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Tracing diet and niche partitioning in Mesozoic archosaurs and dinosaurs using Ca isotopes

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Reconstructing trophic structures of ancient ecosystems is challenging and often relies on inferences made from multiple proxies e.g. dental morphology or rare discoveries such as fossilised gut contents. The nature of these proxies limits their application to reconstruction of palaeodiet, palaeotrophic levels and predator-prey relationships. Traditional isotopes provide more direct proxies of palaeodiet but are hampered by diagenesis and the requirement of large sample amounts. Calcium, a bio-essential element, is a major component of tooth enamel and displays isotopic fractionation between extant plants and animals, as well as within trophic levels.

Here we report the use of a non-traditional stable $\delta^{44/42}$Ca isotope system to infer palaeodiet and palaeoecology within fossil fauna from the Elliot Formation of the Karoo Supergroup (South Africa). The $\delta^{44/42}$Ca isotope system robustly links the study of palaeoecology to biologically mediated isotopic fractionation. We demonstrate that the method is minimally invasive and easily correctable for diagenesis. It can be used to discriminate trophic levels and resource partitioning between different vertebrate clades, including croc-line archosaurs and dinosaur species.

We found that the large-bodied, hypercarnivorous 'rauisuchian' specimens in our study show depleted $\delta^{44/42}$Ca isotope signatures (xÌ„ = -0.82 ± 0.07 ‰; n = 16) in contrast to herbivorous sauropodomorph dinosaurs with means $\delta^{44/42}$Ca ranging between -0.46 ‰ to -0.69‰ (n = 18). Co-occurring sauropodomorph genera show resolvable $\delta^{44/42}$Ca isotopic differences. *Massospondylus, Aardonyx* and *Pulanesaura* specimens yield mean $\delta^{44/42}$Ca values of -0.46 ± 0.05 ‰ (n = 12), -0.59 ± 0.05 ‰ (n=4) and -0.69 ± 0.04 ‰ (n = 2), respectively. These $\delta^{44/42}$Ca differences between 'rauisuchians' and sauropodomorphs allow us to reliably infer carnivores and herbivores in ancient ecosystems. More significantly, these results are evidence of niche/resource partitioning in sympatric herbivorous sauropodomorphs and provide insights into the palaeobiology of ancient animals.

Our novel results indicate that isotopic proxies like $\delta^{44/42}$Ca can be used to better understand dietary niches, foraging habits and metabolic processes within past ecosystems, and overcoming challenges of poor preservation and preserving fossil integrity. Ultimately these isotopic tools can be used to understand dynamics within ancient ecosystems and their response to environmental stress (e.g. mass extinctions).