After 121 years, identification of 'grave robber' fossil solves a paleontological enigma

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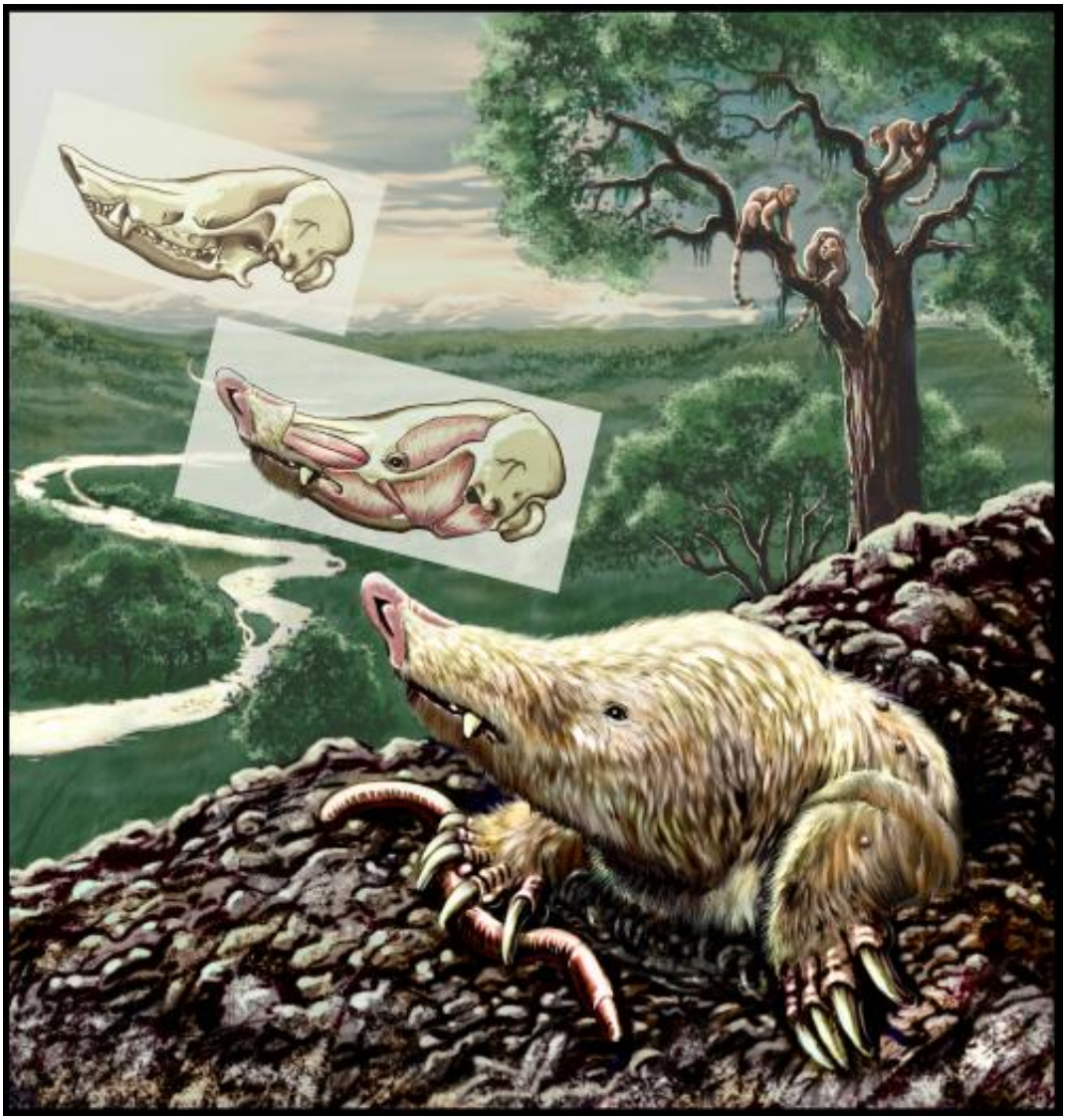

The Miocene mammal *Necrolestes patagonensis* ventures out of its burrow 16 million years ago in Patagonia, present-day Argentina. *Necrolestes* is now recognized as a member of a group long thought to have become extinct shortly

after the extinction of the large dinosaurs at the end of the Cretaceous period. Credit: Reconstruction by Jorge Gonzalez, copyright Guillermo W. Rougier

An international team of researchers, including Carnegie Museum of Natural History scientist John Wible, has resolved the evolutionary relationships of *Necrolestes patagonensis*, whose name translates into "grave robber," referring to its burrowing and underground lifestyle. This much-debated fossil mammal from South America has been a paleontological riddle for more than 100 years.

Scientific perseverance, a recent fossil discovery, and comparative anatomical analysis helped researchers to correctly place the strange 16-million-year-old *Necrolestes*, with its upturned snout and large limbs for digging, in the mammal evolutionary tree. This finding unexpectedly moves forward the endpoint for the fossil's evolutionary lineage by 45 million years, showing that this family of mammals survived the extinction event that marked the end of the Age of Dinosaurs. This is an example of the Lazarus effect, in which a group of organisms is found to have survived far longer than originally thought. Situating *Necrolestes* among its relatives in the fossil record answers one long-held question, but creates others; it reminds us that there is a lot we don't yet know about the global impacts of the massive extinction event 65 million years ago and it challenges assumptions that the well-documented effects that occurred in western North America were experienced globally.

The scientific paper resolving the mystery of *Necrolestes* appears today in Proceedings of the National Academy of Sciences.

A paleontological riddle

Since its discovery in Patagonia in 1891, *Necrolestes* has been an enigma.

"*Necrolestes* is one of those animals in the textbooks that would appear with a picture and a footnote, and the footnote would say 'we don't know what it is,'" says co-author John Wible, Carnegie Museum of Natural History mammalogist and member of the discovery team that also includes researchers from Australia and Argentina. Wible is known for his work on the origins and evolutionary relationships among the three modern mammal groups: placentals (live-bearing mammals such as humans), marsupials (pouched mammals such as opossums), and egg-laying mammals (such as platypuses).

Despite being excellently preserved, the mysterious fossils moved from institution to institution and researcher to researcher, the classification of *Necrolestes* changing with each new move. As recently as a few years ago, *Necrolestes* still could not be definitively classified in a mammal group. A CAT scan of the ear region in 2008 led to another research team's hypothesis that *Necrolestes* was a marsupial. This classification intrigued Wible's co-author on the paper, Guillermo Rougier from the University of Louisville, Kentucky. As a specialist in South American mammals, Rougier was not convinced that the marsupial identification was accurate, and he embarked on his own attempt to make a classification. "This project was a little daunting, because we had to contradict 100 years of interpretation," admits Rougier.

During the process of preparing the fossil for further study, Rougier uncovered characteristics of the skull anatomy that had previously gone unnoted. Based on these newly revealed features, the research team came to the groundbreaking realization that *Necrolestes* belonged to neither the marsupial nor placental lineages to which it had historically been linked. Rather, *Necrolestes* actually belonged in a completely unexpected branch of the evolutionary tree which was thought to have died out 45 million years earlier than the time of *Necrolestes*.

Confusing anatomy

Part of the riddle of *Necrolestes* has always been its seemingly mismatched anatomical features, which never seemed to fit any single classification.

Based on its decidedly upturned snout, sturdy body structure, and short, wide leg bones, researchers had always agreed that it must be fossorial—a burrowing, digging mammal. Burrowing mammals have a wide humerus (upper arm bone) that is specialized for digging and tunneling. The humerus of *Necrolestes* is wider than any other fossorial mammal's, indicating that *Necrolestes* was particularly specialized for digging—perhaps more so than any other known burrowing mammal—but this trait didn't make classification any easier. The simple triangular teeth of *Necrolestes* served it well in feeding on subterranean invertebrates. However, until recently, its teeth have proved of little help in classifying *Necrolestes*, because they are so simplified and show no unambiguous similarities to those of other mammals. Enter *Necrolestes*.

The mystery solved

In 2011, a newly discovered extinct mammal named *Necrolestes* was the key that unlocked the mystery of the burrowing enigma. Discovered by co-author Rougier in South America, *Necrolestes* belongs to the

Meridiolestida, a little-known group of extinct mammals found in the Late Cretaceous and early Paleocene (100 million years ago) of South America. Not only were *Necrolestes* and *Necrolestes* found to have remarkable similarities, they are the only known mammals to have single-rooted molars—most mammals have double-rooted molars. This conclusively showed that *Necrolestes* was neither a marsupial nor a placental mammal, and was in fact the last remaining member of the Meridiolestida lineage, thought to have gone extinct 45 million years earlier.

"If we didn't know those fossils," says Wible of *Necrolestes*, "we might have come to the same conclusion that everybody else had—that the relationships of *Necrolestes* were unknowable."

Evolutionary implications

The mass extinction that ended the Age of Dinosaurs wiped out thousands of species. Included in the devastation were the Meridiolestida, the mammal group to which *Necrolestes* and *Necrolestes* belong, cutting short their evolutionary lineage—or so scientists thought.

Before the conclusive identification of *Necrolestes*, only one member of the Meridiolestida was known to have survived the extinction event, and that species died out soon after, early in the Tertiary Period (65.8 million years ago). *Necrolestes* is therefore the only remaining member of a supposedly extinct group. "It's the supreme Lazarus effect," comments Wible. "How in the world did this animal survive so long without anyone knowing about it?"

In the Lazarus effect, a species previously thought to be extinct is rediscovered—sometimes living, sometimes elsewhere in the fossil record. The Lazarus effect is well represented by the ginkgo tree, thought to be extinct until it was rediscovered growing in China in the 17th century.

The researchers believe that *Necrolestes*'s supreme burrowing adaptations are exactly what enabled it to survive for 45 million years longer than its relatives. "There's no other mammal in the Tertiary of South America that even approaches its ability to dig, tunnel, and live in the ground," explains Wible. "It must have been on the edges, in an ecological niche that allowed it to survive."

The researchers point out that other extinct digging species are known by

many specimens, while *Necrolestes* is only known from a few fossils from a narrow geographic area. This means it was not abundant in its time, which fits with the model of a life form existing in a marginal environment. Rougier comments, "In a way, while not related, it's somewhat similar to how the platypus lives today. There aren't many of them, they are found only in Australia, and they live in a specific niche among modern mammals—just as *Necrolestes* is an isolated lineage only found in South America, with very few individuals living among large numbers of marsupials."

Future research

Necrolestes's survival for 45 million years longer than expected challenges more than a century of scientific thought on the effects of the Late Cretaceous extinction event in South America, and shows how scientific thought is constantly changing based on new evidence. For example, because the paleontological landscape is much better understood in North America and Eurasia, extinction models on those continents were assumed to apply to all continents. Rougier points out, "We can't do that anymore. This story is more complex, a very distinct picture. We're just getting there with South America."

Carnegie Museum paleontologist Matt Lamanna, who has conducted expeditions to Patagonia since 1998, agrees that South America is a hotbed for new paleontological discoveries. "A lot of what we think we know about the Cretaceous–Tertiary extinction comes specifically from western North America," he confirms. "As the fossil record in other regions of the world continues to grow, our understanding of that extinction will undoubtedly continue to change."

The research team is looking forward to filling in the 45-million-year gap between *Necrolestes* and its nearest known relatives, applying that knowledge to other related species that crossed the Cretaceous-Tertiary

extinction boundary—a seemingly South American phenomenon.

Provided by Carnegie Museum of Natural History