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Diet and mobility of fauna from Late Neolithic–Chalcolithic site of Perdigões, Portugal

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ABSTRACT

Perdigões is located in the Alentejo region of south-eastern Portugal, with occupational phases dating from the Late Middle Neolithic to Late Chalcolithic/Early Bronze Age (middle 4th and 3rd millennium BCE) periods. It is a complex site that can be considered as a centre of social aggregation and a part of a larger settlement network. In this study, the nature of animal subsistence patterns as well as husbandry management practices and mobility are examined using stable carbon and nitrogen isotopic values from bone collagen of 35 archaeological faunal samples (*Canis familiaris*, *Bos taurus*, *Bos primigenius*, *Sus* sp., *Ovis/Capra*, *Cervus elaphus*, *O. cuniculus*, *Equus* sp.) and strontium isotope ($^{87}Sr/^{86}Sr$) analysis of 23 enamel samples. To provide necessary biological $^{87}Sr/^{86}Sr$ baseline data, the strontium isotopic composition of 14 modern plant samples were measured. The stable carbon and nitrogen isotope data shows that animals subsisted on a selection of C_3 terrestrial resources, with subtle differences in animal husbandry practices in domesticated animals, while strontium isotope analysis shows that < 5% of analysed fauna is consistent with the local bioavailable strontium isotopic range. Other animals can be divided into two clusters – those having strontium isotope values either lower or higher than the bioavailable range, showing that most of the fauna browsed and grazed within 10 km of the site's surrounding landscape, which is not such an unusual practice during prehistoric times.

1. Introduction

Perdigões is a Neolithic–Early Bronze Age (3500–2000 BCE) site with a long continuous period of occupation, and a significant archaeological importance for addressing the development of social complexity due to its size, time span, diversity of practices (primarily funerary practices) and richness in archaeological assemblages. Perdigões has been studied for almost 20 years, and several publications have been made on different topics (i.e., palaeoenvironmental reconstruction, general synthesis of the site, anthropological and material studies) (Valera et al., 2014a, 2014b). More research is required, however, on the reconstruction of human and animal dietary and mobility patterns since Perdigões could have been an important centre of social aggregation in southwest Iberia (Valera, 2015a).

Stable and radiogenic isotope analysis of teeth and bone has become an established method in historical and archaeological studies to document changes in diet, mobility, residency patterns and exploitation strategies (Fontanals-Coll et al., 2016; Knipper et al., 2013; Saragoça et al., 2016; Al-Shorman and El-Khouri, 2011). This is all due to the principle that ingested food and water leave a chemical 'fingerprint' in body tissues that reflect different components of the diet and the biogeochemical environment in which they are formed (Ambrose, 1993; Bentley, 2006). These studies are usually focused on human skeletons, while faunal remains receive relatively less attention (Guiry, 2012; Reitsema et al., 2013; Müldner et al., 2014; Guiry et al., 2016a, 2016b). Faunal bone studies are mainly used for providing the ecological

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Fig. 1. The site of Perdigões: 1a) geographical location; 1b) aerial photo of the site.

baseline required for understanding and interpreting stable isotope values in associated humans. However, the analysis of faunal skeletons provides an inside view into the relations between animals and humans, enabling the identification of animal management choices and husbandry strategies of prehistoric herders, and the reconstruction of the movements and migratory habits of wild and domestic fauna (Bogaard et al., 2007).

In this study stable isotopes of carbon and nitrogen recorded in bone collagen were used to reconstruct prehistoric faunal nutritional behaviour and to assess evidence for possible changes in animal diet through time that may point to differences in animal management and herding strategies from the Perdigões site. Additionally, strontium isotope analysis of modern plants collected from the surroundings of the Perdigões site were measured to establish the local strontium isotope background which is used to interpret strontium isotope values from faunal tooth enamel, as witness of their movements and for further exploration of the mobility pattern of the human population buried at Perdigões.

1.1. Stable isotope analysis

Since bone is built up from the food an animal consumes it encloses information about its diet. The isotopic composition of bone collagen reflects the protein portion of the diet, while the isotopic composition of the mineral part of bone and teeth (bioapatite) mirrors the composition of dietary proteins, carbohydrates and lipids (van der Merwe, 1992; Lee-Thorp et al., 1989). Bone diagenesis leads to some level of uncertainty in the stable isotopic ratios measured in bone apatite, resulting in the frequent use of the isotopic composition of collagen as a proxy for ancient diet reconstruction.

Carbon and nitrogen isotope values, expressed as $\delta^{13}C$ and $\delta^{15}N$, represent the ratios of the heavier to lighter isotopes ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) in a sample compared to international standards (PDB for carbon and AIR for nitrogen). The ratios are expressed in parts per thousand, or per mil ‰ units. Bone collagen $\delta^{13}C$ values distinguish between dietary components such as C_3 and C_4 photosynthetic plants and the animals that consume them (van der Merwe, 1992; Ambrose, 1993), and can indicate an amount of marine or freshwater protein in the diet as compared to terrestrial proteins (Pate, 1994; De Niro and Epstein, 1978). The movement of carbon through the food chain (from plant to consumer) results in average trophic level shifts of approximately 5‰ between plants and collagen values from herbivores, and only around 1–2.5‰ between collagen from herbivore to carnivore (De Niro and Epstein, 1978; Bocherens and Drucker, 2003). Bone collagen nitrogen isotopic ratios ($\delta^{15}N$) are useful to infer the trophic level of an organism. Between trophic levels, the fractionation of nitrogen isotope leads to an enrichment in $\delta^{15}N$ values of approximately 3‰ from diet to body tissues. Though, there are some debate on this topic, as in some large-scale ecological studies a value of 3–4‰ is used to show an increase in trophic level, while some small-scale animal feeding experiments yield values between 1.5‰ to 6‰ (Hedges and Reynard, 2007; Bocherens and Drucker, 2003; O'Connell et al., 2012). $\Delta\ ^{15}N_{diet\text{-}collagen}$ offset must be interpreted with caution as not to overestimate the importance of different types of food. In this study, we use a value of 3 ± 1‰, which mostly fits with numerous predator-prey relationships in terrestrial ecological situations.

In archaeology, strontium isotopes ($^{87}Sr/^{86}Sr$) can be used to identify migrants and to examine movements of individuals, based on the strontium isotope baseline within the surroundings of the site studied. A common procedure to determine the local strontium isotopic composition is the study of $^{87}Sr/^{86}Sr$ of local fauna (Price et al., 2002). However, the use of domestic animals as indicative of the local range has been a subject of debate because animals can have movement patterns similarly as humans (Maurer et al., 2012). Therefore, in this study modern plant samples were collected from various geological substrates nearby Perdigões and used to characterize the so-called local $^{87}Sr/^{86}Sr$ signal. Unlike carbon and nitrogen stable isotopes recorded in bone collagen, strontium isotopes in enamel are not substantially fractionated and do not undergo remodeling processes. Therefore, $^{87}Sr/^{86}Sr$ archived in tooth enamel reflects the bioavailable strontium isotope values from the region where an individual lived when enamel mineralization took place (Bentley, 2006). However, by using strontium isotopes, it is impossible to identify individuals who moved from locations with similar geological features.

2. Perdigões archaeological site

Perdigões is located in Reguengos de Monsaraz near Guadiana River, Évora district, in the Alentejo hinterland, South Portugal (Fig. 1). It was occupied from Late Middle Neolithic to Late Chalcolithic/transition to the Bronze Age (3500 BCE–2000 BCE) period with a progressive complexity throughout its existence. It is comprised of a set of ditched enclosures with 15 roughly concentric ditches defining > 10 enclosures in a natural theatre, consisting in an inclined circular basin open to the East, like a natural theatre (Valera et al., 2014a, 2014b). The archaeological record of the Perdigões complex gives a complete story of its development and trajectory over the time span of a thousand and a half years.

The site was founded in the Late Middle Neolithic (3500–3400 BCE) with smaller enclosures in the centre of the natural theatre and a Neolithic cromlech in the Eastern side. During the Late Neolithic (3300–2900 BCE) the site progressively grew in complexity and in the Chalcolithic period (2900–2500 BCE) shows an intense and diversified increment of funerary practices and construction of several roughly concentric ditched enclosures, reaching its peak in the Late Chalcolithic (2500–2200 BCE). During all the construction periods the site has