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Stable isotopes in collagen and Late Quaternary carnivore palaeoecology

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Several taxa of large carnivores co-occurred during the late Pleistocene in the steppe-tundra ecosystem, such as wolf *Canis lupus*, cave lion *Panthera leo spelaea*, cave hyaena *Crocuta crocuta spelaea*, brown bear *Ursus arctos* and cave bear *Ursus spelaeus* and *Ursus ingressus*. This abundance of taxa belonging to the same guild raises questions about niche partitioning, especially in terms of dietary specialization and prey selection. Observations of the dietary ecology of the extant relatives of these late Pleistocene carnivores does not provide unambiguous answers as these populations live under very different environmental conditions where other potential prey species are present, but it appears that most of these modern large carnivores are relatively flexible in their prey selection. Palaeontological investigations dealing with faunal associations and activity marks on fossil bones also have their limitations, such as taphonomic biases (palimpsests rather than biological associations) and do not allow the quantification of consumption of various preys.

In contrast, carbon and nitrogen isotopic signatures of bone collagen depend directly on those of the average diet. Since different potential prey species occurring in the steppe-tundra exhibit consistent isotopic differences for these chemical elements, it is possible to relate the carbon and nitrogen isotopic signatures measured in fossil carnivores with the preferential consumption of some prey species. Some amount of quantification can be provided using modified versions of mixing models developed for modern ecosystems. In addition, this isotopic approach is individual-based and it is therefore possible to investigate intra- and inter-population differences in prey selection, as well as possible chronological trends and differences linked to genetic differences by combining isotopic and ancient DNA studies on the same material.

The isotopic approach has already shown that among the tested large carnivores, cave bears of various genetic types are overwhelmingly vegetarian while coeval brown bears are essentially carnivores, cave lions have a marked preference for reindeer, and none of the large carnivores match Neanderthals in terms of megaherbivore consumption (i.e. woolly mammoth and woolly rhinoceros).