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Reconstructing diet at the Neolithic stalled cairn of the Knowe of Rowiegar, Rousay, Orkney, using stable isotope analysis

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ABSTRACT

In this study, human remains from the Neolithic stalled cairn of the Knowe of Rowiegar, Rousay, Orkney (3620–2880 cal BC, 95.4% probability), were analysed for bone collagen stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios in order to determine the dietary adaptations of individuals buried at the site, particularly the contribution of marine protein in the diet. Collagen was extracted from bone from 13 individuals (11 males, 1 female, and 1 sub-adult), and stable isotope data generated were compared with previously-published Neolithic Orcadian faunal data, and with human and animal bone collagen isotope data from other published British Neolithic sites. The results from the Knowe of Rowiegar suggest that the dietary protein of those buried at the site was largely terrestrial in origin, which is similar to other British Neolithic bone collagen datasets, albeit with the possible minor inclusion of marine protein. Intra-group comparison highlights the potentially different dietary habits of the single female and sub-adult individuals sampled from the site compared to the interred males. Geographical variations in both humans and animals (particularly in nitrogen isotope ratios) across Britain are examined, and the consumption of marine fish and the influence of herbivore baseline variability in the study of Neolithic human diet are explored.

1. Introduction

The process of 'Neolithization' and the dietary changes associated with the uptake of agriculture and animal husbandry have been the subject of much archaeological research in recent decades. The speed and spread of the dietary changes associated with the Mesolithic-Neolithic transition, for example, has been debated, with some advocating a gradual continuum from wild to domesticated foods from the Mesolithic into the Neolithic (Thomas, 1999, 2003, 2004, 2013) and others describing a rapid change in diet away from wild foods to mainly terrestrial foods associated with the appearance of Neolithic material culture (i.e. pottery, domesticated plants and animals, megalithic architecture) (Richards et al., 2003a; Rowley-Conwy, 2004, 2011; Schulting and Richards, 2002a). Stable isotope studies conducted on bone collagen from Northern European Mesolithic and Neolithic coastal sites have largely demonstrated an abandonment of marine resources at the onset of the Neolithic period, providing evidence for a dominance of terrestrial protein in the diet (e.g. Schulting and Richards, 2002a, Richards et al., 2003a, Richards and Hedges, 1999). These data have been noted as somewhat contradictory to a number of archaeological finds, such as coastal middens, that seem to support the continuation of a marine 'lifestyle' (Milner et al., 2004; Rowley-Conwy, 2004; Wickham-Jones, 2007). Neolithic zooarchaeological assemblages in Britain support a terrestrially-based diet, and are predominately comprised of domesticate mammals such as sheep, cattle and pigs (e.g. Lawrence, 2012; Montgomery et al., 2013; Nicholson and Davis, 2007; Schulting and Richards, 2009), albeit with some evidence for fish and shellfish (e.g. Armour-Chelu, 1992; Milner et al., 2004; Rowley-Conwy, 2004; Wickham-Jones, 2007) and rodents (Romaniuk et al., 2016). Recent isotope studies on Neolithic human remains from Shetland have served to resolve some of these discrepancies, providing evidence for the continuation of the exploitation of marine foods into the Neolithic in certain areas (Montgomery et al., 2013). Significantly, the study by Montgomery and colleagues utilised both bulk bone (providing a long-term record of an individual's average diet over many years), and the incremental sampling of dentine (providing a short-term, time-series record of isotopic inputs), demonstrating continued, albeit sporadic, use of marine foods in these coastal, island areas. In light of the more diverse picture of regional and spatial variation in Neolithic North-West Europe that is now emerging, further isotope studies, especially in coastal areas or island contexts, are of clear interest in order to understand the nature of Neolithic foodways and the continuing use of marine foods beyond the Mesolithic.

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Orkney is one of the richest archaeological landscapes in Europe. Excavations and natural weather events have unearthed some of the best collections of Neolithic human remains in Britain, providing great potential for the application of biochemical analysis for the purposes of dietary reconstruction (Wickham-Jones, 2005). Stable isotope measurements from Neolithic humans and animals have previously been measured from a small number of Orcadian and Shetland sites (Northern Isles), including Quanterness (Schulting et al., 2010a), Holm of Papa Westray North (Schulting and Richards, 2009), Isbister, Pierowall Quarry, Point of Cott (Lawrence, 2012), and Sumburgh (Montgomery et al., 2013) (Fig. 1). Dietary isotope data have also been reported for other British Neolithic sites outside of the Northern Isles in Scotland, in Wales and England, including Balevullin (Armit et al., 2015); Ascott-under-Wychwood (Hedges et al., 2006); Hazleton North (Hedges et al., 2008); Hazleton, West Kennet, Parc le Breos (Richards, 2000); Hambledon Hill (Richards, 2000; Schulting and Richards, 2009); Priory Farm Cave, Red Fescue Hole (Schulting and Richards, 2002a); Carding Mill Bay, Crarae (Schulting and Richards, 2002b); Eton College Rowing Course (Stevens et al., 2012); Prestatyn, Gop Cave (Schulting and Gonzalez, 2008); Totty Pot (Schulting et al., 2010b); Foxhole Cave (Pettitt, 2000 in Schulting and Richards, 2002a; Schulting et al., 2013a) and Haywood Cave (Schulting and Richards, 2002a; Schulting et al., 2013b) (see Fig. 1 and Supplementary Table 1).

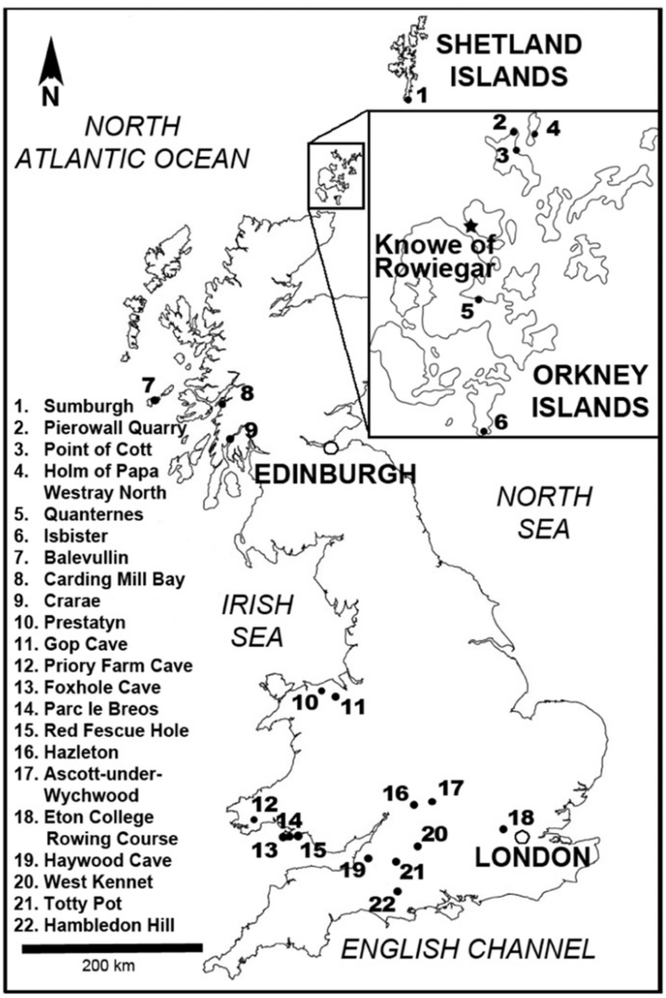

Fig. 1. Map of Britain with inset map of Orkney Islands, showing location of Northern Isles (Orkney Islands and Shetland Islands) and other British Neolithic sites with human dietary isotope data discussed in this paper. Sites include Northern Isles sites of: 1. Sumburgh (Montgomery et al., 2013); 2. Pierowall Quarry, 3. Point of Cott (Lawrence, 2012); 4. Holm of Papa Westray North (Schulting and Richards, 2009); 5. Quanterness and 6. Isbister (Schulting et al., 2010a) and 6. Isbister (Lawrence, 2012). Other British sites include 7. Balevullin (Armit et al., 2015); 8. Carding Mill Bay, 9. Crarae (Schulting and Richards, 2002b); 10. Prestatyn, 11. Gop Cave (Schulting and Gonzalez, 2008); 12. Priory Farm Cave (Schulting and Richards, 2002a); 13. Foxhole Cave (Pettitt, 2000 in Schulting and Richards, 2002a; Schulting et al., 2013a); 14. Parc le Breos (Richards, 2000); 15. Red Fescue Hole (Schulting and Richards, 2002a); 16. Hazleton (North) (Richards, 2000; Hedges et al., 2008); 17. Ascott-under-Wychwood (Hedges et al., 2006); 18. Eton College Rowing Course (Stevens et al., 2012); 19. Haywood Cave (Schulting and Richards, 2002a; Schulting et al., 2013b); 20. West Kennet (Richards, 2000); 21. Totty Pot (Schulting et al., 2010b); 22. Hambledon Hill (Schulting and Richards, 2009).

Here, we present new $\delta^{13}C$ and $\delta^{15}N$ isotope data from 13 individuals from the Neolithic stalled cairn Knowe of Rowiegar on Rousay, Orkney (Fig. 1). The research goals of this study are twofold: (i) to assess the broad dietary habits of this group of individuals using stable isotope analysis, particularly the relative contribution of marine and terrestrial protein to the diet; and (ii) to compare the Knowe of Rowiegar stable isotope data with the previously-published isotope data from the Northern Isles (Orkney and Shetland) and other British sites in order to add to the broadening picture of dietary patterns in Neolithic Britain.

2. Reconstructing Neolithic diet using stable isotope analysis

The application of stable isotope analysis in palaeodietary studies is based upon the principle that the isotopic ratios of foods consumed during life are reflected in the isotopic ratios of human and animal body tissues. The technique is now well-established in archaeology and anthropology, with the stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) from the protein bone collagen commonly utilised to investigate the types of protein consumed during life (e.g. Vogel and van der Merwe, 1977; DeNiro and Epstein, 1978, 1981; Schoeninger et al., 1983). Due to turnover rates, bone collagen isotopic values provide a long-term, average picture of an individual's diet that is predominantly based on protein source only, albeit with some influence from other macronutrients (Froehle et al., 2010).

Carbon stable isotope ratios are used to detect the consumption of plants of different photosynthetic pathways (C_3 and C_4), and to differentiate between terrestrial and marine foods (Tauber, 1981; Schoeninger et al., 1983; Schoeninger and DeNiro, 1984). Nitrogen stable isotope ratios are mainly used to assess the trophic level of animal protein in the diet (Müldner and Richards, 2007). This is possible due to the 'trophic level effect', whereby nitrogen stable isotope ratios increase with each step up the food-chain by around 3–6‰ (Bocherens and Drucker, 2003). Given that aquatic ecosystems tend to have longer food chains, elevated $\delta^{15}N$ values can also be indicative of freshwater or marine dietary inputs (Richards et al., 2001). Therefore, the measurement of $\delta^{13}C$ and $\delta^{15}N$ values of humans and animals can allow the reconstruction of trophic relationships within archaeological ecosystems, and permit the identification of likely sources of human or animal dietary protein.

Even in purely C_3 terrestrial environments (i.e. northern and temperate Europe) there are different environmental effects that can lead to different $\delta^{13}C$ values in soils and plants resulting in variations at the base of the food chain. These include: water availability, temperature, light intensity, partial pressure of CO_2 and nutrient availability (Ambrose, 1993; O'Leary, 1995). Climatic fluctuations can also generate changes in naturally-occurring $\delta^{13}C$ values (van Klinken et al., 2000; Richards et al., 2003b) and the composition of modern atmospheric CO_2, which is altered as a result of fossil fuel combustion, also affects $\delta^{13}C$ values (Heaton, 1999). The $\delta^{15}N$ values of soils and plants can also be significantly influenced by environmental factors such as rainfall, aridity and soil pH (see review in Szpak, 2014). These environmental processes can lead to isotopic variations at the baseline environmental level, which may be passed 'up the food chain' to animal and, ultimately, human consumers (Britton et al., 2008). Furthermore, animal husbandry practices, such as manuring or deliberate foddering/grazing regimes have been demonstrated to influence baseline isotopic signals in domestic fauna (Balasse et al., 2005; Bogaard et al., 2007; Britton et al., 2008; Cramp et al., 2014; Jones et al., 2012; Jones and Mulville, 2016; Müldner et al., 2014).