Stable isotope analysis of koala bone collagen, enamel carbonate and diet

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Stable isotope analyses of terrestrial mammal remains have been widely used to investigate the diet and ecology of modern and fossil species. This is predicated on different dietary sources having distinct isotopic compositions, which are taken up by animals in the environment and recorded in their body tissues (DeNiro and Epstein, 1978). Whilst the use of stable isotopes in palaeodiet research is used extensively overseas in the archaeological, palaeontological and ecological fields, it is currently an underused within Australian palaeoecology. We are examining how stable isotopes in marsupials reflect diet and environmental, with the overriding aim of applying stable isotopes in fossil faunas to investigate past diets and climates in Australia’s prehistory.

During 2004 a study was completed of the carbon, nitrogen and oxygen isotope composition of bone collagen, enamel carbonate and diet of modern koalas (Phascolarctos cinereus) from populations at six locations in eastern Australia. The koala is an ideal species for this research as they eat a homogenous diet of eucalyptus leaves, inhabit eucalypt forests that grow in variety of climatic zones, and do not migrate seasonally. Moreover, koalas are non-obligate drinkers that obtain the majority of their water from plant leaves (Ellis, Melzer et al., 1995). The homogenous nature of the koala diet can be considered ‘a constant’, and thus provides a unique opportunity to detect possible climatic influences on the isotopic signatures of bone collagen and teeth.

This study began by characterizing the carbon isotope composition of koala diets based on analyses of eucalyptus leaves and koala faeces undertaken at the ANU Research School of Biological Sciences. The carbon isotope values of faeces and leaves from each site were found to be within 0.5‰ of each other, indicating that koala faeces are a good representation of dietary inputs.

Carbon and nitrogen isotope analysis of bone collagen was undertaken at the Research Laboratory for Archaeology, University of Oxford (with Dr Tamsin O’Connell and Dr Peter Ditchfield), and carbon and oxygen isotope analysis of enamel carbonate was undertaken at the Research School of Earth Sciences, Australian National University.

The carbon isotope compositions of bone collagen and enamel carbonate were compared to the koala diets to calculate the fractionation between diet and these tissues. The average fractionation between diet and bone collagen in koalas is 7‰. This is smaller than the 4‰ fractionation that is commonly observed in other large mammals (Ambrose, 1993). The fractionation observed between diet and enamel in koalas is 10.5‰, which is within the range (9-14‰) observed in other large mammals (Cerling and Harris, 1999). These isotopic fractionations can be applied to accurately reconstruct the carbon isotope values of fossil koala diets.
The second part of the study examined levels of isotopic variability in the each koala population. The mean carbon isotope inter-population variability for bone collagen and enamel was 1.38±0.66‰, and for the combined populations was 1.78±0.46‰ (1 sd) respectively. Variability in nitrogen isotopes was considerably larger at 4.66±1.6‰ (1 sd), and in oxygen isotopes was 2.89±1.36‰ (1 sd). The range of isotope values at each site was highly variable with, for example, a population from Springsure in Queensland having a 6.85‰ range in nitrogen isotope values. This part of the study indicates that for any comparison of isotopic variability between population averages to be meaningful, the variation within a single population needs to be explored first.

The final part of the study has examined the relationships between the population mean isotope values and a series of environmental variables, including precipitation, humidity, potential evaporation and temperature. Two examples of the correlations for bone collagen nitrogen isotope values and enamel carbonate oxygen isotope values with local precipitation are illustrated in figures 1 and 2. These figures show that the observed relationships between nitrogen and oxygen isotopes in koalas and precipitation in Australia are not strong. The nitrogen isotope results are contrary to observations elsewhere, where nitrogen isotopes in mammals become more positive as precipitation decreases (Sealy, van der Merwe et al., 1987; Gröcke, Bocherens et al., 1997; Handley, Austin et al., 1999).

This study has established the baseline information that is needed to reconstruct koala diets using carbon isotopes and has found that inter-population variability must be considered. The factors affecting the relationships between environmental variables and isotopes in koalas are under further investigation.

References


1. Research School of Biological Sciences, ANU