Herbivore or carnivore? A new toolbox for the study of extinct reptiles

January 8 2025, by Kathrin Voigt

A green iguana, enjoying a bowl of salad. Credit: Daniela Winkler

Evolution has resulted in the development of both herbivores and

carnivores—but how? What type of food did extinct vertebrates eat? And how can we gain insight into the diets of these creatures? In living animals, we can simply observe what they feed on today. In the case of extinct species, however, researchers rely on morphological or chemical information supplied by fossils.

A team led by Professor Thomas Tütken of Johannes Gutenberg University Mainz (JGU) has now compiled a reference framework of isotope compositions indicating the type of diet for extant reptiles that represents a useful reference dataset to reconstruct the diet of fossil reptiles.

"This reptile reference framework is a convenient toolbox that will enable us to better reconstruct the diet of extinct animals, such as dinosaurs," explained Tütken. "A set of comparable data of this kind has not previously been available." The corresponding research paper was published in *Proceedings of the Royal Society B: Biological Sciences*.

Reptiles have very different nutritional habits

Today's reptiles show a wide variety of dietary preferences, ranging from plant- to animal-feeding. And there are also species that specialize in the consumption of a particular food: the marine iguana of the Galapagos lives on algae, chameleons eat only insects, Gila monsters are fond of eggs, and apex predators like the saltwater crocodile and the Komodo dragon rely entirely on meat.

"This diversity makes it difficult to reconstruct the nutritional habits of extinct animals," said paleontologist Tütken of the JGU Institute of Geosciences.

The oldest known ancestors of our modern reptiles existed more than 300 million years ago. The earliest known reptile, Hylonomus, was lizard-

like and lived about 315 million years ago in what is now Canada. These early reptiles often shared characteristics in the morphology of their skulls, jaws, and teeth that indicate a tendency towards an insectivorous diet. The exact time in the geologic past when reptiles underwent a dietary shift from insectivores to carnivores and herbivores is yet unclear.

Skull of a green iguana (Iguana iguana) . Credit: Daniela Winkler

Geochemical reference frame based on the data of 28 reptile species

The reference framework put together in Mainz can be used to determine the nutritional habits of living as well as extinct vertebrates. Tütken's team collected data from 28 living reptile species by analyzing the calcium and strontium isotopes present in their bones and teeth. These isotopes differ systematically depending on diet.

"To obtain a wide spectrum for comparison, we selected reptiles with pronounced herbivorous or carnivorous behavior, and we also included those with specialized dietary preferences," added Tütken.

Animals studied include alligators, monitor lizards, iguanas, chameleons, and many more. With regard to calcium, the researchers paid particular attention to the isotope ratio of calcium-44 and calcium-42. It turned out that with every step in the food chain, the concentrations of calcium-44 and calcium-42 declined.

"Overall, the values are highest in insectivorous reptiles, clearly differentiating these from animals with other feeding behaviors," emphasized the lead author of the paper, Dr. Michael Weber.

The isotope ratios are lower in herbivores and even lower in carnivores. The researchers were even able to detect evidence for special eating habits of marine iguanas and egg-devouring reptiles.

The isotope ratios of stabile strontium-88 to strontium-86 are comparable in the same species, but they provide even more detailed information on nutrition.

"We set up the first extensive reference system of stable strontium isotopes as a dietary proxy. The results for strontium are largely consistent with those for calcium isotopes in respect of the various nutritional forms," clarified Dr. Katrin Weber, co-author of the paper and former doctoral candidate in the research group of Professor

Thomas Tütken.

"In contrast to calcium, only small traces of strontium are present in teeth and bones, and these are prone to alteration processes in the ground holding those fossils. Since the use of strontium can be problematic with respect to extinct species, calcium isotopes offer better prospects here."

Using the existing reference frame for mammals for comparison, the analysis also showed that the calcium isotope ratio in reptiles is larger than in mammals—even when nutritional behavior is the same. The researchers tend to attribute this fact to various physiological factors. However, this also demonstrates that the data for mammals cannot be directly used for assessing the feeding habits of prehistoric reptiles, such as dinosaurs.

Mechanical wear patterns on teeth supply additional information on dietary tendencies

In addition to the chemical traces of ingested food, the research team also analyzed mechanical tooth wear caused by the diet as a complementary approach for dietary reconstruction. Based on tiny scratches on the surface of teeth, researchers can determine whether an animal consumed hard or soft foods, thus providing further information on the diet of extinct species.

The data was collected by studying the teeth of the same modern reptiles in collaboration with Dr. Daniela Winkler, now at Kiel University, and has now been combined with the new isotopic data. The combination of these two sets of data allows the researchers to distinguish between faunivores that would have ingested larger quantities of abrasive hard tissue, such as shells or bones, and animals whose diet consisted of mainly soft food.

"In order to understand and interpret the data for chemical and mechanical patterns of nutritional behavior from fossil finds, we first had to determine the corresponding information for related modern species with their known dietary preferences. As a result, we now have a reference frame for comparison that enables the precise diet assessment and thus a more accurate reconstruction of the feeding habits of extinct species," concluded Professor Tütken.

More information: Michael Weber et al, Calcium and strontium isotopes in extant diapsid reptiles reflect dietary tendencies—a reference frame for diet reconstructions in the fossil record, *Proceedings of the Royal Society B: Biological Sciences* (2025). DOI: 10.1098/rspb.2024.2002

Provided by Johannes Gutenberg University Mainz