Elephants: Earth's giant climate change canaries

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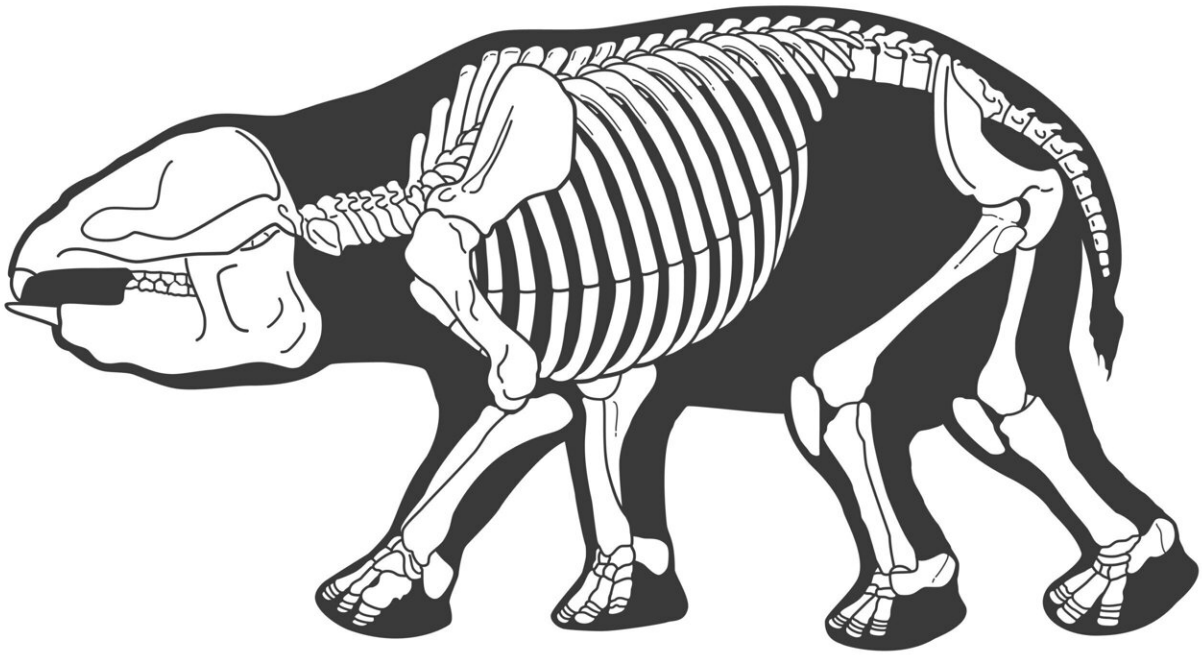

More than 6 feet tall and 4,500 pounds, Barytherium emerged in the Oligocene about 25 to 30 million years ago as the first proboscidean of immense size. Image courtesy: Bill Sanders

In 2013, University of Michigan researcher Bill Sanders was invited to the Arabian Peninsula by an international team studying fossils and fossil sites in Abu Dhabi.

Sanders, a paleontologist, has been studying proboscideans, the order of mammals to which elephants belong, since graduate school in the 1980s. But on the Arabian Peninsula, his colleagues wanted to show him something he had never seen before.

They drove out into the desert, an expanse of land that would have been connected to the African continent 8 million years ago. At that time, the animals that ranged the landscape migrated back and forth between the continents. Some 7 million to 8 million years ago, a herd of at least 13 elephants trod the desert. The evidence was right in front of Sanders and his colleagues: a series of giant footsteps imprinted in the carbonate-rich sediment.

"You could see this big plane of land, about three football fields long. I could see immediately the footprint of our elephants captured on that plane from 8 million years ago, and one big set of footprints crossing those," Sanders said.

He recognized straightaway that he was looking at the trackways of a matriarch-led herd of elephants. Then, he saw a lone set of footprints—a big bull male who had later wandered across their path. The male would have been spending his time alone, like his contemporaries, and visiting female-led herds only when he wanted to mate.

The male likely stood for a moment, sniffed the air after the departed herd, and then continued on his way.

"I immediately burst into tears. I was overcome by emotion," Sanders said. "All my colleagues recognized what an impact this rare, fossilized evidence of behavior had on me, what a singular moment this was."

Sanders has devoted his 40-year research career to tracking 60 million years of Afro-Arabian proboscidean—elephants and their ordinal

relatives—evolution. In a recent project, he has traced the earliest signs of proboscideans in the fossil record, up until our modern elephants. His survey was recently published in a book titled "Evolution and Fossil Record of African Proboscidea."

But, over the eight-year course of his project, Sanders watched elephants' numbers slip to precarious lows, the demise of elephants underscoring a new urgency and meaning for the book.

"Elephants, in a way, are the giant versions of canaries in a mine for the planet. If we cannot sustain animals as big and as capable and as versatile as elephants," Sanders said, "then that means we have ripped a hole in the fabric of life on Earth in a way that could actually be very dangerous to ourselves. It could lead to our own demise."

Proboscideans the size of poodles

Eritherium was the first proboscidean to emerge, in the middle of the Paleocene Epoch, about 60 million years ago.

"The very earliest proboscidean would have been the size of a French poodle. It would look something like a river rat. No big ears. The nose was at the very front of the face," Sanders said. "They didn't have trunks or tusks. Those were features acquired over time."

For more than half of its 60 million years, proboscideans lived in isolation on the Afro-Arabian supercontinent, the landmass that existed before the African continent split from the Asian continent.

By the Oligocene, between 25 million to 30 million years ago, 11 more families emerged. More than 6 feet tall and 4,500 pounds, Barytherium was the first immense-sized proboscidean.

Gomphotheres emerged around 30 million years ago and dominated the continent until about 8 million years ago, into the early part of the late Miocene. Similar in size to the Asian elephant, some genera of gomphotheres had elongated lower jaws while others more resembled present-day elephants. Our modern-day elephants descended from one of these gomphothere lineages.

When the Afro-Arabian continent collided with the Eurasian continent, the Order bloomed. Mammoths and mastodons grew long fur and ranged through Siberia and North America. Tetralophodons, proboscideans with four tusks, lived throughout Europe, Asia and Africa. Dozens of others tested their fate nearly all over the world. Ultimately, numerous proboscidean families rose and fell and rose again over tens of millions of years.

More than 180 families have been described, and are now extinct. Now, just three species of elephants remain: the African forest and savannah elephants, and the Asian elephant.

The business of being big: Ears, teeth, trunks and the keys to elephant evolution

Understanding proboscidean evolution is important, Sanders said. The animals are a keystone of African faunas, ecologically dominant and vital, and the oldest continuously surviving African mammals who bear offspring by growing a placenta. There is no other mammal group in Africa that researchers can trace back as far, Sanders said.

"We're trying to understand the rich branching of Proboscidea throughout time—why did some groups succeed and other groups die out?" Sanders said. "I had to survey what we know from geology and geochemistry about global climate and local habitat. I talked with many

other paleontologists about animals that lived alongside proboscideans so that I could understand the planet proboscideans lived on."

Sanders realized different groups of proboscideans had not been well sorted throughout years of discovery. He began reviewing the known fossil record and sorting animals into their own categories. That way, the researchers could name each group's lineage.

It was necessary work: Sanders had to understand the context of each group of proboscidean and the time period to which they were dated. That way, he could identify which characteristics allowed certain lineages to last for longer periods of time compared to others.

Some characteristics key to different groups' survival, Sanders found, were the way that proboscideans' teeth developed, emerged and were constructed. Many mammals, including humans, have entire sets of teeth replaced at once. Their teeth grow vertically through their jaws, popping their "baby" teeth out and replacing them with a permanent set of "adult" teeth. But instead, elephants' teeth and the teeth of some of their ancestors rotate up from the back of their jaws forward, like a moving walkway of molars. That way, the elephants don't grow—and therefore don't wear out—all of their teeth at the same time.

"Elephants can't get false teeth. Other mammals can't get false teeth. When mammals wear out their teeth, they die," Sanders said. "One of the advantages for elephants is that they can extend their lifespan by this horizontal rotation of molars. This expands the amount of time they can have babies, as well as the number of babies they can have to grow their population."

The current-day elephants' defining characteristics—their size, their ears, their trunks—are also what enabled them to survive for so long, Sanders said.

If you're big, you can eat a wider range of food. Food doesn't have to be as high quality as food might need to be for a smaller animal. And the larger you get, fewer predators can eat you. But the larger you are, the more difficult it is to reach the ground to graze grass or to find other plants. And so elephants evolved a long trunk.

"An elephant's trunk has hundreds of thousands of small muscles inside of it. It's as versatile as your hands," Sanders said. "Elephants can pick a penny up off the ground."

Their tremendous sense of scent allows them to communicate with each other. They use their tusks to prise trees from the ground for their leaves. Males use their tusks for protection, for combat with other males for access to females, and as a characteristic for sexual selection. They invest energy in making themselves and their tusks bigger, Sanders said, while females put energy into developing offspring.

Their large ears also serve a purpose, although African savannah elephants' ears are larger than those of forest elephants. More challenged physiologically by their open-country hot environment, African savannah elephants have giant ears filled with blood vessels and capillaries. Fanning their ears can cool the giant-bodied animals. But for both species, flapping their ears could also mean something else.

"If they're flapping their ears a lot, they're pretty disturbed. It isn't just that they're cooling off. Sometimes they're perturbed by something and they're letting other elephants know that," Sanders said. "If an elephant is in front of you and its ears are rolled forward, run like hell."

Giant canaries on an inescapable planet

Humans and elephants have long had an intertwined history. Our relationship dates back to near the time those tracks appeared in the

Arabian Peninsula. Then, African elephants grazed the regions where our human ancestors emerged, opening up the landscape, Sanders said.

"At that time, our own group of bipedal apes, our ancestral precursors, our human ancestors appeared as well, taking advantage of being bipedal to exploit mosaic habitats that would not be as widespread if elephants weren't modifying the landscape with their activities," he said.

But as Sanders was completing his survey, both African forest and savannah elephants slipped a rung lower on the endangered species list. African savannah elephants are now listed as endangered, while forest elephants are critically endangered.

Habitat destruction, human-elephant conflict over land access, and illegal wildlife trade has slashed African savannah elephant populations by 60%, and African forest elephant populations by nearly 90%, according to the World Wildlife Fund.

Both groups teeter on the edge of extinction.

"What the fossil record taught me was, here was this complex evolutionary journey with a lot of accidents—accidents of time, of climate—along the way. And elephant ancestors were opportunistic and made do as best they could in the evolutionary picture. But there was no guarantee that elephants would be the product of that story, of that evolutionary journey," Sanders said.

"It's an irreproducible, incredibly rich journey of evolution. It would be tremendously tragic to lose them because of human factors: climate change, poaching, fighting over land. People want to farm and elephants want to exist. In a way it's cruelly ironic that elephants could be brought to extinction by the very animal they helped to produce."

The project incorporates the work of generations of paleontologists, and benefited greatly from the efforts of University of Michigan colleagues, according to Sanders. These U-M colleagues include scientific illustrators Carol Abraczinskas, John Klausmeyer and the late Bonnie Miljour, and undergraduate assistants Gerhard Mundinger, Jacob Lusk and Austin Babut.

Provided by University of Michigan