New research helps paleontologists to understand horse fossils and those that are missing from the record

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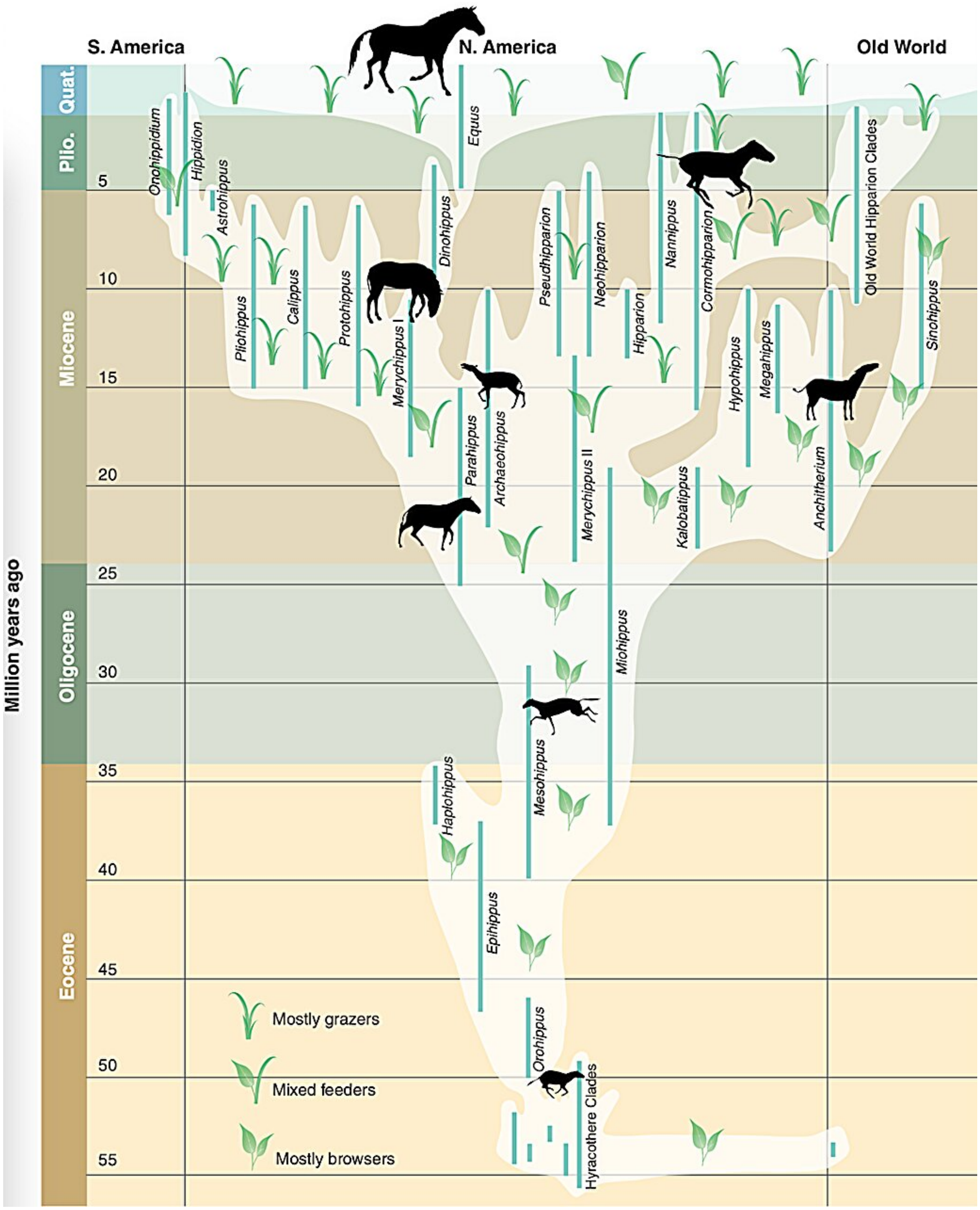

Phylogeny, geographic distribution, diet and body sizes of the family Equidae over the past 55 million years. Credit: *Science*. MacFadden, 2005. Reprinted with permission from AAAS.

Many people assume that horses first came to the Americas when Spanish explorers brought them here about 500 years ago. In fact, recent research has confirmed a European origin for horses associated with humans in the American Southwest and Great Plains.

But those weren't the first horses in North America. The family Equidae, which includes domesticated varieties of horses and donkeys along with zebras and their kin, is actually native to the Americas. The fossil record reveals horse origins here more than 50 million years ago, as well as their extinction throughout the Americas during the last Ice Age about 10,000 years ago.

We are paleontologists who focus our research on various types of fossils, including ancient horses. Our most recent work used computer statistics to analyze gaps in the fossil record to infer more about which horse species really did and didn't live in one ancient habitat in Florida.

Horses evolved as ecosystems changed

People have collected fossil horses throughout North America for centuries. Because horse fossils are abundant and widespread across the continent, scientists often point to the long span of the horse family as evidence of long-term evolutionary change.

Paleontologists like us, who study extinct mammals, almost never find complete skeletons. Instead, we focus on durable fossil teeth, which help us understand ancient diets, and fossil limbs, which help clarify how these animals moved.

Horses are eating machines. In the wild today, they primarily feed on grasses that don't provide much nutrition, and thus they need to consume large quantities to survive. The large teeth of modern horses and their ancestors are adapted primarily for grazing on gritty grasses. They replaced smaller teeth of more primitive horses adapted to browsing on soft leafy vegetation.

We know what horses ate millions of years ago by studying distinctive microscopic scratches, pits and other wear patterns on their teeth that were created as the ancient horses chewed plant foods. And analyses of carbon preserved in fossil teeth show that coexisting horse species ate different plants; some browsed on leaves from bushes and trees, some grazed on grasses, and yet others were mixed feeders.

The change in tooth shape tracks the change in dominant vegetation types in North America, from tropical forests that then gave way to the great expansion of open prairie grasslands. As the climate and flora changed over millions of years, horses shifted from being largely forest-dwelling browsers to largely open-country grazers. Their teeth and feeding patterns adapted to the environment.

Another adaptation is visible on horses' feet. Modern horses have one hoofed toe on each foot. Many extinct fossil horses—the ancient ancestors of today's horses—had three toes per foot. The single toe on each elongated foot is good for rapid and sustained running to evade predators and for long-distance seasonal migrations. The more ancient three-toed feet provided stability on unstable or wet ground. The adaptation from three toes to one was likely in response to changing habitats.

But even as the environment changed, one distinct species didn't completely replace another overnight. The fossil record in North America documents periods millions of years ago when multiple horse species coexisted on the ancient landscapes. Species were of different sizes and had teeth equipped for munching different plants, so they weren't competing directly for the same foods. Different habitats within these ancient ecosystems likely had some species more adapted to forests and others more adapted to grasslands.

Understanding Florida's fossil record

Paleontologists have been collecting horse fossils in Florida for over 125 years. The Florida Museum of Natural History at the University of Florida, where we work, has more than 70,000 fossil horse specimens from more than a thousand locations across the state.

One of our more prolific fossil sites, Montbrook, provides a glimpse of a 5.8 million-year-old ancient stream bed. It preserved more than 30 extinct mammals, including rhinos, elephants and carnivores, as well as hundreds of bones and teeth of fossil horses.

Although six horse species are known elsewhere in Florida, we have only found four so far at Montbrook. This smaller number of horse species perplexed us, so we decided to investigate. Did the two "missing" horse species truly not live at Montbrook, or have scientists simply not discovered their fossil remains yet?

We designed a theoretical model that compares Montbrook, with only four horse species, to other fossil sites in Florida that contain all six. Using a statistical technique that scientists call "bootstrapping," our computer essentially simulated continued fossil collecting over time. We generated 1,000 theoretical fossil collection events based on the fossil species counts from the sites where all six are present, to predict the probability of collecting the species that are currently missing at Montbrook.

Results from our simulation show that the two missing horse species at Montbrook were absent for different reasons. One of the horses is likely to be truly absent; the other may still be discovered with further excavation.

Probing 'gaps' in the fossil record

Knowing a species is absent is just as important as knowing when one is present at a fossil site. Absences may be indicators of underlying ecological and biological drivers changing population dynamics. Coupled with other types of analyses, researchers can apply this kind of predictive modeling across many fossil species and ancient landscapes.

Ever since Charles Darwin proposed his theory of evolution, scientists have known that the fossil record is incomplete, resulting in gaps in our knowledge of the ancient past and evolutionary change. Paleontologists are challenged to explain these gaps, including which species were or were not present at particular fossil sites.

Gaps can result from certain materials, such as teeth and shells, which are often more durable than porous bone, fossilizing better than others. Likewise, different chemical conditions during fossilization, and even the amount of time spent collecting fossils at a particular site, can contribute to the lack of knowledge.

Fortunately, fossil horse teeth preserve quite well and are commonly found. As new discoveries are made, such as those from our ongoing excavations in Florida, they'll help clarify and narrow gaps in the fossil record.

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