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Identification of pastoral sites using stable nitrogen and carbon isotopes from bulk sediment samples: a case study in modern and archaeological pastoral settlements in Kenya

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Abstract

The identification of pastoral sites in the East African archaeological record is problematic. Recently, a method for the identification of degraded livestock enclosure sediments had been developed that takes into account the geoarchaeological indicators of micromorphology, phytolith concentrations and the mineral assemblages. This suite of indicators may not always be present in degraded livestock enclosure sediments. This study presents an additional indicator by which degraded livestock enclosure sediments may be identified, namely the isotopic composition of organic nitrogen measured on bulk sediment samples. We studied a highly controlled ethnoarchaeological sequence of abandoned Maasai livestock enclosure sediments sampled in Rombo area, southern Kenya. The results were compared to archaeological sediments from the Elmenteitan Pastoral Neolithic site of Sugenya, southwestern Kenya, radiocarbon dated to ca. 2000 BP (uncalibrated). The sediments from both sites were studied using all four types of analyses, i.e., micromorphology, mineralogy, phytolith concentrations, and stable carbon and nitrogen isotopic compositions on bulk sediment samples. The results show that in abandoned livestock enclosure sediments of known ages a significant enrichment in the heavy nitrogen isotope (^{15}N) occurs, and that carbon isotopic compositions may be useful for differentiating cattle from caprine enclosures following their dietary preferences (i.e., grazers vs. browsers). A similar pattern of ^{15}N enrichment is observed in sediments sampled within the site of Sugenya while sediments sampled outside the site's perimeter are generally depleted in ^{15}N. The micromorphological, mineralogical and phytolith analyses support the conclusion that the sediments from within the site of Sugenya represent degraded livestock enclosure sediments. The carbon isotopic composition from the degraded dung deposits strongly suggests that livestock kept at Sugenya were cattle. Overall, this study presents new empirical data that can be used for the identification of livestock enclosures, and shows that the isotopic signatures and geoarchaeological indicators can preserve for at least two millennia.

Keywords: Pastoralism; Dung; Nitrogen isotopes; Carbon isotopes; Geoarchaeology; Kenya

1. Introduction

Cattle pastoralism in Africa has developed as early as 10,000 years ago (Bradley et al., 1996; Marshall and Hildebrand, 2002; Wendorf and Schild, 1998) and spread from the Eastern Sahara to central and western Sahara and the Sahel, to Sudan and East Africa, and to southern Africa, in the course of ca. 8000 years (Marshall and Hildebrand, 2002). Many scholars have highlighted an interpretational problem that exists in certain regions of Africa where apparent co-existence of pastoralists with hunter-gatherers resulted in mixed assemblages of lithics, ceramics and faunal remains in single sites

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(Ambrose, 1984; Gifford-Gonzalez, 1998; Marshall, 1990, 1994, 2000; Smith, 1992). It was therefore important to develop a method by which pastoral sites could be identified unequivocally. Recently, such a method has been developed by Shahack-Gross et al. (2003). The rationale behind the method was that pastoral sites always include livestock enclosures that protect the animals from predators where large amounts of dung accumulate. Thus identification of degraded dung deposits in archaeological sites would imply that they have been occupied by pastoralists, and by default, those sites that do not contain dung remains should be assigned to hunter-gatherers. The Shahack-Gross et al. (2003) method relies on three types of geoarchaeological indicators based on the durable remains of degraded dung, namely high concentrations of phytoliths, an undulating microlaminated micromorphological structure, and a mineralogical assemblage that includes opal (the mineral phytoliths are composed of), monohydrocalcite (the mineral dung spherulites are assumed to be composed of), and dahllite (a mineral that forms *in situ* after organic matter degradation).

The study conducted by Shahack-Gross et al. (2003) included an ethnoarchaeological component conducted in southern Kenya among the Kisongo Maasai near the town of Rombo (Fig. 1). The research strategy was based on comparisons between modern and degraded livestock dung in enclosures at Maasai settlements and control sediments (soils) in the vicinity of the sampled settlements that are devoid of visible dung remains. Shahack-Gross et al. (2003) sampled livestock enclosure sediments from one inhabited Maasai settlement (called Boma in Swahili) and a series of four abandoned bomas with the help of a local Maasai elder, who also supplied information as to the timing of abandonment, settlement structure and specific locations of cattle and caprine (i.e., sheep and goats) enclosures. By so doing, a taphonomic sequence of dung degradation in livestock enclosures was obtained. The sediments from this taphonomic sequence thus provide an opportunity to study anthropogenic deposits from a highly controlled cultural context.

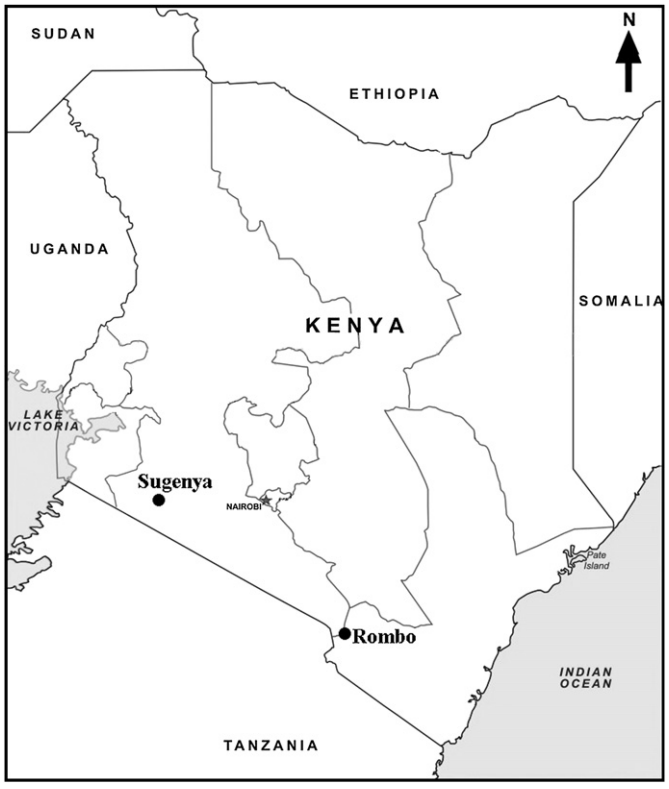

Fig. 1. Map of Kenya showing the location of the two study sites. The ethnoarchaeological part of the study took place in the Rombo area. The archaeological excavation took place in the site of Sugenya (Lemek-Mara region).

Despite its availability since 2003, the method of Shahack-Gross et al. had never been applied for the identification of dung remains in African archaeological sites. It had been successfully used, however, in the Mediterranean region in Israel where several phytolith-rich layers (dating to the 1st and 2nd millennia BC) were identified in the urban site of Tel Dor as originating from either degraded or burned livestock dung (Albert et al., 2008; Shahack-Gross et al., 2005). These studies identified the dung remains based on the three lines of geoarchaeological evidence reported by Shahack-Gross et al. (2003) and also based on the concentrations of dung spherulites (Canti, 1997, 1998, 1999).

Overall, four indicators are currently known for the identification of degraded livestock enclosures sediments, i.e., large amounts of grass phytoliths, a microlaminated structure, authigenic phosphate minerals and dung spherulites (see also Macphail et al., 2004). Several studies in European contexts have highlighted possible complications with the use of the indicators mentioned above. Brochier et al. (1992) noted that dung spherulites do not preserve in open air sites in Sicily, Canti (1999) showed experimentally that dung spherulites are prone to dissolution in water, and Albert et al. (2008) report that while the concentration of dung spherulites is in the order of tens of millions in 1 g of ashed fresh dung, their concentration in archaeological sediments is less than 1 million in 1 g of sediment. Macphail et al. (1997) noted that in the ashed dung levels at Arene Candide (Italy) low concentrations of phytoliths occur and this was attributed to animal fodder that is based on woody species, known to produce low amounts of phytoliths relative to grasses (Albert et al., 1999; Tsartsidou et al., 2007). Moreover, low amounts of phytoliths will presumably result in the absence of a microlaminated structure. Therefore, depending on environmental and cultural factors, it is conceivable that in certain regions in the world, and following certain foddering practices of the herders, not all lines of evidence will be present when attempting to identify degraded livestock dung in archaeological sites. Here we present a study in which we identify a fifth line of evidence by which degraded dung deposits may be identified using stable nitrogen isotopic composition.

Direct studies on the stable nitrogen isotopic composition of dung, prior to this study, are not available. Dung had been studied indirectly, however, through the ^{15}N enrichment that had been observed for plants grown in manured fields (e.g., Bol et al., 2005; Choi et al., 2002; Simpson et al., 1999). Recently, Commisso and Nelson (2006) highlighted the use of nitrogen isotopes in plants that grow on historical