Meat-eating dinosaurs not so carnivorous after all

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New research by Field Museum scientists finds widespread herbivory in bird-like theropod dinosaurs. Four of the 90-theropod species involved in the study shown with dietary interpretations. All four species derive from the famous feathered dinosaur beds of the Early Cretaceous Yixian Formation, P. R. China, leading the scientists to speculate that dietary diversity may have contributed to the large numbers of contemporaneous theropods in ecosystems like those of the Yixian. Credit: Dennis Finnin and Roderick Mickens, copyright American Museum of Natural History

Field Museum scientists used statistical analyses to determine the diet of 90 species of theropod dinosaurs. Their results challenge the conventional view that nearly all theropods hunted prey, especially those closest to the ancestors of birds.

Tyrannosaurus rex may have been a flesh-eating terror but many of his closest relatives were more content with vegetarian fare, a new analysis by Field Museum scientists has found.

The scientists, Lindsay Zanno and Peter Makovicky, who will publish their findings in the journal Proceedings of the National Academy of Sciences, used statistical analyses to determine the diet of 90 species of theropod dinosaurs. Their results challenge the conventional view that nearly all theropods hunted prey, especially those closest to the ancestors of birds. Rather, Zanno and Makovicky show that among the most bird-like dinosaurs-known as coelurosaurs-plant eating was a common way of life. "Most theropods are clearly adapted to a predatory lifestyle, but somewhere on the line to birds, predatory dinosaurs went soft," Zanno says.

Theropods are a group of bipedal dinosaurs colloquially known as "predatory" dinosaurs. Among theropod dinosaurs, all modern birds and several groups of their closest extinct relatives belong to a subgroup known as Coelurosauria. Coelurosauria also includes the iconic hunters Tyrannosaurus and Velociraptor. Most coelurosaurs were feathered. The most intelligent dinosaurs and those with the smallest body sizes also belong to this group.

The study was funded in part by the National Science Foundation. Lead author Lindsay Zanno's research was supported by a John Caldwell-Meeker Fellowship and by a Bucksbaum Fellowship for young scientists.

Pinning the Diet on the Dinosaur

Deducing the diet of extinct animals isn't always straightforward. In all but the rarest cases, paleontologists have nothing but fossilized bones and teeth to work with. Sometimes figuring out what a dinosaur ate is fairly obvious. No one doubts, for example, that the bone-crunching teeth and jaws of Tyrannosaurus rex were the tools of a megapredator or that the tooth batteries of Triceratops were used for shearing plant material. However, many coelurosaurian dinosaurs have more ambiguous adaptations such as peg-like teeth at the front of the mouth or no teeth at all so determining their diet has been a challenge. "These oddball dinosaurs have been the subject of much speculation" says Makovicky, "but until now, we have not had a reliable way to choose between competing theories as to what they ate."

Fortunately a small percentage of these species also preserve clear-cut evidence of diet with their skeletal remains. Fossilized dinosaur dung, stomach contents, tooth marks, the presence of stones within the stomach that serve as a gastric mill for digesting vegetation, and even two dinosaur species preserved locked in the throes of combat all provide a direct window on diet. After collecting dietary data for almost 100 coelurosaur species, Zanno and Makovicky used statistical analyses to test whether certain skeletal traits (such as the loss of teeth or a long neck) could be found to correlate with direct evidence of plant eating among coelurosaurian dinosaurs.

They found almost two dozen anatomical features statistically linked to direct evidence of herbivory including a toothless beak. "Once we linked certain adaptations with direct evidence of diet, we looked to see which other theropod species had the same traits," Zanno said, "then we could say who was likely a plant eater and who was not."

Applying their data on diet, the researchers found that 44 theropod species distributed across six major lineages were eating plants and that the ancestor to most feathered dinosaurs and modern birds had probably already lost its appetite for flesh alone. Because plant eating was found to be so widespread in Coelurosauria, the hypercarnivorous habits of T. rex and other meat eating coelurosaurs like Velociraptor should be viewed "more as the exception than the rule," Zanno says. "This new research firmly supports what we've have been speculating about for some time," she says. "Its time to start seeing these animals in a new evolutionary context." The researcher's findings also suggest that iconic predators such as the Velociraptor of Jurassic Park fame and their close relatives may have evolved from omnivorous ancestors-an idea Zanno proposed last year in 2009 based on the discovery of a new plant-eating coleurosaur, Nothronychus graffami.

How to Make a Plant Eating "Predator"

Besides identifying diet, the researchers analyzed whether different groups of coelurosaurs followed the same evolutionary pathways toward an herbivorous diet. They found that over time, species lost their flesh-rending teeth, developing strange tooth types such as peg-, wedge-, and leaf-shaped teeth, and ultimately, some lost most or all of their teeth altogether and replaced them with a bird-like beak. While the new research suggests that dinosaurs evolved beaks to aid their transition to plant eating, once that innovation was accomplished, beaks continued evolving into a myriad of forms and help support a high degree of dietary diversity in modern birds. "This is a clear-cut indication that the repeated evolution of a toothless beak in theropod dinosaurs is linked to plant eating," Zanno says. However, "once a beak appeared on the scene, it continued to evolve. Theropods would have used their beaks in a myriad of ways; they still do," she said.

Zanno and Makovicky also found that a toothless beak only evolved in lineages known to have had a gastric mill for grinding plants. In lineages where a gastric mill is not yet known, such as the bizarre, sickle-clawed therizinosaurs, the species retain teeth at the back of the mouth for shredding plant material.

Besides losing teeth and evolving beaks, the researchers found that as several lineages of coelurosaur turned to plant eating, they also evolved longer necks, which may have helped the animals to expand their browsing range.

A Dietary Advantage?

Coelurosaurian theropods were an extremely successful group of dinosaurs throughout the Cretaceous Period (145-65 million years ago) and many different species of coelurosaurs inhabited the same ancient environments but scientists have yet to figure out why. One theory is that the break up of continents and origin of new habitat opened up new dietary niches for coelurosaurs to explore. Zanno and Makovicky speculate that dietary diversification also may have played a role in their success. "The ability to eat plant materials may have played a pivotal role in allowing coelurosaurian dinosaurs to achieve such remarkable species diversity," Zanno noted, "but more study is needed to understand what role dietary shifts may play in evolutionary processes."

Because ceolurosaurian dinosaurs include the closest extinct relatives of birds, understanding their biology is also extremely important to understanding how, why, and under what conditions birds evolved and first took flight.

"We don't know what drove the ancestors to birds to take flight," she says, "seeking food in the trees is just one of many possibilities."

Using statistical analysis to find correlations between physical traits and diet could offer a new window as to how evolution works, the researchers said, and these techniques could be used to provide new insight into the common practice of becoming an herbivore throughout vertebrate history. Makovicky summarizes, "Being able to establish diet in extinct animals with confidence will allow us to start tackling even broader questions, such as whether animals tend to increase in body and diversity when they evolve herbivory."

Provided by Field Museum