

Oklahoma's Serengeti

A new study of 6.6-million-year-old fossils from the Oklahoma Panhandle uncovers a highly diverse mammalian ecosystem during the expansion of grasslands.



Reconstruction of the Optima ecosystem by Cypress Hornung.

Summary – The Miocene Epoch was an incredibly important time for the evolution of North American ecosystems. During the last 10 million years, the Great Plains became more arid, and grasses took over as the main vegetation on the landscape. In modern times, these grasses are the main food source for many animals living in the region. However, exploiting this growing resource didn't come without a cost. Grass contains abundant silica-rich particles and is covered with grit (sand, dust), both of which can wear teeth quickly. This is one of the reasons why horses have tall teeth and such deep jaws, without these traits their teeth would wear away too quickly drastically shortening their lifespan. The expansion of grasses correlates with distinct shifts in the bones and teeth of grazing mammals as well as the chemical signatures contained within. Documenting these changes provides scientists the ability to document how and when the grasslands of the region became established and how they affected the animals that lived there.

The site focused on in this study is called Optima and is located near present day Guymon, Oklahoma. The site was worked by WPA-supported crews working for the University of Oklahoma during the early parts of the 20th century. Fossils at these sites are dominated by horses, but also include many small animals, rhinoceroses, camels, multiple types of dogs, a sabre-tooth cat, and a bear. This ecosystem diversity is far more reminiscent of modern-day Africa than Oklahoma. To determine how such diversity could exist, we looked at the teeth of these fossils for distinct wear, breakage, and chemical patterns that could help us determine what these animals were eating. We found a distinct difference between the horses and all other animals, in that they had heavily worn teeth with a chemical signature of ingesting

grasses. This tells us that by 6.6 mya, grasses were established sufficiently to become a major food source for the most abundant animals in the region. The camels, rhinos, pigs, elephants, and small mammals all had varying degrees of wear on their teeth and a chemical signature unlike grasses; indicating that they would preferentially eat shrubs, leaves, and non-grass foliage.

The predators also showed a high degree of dietary differences between species. The tiger-sized sabre-tooth cat (named *Amphimachairodus*) seemingly ate horses based on the chemistry of its teeth matching closer to horses than any other prey item. Their teeth also showed few breaks indicating that this cat did not chew bone often, an indicator that food was mostly plentiful at the time. The two species of dogs investigated were much smaller than the cat (coyote to bulldog size) and were likely more generalized in their diet. One dog, *Borophagus*, specialized in crushing bones for marrow (much like a modern hyena) indicated by its short jaws and highly worn and broken teeth. Unlike the other predators, the bear (*Agriotherium*, the size of a modern grizzly) showed the most unusual tooth chemistry. We suspect that this was due to this animal having a more omnivorous diet than the dogs or cats

Taken as a whole, we now have a more complete picture of how changing plants at the base of the food chain affected the diets of mammal communities in North America during the expansion of grasslands. These differences explain how the Great Plains could maintain such a large diversity of animals in contrast to today's depauperate mammalian communities.

FAQ

What large animals were present 6 mya in Oklahoma?

Oklahoma was home to an array of large creatures. Beyond alligators and giant tortoises found at the Optima site or nearby deposits, mammals were the most abundant big creatures found. We had multiple species of horses, camels, pronghorns and antelope-like creatures, a pig, a rhinoceros, an elephant, an early beaver, a prairie-dog-like creature, two small dogs, a badger, a sabretooth cat, and a large bear were all included in this study.

How different was the environment back then?

Geographically the landscape was not unfamiliar, however climatically it would be wetter and moderately warmer than today. Instead of vast rolling grasslands, the landscape was covered in forest and Serengeti-like environments.

Is this site rare for the region?

The Optima site is amazing in its preservation of abundant mammal fossils dating back over 6 million years. However, it isn't the only site from this time in North America. Similar sites in Texas, Kansas, and Nebraska, tell a similar story about how grasses became the dominant plant in the region during the Miocene.

If the fossils aren't rare, why is this study important?

This study looks at how all these similar animals were able to coexist (at least temporarily) in this environment. Competition between animals inevitably leads to extinction, so most ecosystems cannot have too many animals with the same lifestyle before one species loses out. The presence of multiple large herbivores and carnivores indicated that there must be something more going on to maintain such high diversity. By looking at the chemistry of their teeth (stable isotopes), tooth wear, and tooth breakage, we were able to reconstruct a rough outline of what these animals were eating and how they each occupied a different role in their environment. This limited competition between similarly sized animals allowed many more species to coexist, until grasslands expanded further and there were less diverse plants to eat later in the Miocene.

Quote about the project by lead author Joseph Frederickson (UWO):

How did you collect the data?

I worked on the geochemistry and helped quantify tooth wear. The nature of this project required an interdisciplinary approach to help differentiate the ecology of these different mammals.

What surprised you about the results?

I did not expect to find such a distinction in diet between the horses and other herbivores and the bear and other predators. In modern ecosystems, horses and bears have relatively distinct diets (grass and omnivore, respectively) from their competition; however, in the past this wasn't always the case. Seeing what biologists call "niche partitioning", or dividing up roles within an environment to limit competition, is an important key to how Oklahoma supported so many big animals.

How does it feel to work on such old dead animals?

Without fossils, we would have no clue what life looked like in the past. Amazing fossil localities, like the Optima site, help give us a unique view into the world before humans.

Quote about the project by undergraduate author Olga Castañeda (SWOSU):

How did you collect the data?

I collected data by looking over various images of teeth from fossil skulls and rating them on a scale based on the degree of wear. We made multiple measurements for each tooth and averaged out the score to reduce error. Additionally, I visited specimens at the Sam Noble Museum of Natural History and further observed the massive collection of fossils in person. Other authors worked on the tooth geochemistry and breakage aspects of the paper.

What surprised you about the results?

What I found most surprising is the number of different animals that were identified to be co-existing with one another in Oklahoma. I was specifically fascinated with the sabretooth cat. The sabretooth cat did not have much tooth damage which indicates that it didn't have to rely on skeletal remains of its prey to survive.

How does it feel to work on such old dead animals?

I find it absolutely spectacular that I got to work with such old fossils. It feels like a mystery or puzzle that can be solved by piecing all the data together and getting one big picture. How cool is it that I get to be a part of a team that helped discover more information about the world we live in? I hope by sharing our results we can continue to make new findings about the history of our planet.