Testing the methodological utility of trace element analysis for detecting dietary differences in fossil fauna from Turkana

Introduction

Trace element analysis (Sr/Ca, Ba/Ca, Mg/Ca) has been utilized to gauge diet in fossil hominins. Biopurification of Sr, Ba, Mg relative to Ca, increases with trophic space and consequently carnivores exhibit trace element ratios lower than sympatric herbivores. Previous work has characterized South African ecoclines and has been used to infer past consumption in Australopithecus and Paranthropus. Trace element ratios successfully parsed out trophic level in an eastern African modern mammalian ecosystem (Laikipia, Kenya). Previous work found browsing (a diet comprised of Sr, Ba depleted leaves) display lower Sr/Ca, Ba/Ca dietary value relative to sympatric grazers. Yet contrary to previous work, our modern study in eastern Africa found no significant separation among herbivorous taxa. Here we present a pilot study in eastern Africa asaying the relationship between Sr/Ca, Ba/Ca values in herbivorous fossil taxa to determine if the modern faunal pattern found in Laikipia, Kenya persists through time.

Nakhuwaci Formation, West Turkana, Kenya

The Nakhuwaci Formation, one of three main formations in the upper part of the Turkana Basin, is situated west of Lake Turkana and encompasses sediments dating to the Pleistocene. The Nakhuwaci Formation is comprised of eight members and ranges in age from 4 Ma to 0.7 Ma.

Numerous hominin-bearing archaeological sites are found within the Nakhuwaci Formation including Lokenatkali 1 (early Homo), Naiyena Engol (Homo), and Kalokol 6 (Paranthropus boisei). Fauna included in the study are from eleven sites: Lomokwia 1, Nasura 1, Nasura 2, Nasura 3, Lokalalei 1, Lokalalei 2C, Naiyena Engol 1, Naiyena Engol 2, Nadung’3, Nakhuwaci 6, Kalokol 6. Site dates from Roche (2011) and Chris Lepege (pers. comm).

Sample Collection and Pretreatment

Faunal samples analyzed here were excavated by the Turkana Archontological Project and are housed in the Archaeological Department of the Kenya National Museums in Nairobi.

Next, between 2.0-3.5 mg of enamel powder from each specimen was weighed and treated with 0.5 mg of 65% HNO3 in Teflon beakers. The solution was evaporated to dryness on a hotplate. Residue was dissolved, according to standards of the lab, into 5 mL of 2% HF to be analyzed. Two modern zebra samples were analyzed multiple times to serve as an internal standard between runs. NIST SRM 1400 (bone ash) was used as the external standard. Error is estimated as ±3%.

Results: Sr/Ca Herbivore Site Comparisons

We found no significant difference in Sr/Ca among herbivorous taxa at individual sites (NY1, NY2, LA1, LA2, LC3) or when all sites were combined. Similar to the findings in Laikipia, Kenya, Nakhuwaci fossil C3, browser and C4 grazers Sr/Ca ratios do not differ from one another.

Results: Ba/Ca Herbivore Site Comparisons

We found no significant difference in Ba/Ca among herbivorous taxa at individual sites (NY1, NY2, LA1, LA2, LC3) or when all sites were combined. Similar to the findings in Laikipia, Kenya, Nakhuwaci fossil C3, browser and C4 grazers Ba/Ca ratios do not differ from one another.

Results: Sr/Ca and Ba/Ca Modern-Fossil Comparisons

We found good agreement between fossil and modern Sr/Ca (R2=0.96) and Ba/Ca (R2=0.92) ratios of tragelaphi, antilopini, redundini and hippopotami/equinini. Notably for Ba/Ca, the distribution of data prevents a meaningful interpretation.

Future Directions: Indicators of trophic level

In Laikipia, predators showed lower Sr/Ca and Ba/Ca than their prey. In the Nakhuwaci sample, one Panther species from Kalokol 6 was the only terrestrial carnivore available for analysis. Here we compare the Panther to one specimen of Papio available from Kalokol 6. Many conclusions cannot be derived from a single carnivore, yet the lower Sr/Ca and Ba/Ca ratios of Panther (carnivore) relative to Papio (omnivore) is intriguing and warrants further research.

Vegetation Structure of the Nakhuwaci Formation

Pedogenic carbonate (δ13C values (Quinn et al., 2013, unpublished; Harmand et al., 2015) were used to calculate the fraction of woody cover through time in the Nakhuwaci Formation.

Despite change in the vegetative structure in the Nakhuwaci Formation, the relative Sr/Ca and Ba/Ca ratios among fossa taxa do not vary by site, implying that trace elements may be useful at gauging dietary differences among time-transgressive faunal assemblages and vegetation community changes.

Monitoring Diagnosis

We gauged diagnost in the Turkana fossil enamel samples by measuring Mn, Zn, RB, Y, La, Sm, Yb, Th, and U. Concentrations of Mn and Zr are significantly higher in the fossil enamel samples than in the modern assemblage. We interpret that the Turkana fossil enamel samples have undergone element-specific diagenetic effects, but still holds promise for traces element analysis for inferring trophic level.

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