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Oxygen isotope analysis of skeletal bioapatite of modern rodents - implications for (palaeo-)climatic studies

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Starting with pioneering studies in the mid 1980's (e.g. Longinelli, 1984), palaeoclimatic reconstructions based on the oxygen isotope composition of skeletal bioapatite (i.e. bone and tooth material) ($\delta^{18}O_{AP}$) from fossil large mammals rapidly became an established method. The most common approach is the reconstruction of the oxygen isotope composition of local surface water ($\delta^{18}O_{LW}$) from $\delta^{18}O_{AP}$ by developing taxon specific empirical calibration equations between $\delta^{18}O_{AP}$ and $\delta^{18}O_{LW}$ for modern mammals. This is possible because $\delta^{18}O_{LW}$ is one of the main oxygen input sources of mammals and they are homeothermic, with body-temperatures of around 37°C, which results in a constant oxygen isotope fractionation between body-water and mammalian bioapatite.

Today, new and improved mass spectrometric techniques allow oxygen isotope analysis of only mg-sized sample amounts of bioapatite, bringing small mammal taxa, e.g. rodents, into the focus of interest. As reviewed by Grimes et al. (2008), the main advantages of small mammals vs. large mammals are: (1) a higher abundance of fossil tooth specimens, (2) better biostratigraphic age constraints of the fossil taxa, which enhances the stratigraphic resolution and finally (3) a restricted habitat of the small mammals lacking long distance migratory behaviour thus reflecting better local climatic conditions than large mammals. Therefore skeletal bioapatite of small mammals is a valuable palaeoclimatic archive.

However, important prerequisite for the use of teeth and bones of small mammals in palaeoclimatic studies is a thorough understanding of inter- and intra-specific as well as intra-individual and tissue-specific oxygen isotope variability. For this purpose we systematically investigated incisores, different molars and bone of seven sympatric modern rodent species derived from barn owl pellets collected at a single locality in NW-Germany in spring 1995.

Inter-specific oxygen isotope variations are related to differences in physiology, population dynamics, diet and/or drinking behaviour. The present case study indicates only minor differences between the investigated seven arvicolid and murid species. Intra-specific oxygen isotope variations seem mostly to reflect variations in the $\delta^{18}O$ values of ingested drinking and food water (i.e. seasonal differences and/or isotope fractionation by evaporation). The studied samples display relatively low intra-specific oxygen isotope variations, comparable to those observed for large mammals. Significant intra-individual oxygen isotope variations were found between bone and tooth material from the same specimens. This is related to the different growth-modes of the respective tissues recording different ontogenetic periods. Thus, for the purpose of the reconstruction of $\delta^{18}O_{LW}$, a considerable bias can occur, if calibration equation developed on bone material are applied to tooth data and vice versa. Taking tissue formation times and population dynamics into account bioapatite of rodent skeletal remains seems to be well-suited to reconstruct $\delta^{18}O_{LW}$ values.

Grimes S.T., Collinson M.E., Hooker J.J., Mattey D.P. (2008) Is small beautiful? A review of the advantages and limitations of using small mammal teeth and the direct laser fluorination analysis technique. Palaeogeography, Palaeoclimatology, Palaeoecology 266: 39-50.

Longinelli A. (1984) Oxygen isotopes in mammal bone phosphate: a new tool for paleohydrological and paleoclimatological research? Geochimica et Cosmochimica Acta 48: 385-390.