ELSEVIER

Journal of Archaeological Science 35 (2008) 2111–2118

Journal of Archaeological SCIENCE

http://www.elsevier.com/locate/jas

Stable isotope evidence for salt-marsh grazing in the Bronze Age Severn Estuary, UK: implications for palaeodietary analysis at coastal sites

Kate Britton*, Gundula Müldner, Martin Bell

Department of Archaeology, University of Reading, Reading, UK

Received 29 August 2007; received in revised form 6 January 2008; accepted 22 January 2008

Abstract

Stable isotope analyses of modern coastal and salt-marsh plant species ('salt-loving' plants or halophytes) have demonstrated that these are significantly enriched in ^{15}N compared to other terrestrial plants. Coastal salt-marshes were far more extensive in the past than they are today. They represented a vast and much-exploited resource in many areas of the UK and north-western Europe and were considered to be prime land for the grazing of animal stock.

This paper aims to test whether the unusual isotope chemistry of halophytes and other coastal plants allows for the identification of salt-marsh grazing in the past through the stable isotope analysis of herbivore skeletal remains. We present the results of carbon and nitrogen stable isotope analysis of bone collagen of herbivores from the middle and late Bronze Age sites of Brean Down, Redwick and Peterstone in the Severn Estuary, UK. Here, direct archaeological evidence indicates salt-marsh grazing as a deliberate herding strategy.

The animal bone isotope data from these three Severn Estuary sites are significantly enriched in ^{15}N in comparison to other Holocene faunal data-sets from the UK. We interpret this as evidence that the isotopic signatures of coastal and salt-marsh plants are passed on through the food chain and conclude that stable isotope analysis of animal bone collagen has great potential for investigating salt-marsh or coastal exploitation in the past. Our results also demonstrate that herbivore stable isotope values may vary significantly between different sites and regions within the UK. They underline the necessity for complementary faunal data-sets when undertaking palaeodietary analyses of human remains.

Keywords: Stable isotope analysis; Carbon; Nitrogen; Bone collagen; Salt-marsh; Halophytes; Coastal; Severn Estuary; Bronze Age

1. Introduction

Salt-marshes are among the most biologically productive ecosystems in the world. Serving as a transitional zone between the land and sea, they are inhabited by 'salt-loving' halophytic herbs and grasses. Prior to regimes of banking and land-claim, areas of salt-marsh were far more extensive and, along with other coastal and inter-tidal grassland areas, represented a vast, rich and readily exploitable natural resource (Allen, 2000, p. 1157). There are numerous archaeological, ethnographic and historical references to the human exploitation of salt-marshes which range from the consumption of halophytes by Native Americans (Heizer and Napton, 1969) to the grazing of life-stock on the vast salt-marshes of medieval England (Oschinsky, 1971; Lepine et al., 2006). Tracts of salt-marsh throughout England, Wales and France are still exploited for the same purpose today, with salt-marsh lamb (*agneau pré-salé*) prized for its light and delicate flavour.

A recent and extensive study of flora across a number of different ecosystems in California demonstrated that, despite great inter- and intra-habitat variability, salt-marsh plants routinely displayed significantly higher $\delta^{15}N$ ratios than either terrestrial or freshwater species (Cloern et al., 2002). A similar trend towards high $\delta^{15}N$ values has also been recognised in non-halophytic coastal flora as well as plants in inland salt-pans (Virginia and Delwiche, 1982; Heaton, 1987). The relationship between proximity to the coast and/or salinity of

* Corresponding author. Department of Archaeology, Durham University, South Road, Durham DH1 3LE, UK. Tel.: +44 191 334 1100; fax: +44 191 334 1101.

E-mail address: k.h.britton@dur.ac.uk (K. Britton).

0305-4403/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jas.2008.01.012

the environment and elevated plant $\delta^{15}N$ is not fully understood. However, as elevated $\delta^{15}N$ ratios are observed not only in plant tissues but also in coastal/saline soils, it is usually attributed to enrichment of nutrient nitrogen in the soil rather than to metabolic responses of the plants themselves (Heaton, 1987). The ^{15}N enrichment of soil nitrogen has been explained by a number of factors, including the input of ocean-derived nitrate by sea-spray (Virginia and Delwiche, 1982) and the effects of salinity on processes of nitrification, denitrification and ammonium absorption (Heaton, 1987; Ambrose, 1991). Heaton (1987) also suggested that the large variability seen between data-sets might be explained by differences in local rainfall, which would serve to either accentuate or reduce the effects of sea-spray and/or salinity on the soils.

Whatever the reasons behind the unusual isotopic composition of halophytes and other littoral plants, their elevated δ-values will be passed on through the food chain and should consequently be observed in herbivore tissues as well as, ultimately, in human consumers. The distinctive isotopic signatures of coastal/salt-marsh plants could therefore not only provide a tool for identifying herding practices involving salt-marsh and coastal grazing through stable isotope analysis of herbivore skeletal remains, they may also be pivotal for the interpretation of human palaeodietary data. In this paper, we aim to explore both possibilities by testing whether a 'coastal signature' may be observed in salt-marsh grazed domesticates even from a high rainfall coast as Britain.

2. Stable isotope analysis for the reconstruction of animal diet and husbandry strategies

Stable isotope techniques are based on the principle that human or animal body tissues reflect the isotopic composition of the food and water ingested throughout life. Data from laboratory and field experiments have confirmed that biological tissues reflect controlled diets and that the combination of carbon and nitrogen stable isotope ratios in skeletal remains (bone, tooth enamel and dentine) can provide a direct measure of the diet of the individual in question (Schwarcz and Schoeninger, 1991; Ambrose, 1993).

The relative abundance of the stable isotopes of carbon, ^{13}C and ^{12}C ($\delta^{13}C$), varies characteristically between different biomes; e.g. between plants of different photosynthetic pathways (Smith and Epstein, 1971; DeNiro and Epstein, 1978) or between terrestrial and marine ecosystems (Schoeninger and DeNiro, 1984). The stable isotope ratio of nitrogen ^{15}N and ^{14}N ($\delta^{15}N$) increases by 3–5‰ with each step up the food chain (Bocherens and Drucker, 2003) and is therefore useful as an indicator of trophic level. Absolute $\delta^{15}N$ values of animals of the same trophic level depend on a variety of factors, however, especially on the ^{15}N levels of the plants at the base of the food chain. A range of variables can lead to depletion or enrichment in plant ^{15}N, which, in turn could affect the tissue $\delta^{15}N$ values of animal feeders. These factors include temperature and water availability (Schwarcz et al., 1999), soil type and the use of fertilisers (Choi et al., 2003; Schwertl et al., 2005), stocking rate of animals in a field (Schwertl et al., 2005), salinity (Heaton, 1987; van Groenigen and van Kessel, 2002) and proximity to the coast by input of marine nitrate through sea-spray (Virginia and Delwiche, 1982; Heaton, 1987) or marine biomass (Hicks et al., 2005).

Provisioning for domestic stock is pivotal to any agricultural society and grazing, foddering and seasonal herding strategies were essential components of animal husbandry in ancient economies. Numerous studies have utilised carbon and nitrogen stable isotope analysis to investigate animal management in the past. These range from the characterisation of feeding strategies with isotopically distinct fodder, such as seaweed (Balasse et al., 2005) or millet (Pechenkina et al., 2005) and the inference of dairying from isotopic data for the weaning age of cattle (Balasse and Tresset, 2002), to reconstructions of the proportions of C_3 and C_4 plants in animal diet and their implications for transhumance (Balasse, 2002; Balasse et al., 2002; Richards et al., 2003; Makarewicz and Tuross, 2005; Zazzo et al., 2005). Although modern, experimental studies can utilise a range of biological tissues (e.g. hair, blood, etc), archaeological investigations are usually confined by preservation to the analysis of skeletal remains. Among these, bone (and dentinal) collagen is the preferred analyte, not only because it is the primary nitrogen source in bone but also because its preservation and isotopic integrity can be assessed by means of a number of quality indicators (DeNiro, 1985; van Klinken, 1999). Bone is renewed constantly and therefore reflects a long term dietary average, whereas dentine undergoes very little remodelling after it is laid down during tooth formation (Hillson, 1996, pp. 182–197).

3. Salt-marsh exploitation in The Severn Estuary, UK

The Severn Estuary is located on the south-west coast of England (Fig. 1), at the mouth of the three major rivers Severn, Wye and Avon. It has the largest catchment of any estuary in Britain and is remarkable in its size and vast tidal range (Rippon, 1997, p. 14). The inter-tidal zone consists of mudflats, sandbanks, rocky platforms and some of Britain's largest expanses of salt-marsh, substantial areas of which are now protected by Natural England and the Countryside Council for Wales. Many archaeological sites of prehistoric and later date are present within the Holocene sediment sequence (Bell et al., 2000).

The site of Brean Down is located on an extension of the Mendip Hills, forming a promontory into the Bristol Channel between Weston-Super-Mare (to the north) and Bridgewater Bay (to the south) (Bell, 1990, p. 1). The stratigraphic sequence at Brean Down is deep and spans from the end of the Neolithic through to the post-medieval period, including 5 distinct Bronze occupation horizons as well as a sub-Roman cemetery. A rich material culture and faunal assemblage are associated with both mid- and late Bronze Age contexts (1000 cal BC and 800 cal BC, respectively) (Bell, 1990). Briquetage, which would have been used in the extraction of salt from brine or brackish water, indicate the direct exploitation of salt-marsh resources in the middle Bronze Age (Bell, 1990). Today the raised site of the Down is surrounded by extensive