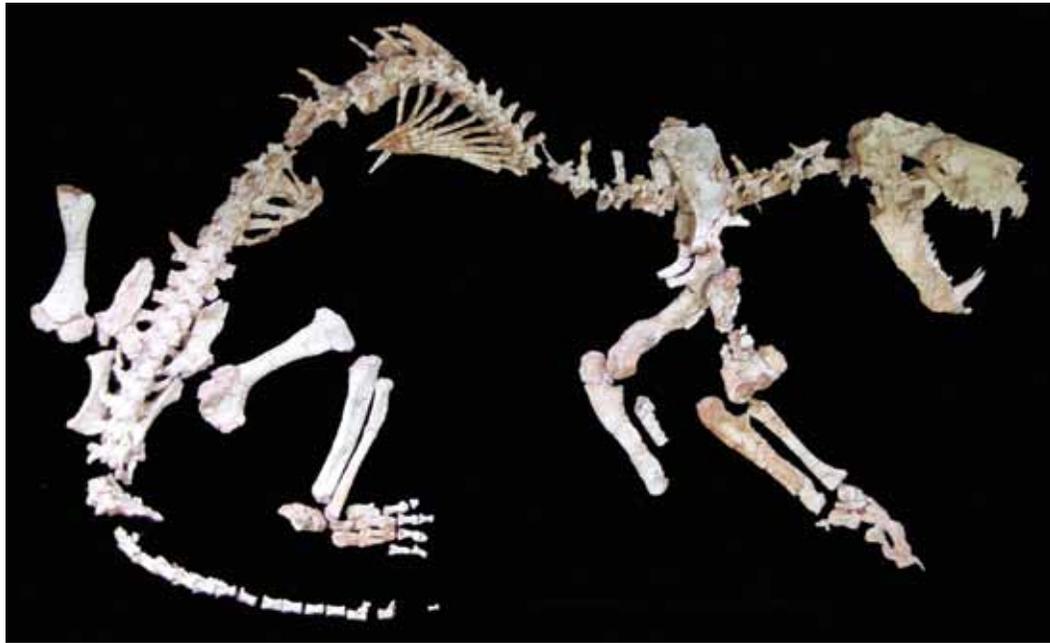
It fell to Melo to shed light on the matter in his Master’s research, in which he compared the skull described by Abdala to other materials—more skulls, pieces of jaw and a few fragments of bones from the body—from the unidentified species, which had been collected later at the same site and were preserved by researchers from UFRGS and the Zoobotanical Foundation of Rio Grande do Sul.

“It could have been a very closely related species, but in the final analysis, we haven’t found any difference between it and *Menadon besairiei*,” says Melo, who is in the midst of his doctoral research on transversodontids under Soares’ advisorship. “It is likely to be the same species found in Madagascar.”

The discovery helps piece together two parts of the geological puzzle that paleontologists need to assemble in order to reconstruct the history of life in the Triassic. “Not every place in the world has preserved rocks of the same age,” Soares explains. The similarity between the fossil fauna from Rio Grande do Sul and from Madagascar—great enough to share a species—confirms that the sandstone layers in Santa Cruz do Sul and Isalo II are likely the same



Botucaraitherium belarmino: a carnivorous cynodont slightly larger than a rat, with sharp, pointed teeth (above), adapted for an insect-based diet



The carnivore *Trucidocynodon riograndensis*, which grew as large as 1.2 meters: one of the most complete cynodont skeletons ever found in Brazil

such as grains of pollen and pteridophyte spores, which are abundant in all periods. “Our problem is that the rocks from the Triassic in Rio Grande do Sul were deposited on the banks of rivers and floodplains, which are well-aerated environments,” Melo explains. “Oxygen destroyed the pollen and spores. The only way to date the rocks is through vertebrate fossils.”

The group of cynodonts that became most extensively diversified in the Middle Triassic was the transversodontids. Unlike other cynodonts, which were generally carnivorous or omnivorous, transversodontids were herbivores. Their teeth were specialized for eating roots, leaves or any other plant matter that was available in the hot, semiarid climate that predominated in the interior of Pangaea.

COMPETITION AMONG HERBIVORES

The transversodontids had to compete for food with the other large herbivores of the period—the dicynodonts, which were related to the cynodonts but did not have mammalian features, and the rhynchosaurs, which were reptiles. The large predators of these herbivores were the Pseudosuchia, reptiles similar to giant crocodiles. One of the Pseudosuchia that lived in Rio Grande do Sul and was also discovered in rocks in Santa Cruz do Sul is *Dagasuchus santacruzensis*, described by UFRGS’ Marcel Lacerda and colleagues in an article published in 2015 in the *PLOS One* journal.



The layers of Triassic rock younger than those in Santa Cruz do Sul, however, suggest that all the known transversodontids were extinct long before the end of that period. Nevertheless, other cynodont species lived on until the Late Triassic, exhibiting extraordinary forms such as those of *Trucidocynodon riograndensis*, a cynodont that had protruding canines, was 1.2 meters in length and may have been carnivorous. Found in 2009 in 220-million-year-old rocks in the municipality of Agudo, also in Rio Grande do Sul, the fossilized skeleton of *Trucidocynodon* is one of the most complete cynodont skeletons ever discovered.

Another interesting cynodont group, found only in rocks from the Upper Triassic—230 million to 200 million years ago—in the Santa Maria Formation, Rio Grande do Sul, consists of small animals of about 10 centimeters in length with

serrated teeth, useful for an insect-based diet. “There is no other cynodont group in the world as similar to a mammal as the ones discovered in Rio Grande do Sul,” Soares notes. Of these small cynodonts, known as mammaliamorphs, the species she and her colleagues most recently described is *Botucaratherium belarminoi*, found in 2014 in the municipality of Candelária, in Rio Grande do Sul. “We have three more new species being examined,” says Soares, who hopes to discover another species of the first mammals, which emerged in the Late Triassic and probably coexisted with the cynodonts. “We’ll find it one day.” ■

Scientific article

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