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Isotope evidence for the intensive use of marine foods by Late Upper Palaeolithic humans

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Abstract

We report here on direct evidence for the intensive consumption of marine foods by anatomically modern humans at approximately 12,000 years ago. We undertook isotopic analysis of bone collagen from three humans, dating to the late Palaeolithic, from the site of Kendrick's Cave in North Wales, UK. The isotopic measurements of their bone collagen indicated that *ca*. 30% of their dietary protein was from marine sources, which we interpret as likely being high trophic level marine organisms such as marine mammals. This indicates that towards the end of the Pleistocene modern humans were pursuing a hunting strategy that incorporated both marine and terrestrial mammals. This is the first occurrence of the intensive use of marine resources, specifically marine mammals, that becomes even more pronounced in the subsequent Mesolithic period.

Keywords: Diet; Stable isotopes; Upper Palaeolithic; Collagen; Wales; Marine

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Introduction

Archaeological and isotopic evidence of Middle Palaeolithic hominid diets in Europe has largely shown that terrestrial based foods, mainly herbivore meat, was the predominant dietary source (Richards et al., 2000a; Bocherens et al., 2001). There is evidence of a broadening of the resource base to include smaller game, including aquatic birds and fish, by anatomically modern humans in the Mid Upper Palaeolithic period (i.e. Gravettian) period (*ca*. 28,000 to 21,000 BP) (Richards et al., 2001; Stiner, 2001; Pettitt et al., 2003). In the later Upper Palaeolithic there is evidence of an increasing use of marine foods, especially evident in artwork and in the faunal record in southern France. However, isotopic analysis of a number of these human remains from the Solutrean and Magdalenian of France did not indicate any significant marine protein consumption (Hayden et al., 1987). In early Holocene Europe there is good archaeological and isotopic evidence for increasing dietary specialisation in the form of the evidence for the significant consumption of marine foods at coastal sites, approaching 100% of dietary protein intake, in the later Mesolithic periods (*ca*. 10,000 to 5000 BP) in Denmark, Portugal, France and the UK (Tauber, 1981; Lubell et al., 1994; Richards and Hedges, 1999; Schulting and Richards, 2001; Richards et al., 2003). This Late Mesolithic narrowing of the resource base to only marine resources has been widely interpreted as a prelude to the extreme narrowing of the resource base to agricultural and pastoral foods in the subsequent Neolithic period. What has not been evident in the record, so far, is direct isotopic evidence for the beginning of this increasing resource base intensification in the later Palaeolithic.

Measurement of the ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes in bone collagen is a well established method for determining the relative amounts of marine *vs*. terrestrial protein in human lifetime diets (for reviews see Schwarcz and Schoeninger, 1991; Katzenberg, 2000; Sealy, 2001).

We sampled four human (representing at least three individuals) and two faunal bones from Kendrick's Cave, Great Orme's Head, North Wales, UK (Sieveking, 1971; Eskrigge, 1880; Dawkins, 1880; Green and Walker, 1991) (Table 1). This site is located on the north coast of Wales, and it would also have been close to the coast at the time of occupation. The site was 'excavated' in the 19th century by the lapidary Thomas Kendrick who dug out the cave deposits as he was enlarging his workshop (Sieveking, 1971). A description of the material recovered is given by Eskrigge (1880) and a description of the human remains, three adults and one child, given by Boyd Dawkins (1880). In this early report of the finds from this cave, there is the mention of the recovery of some faunal remains, including badger, horse, sheep/goat, boar and ox, some of which are certainly of a younger age than the humans. These finds include the famous engraved horse mandible from the site (Sieveking, 1971). No mention is made of the recovery of marine mammal or fish remains. The absence of marine fauna, especially

Table 1
Sample description and bone collagen stable isotope data for humans and fauna from Kendrick's Cave

Sample	Species	Description	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N	^{14}C Age
57	*Homo*	Rt Humerus	−17.9	13.8	44.0	15.1	3.4	11,880 ± 90(OxA-7003)
59	*Homo*	Rt Femur	−18.0	13.4	44.0	15.3	3.4	11,930 ± 90(OxA-7004)
60	*Homo*	Rt Femur	−17.7	13.9	42.8	14.8	3.4	12,090 ± 90(OxA-6114)
69	*Homo*	Lt femur	−18.1	13.7	41.3	14.2	3.3	11,760 ± 90(OxA-7002)
25	*Bos/Bison*		−20.5	2.8	42.9	15.1	3.3	12,410 ± 100(OxA-6146)
31	*Capreolus capreolus*		−21.7	3.1	30.3	10.7	3.3	11,795 ± 65(OxA-6116)

The four human samples represent an MNI of three, as the right humerus is of a younger individual (sub-adult) than those represented by the three femurs. Also included are criteria used to determine the preservation of the collagen. The values of these criteria conform to the accepted values for well preserved bone collagen (e.g. DeNiro, 1985). All samples were prepared and measured at the Department of Archaeological Sciences, University of Bradford, UK. $\delta^{13}C$ values are reported relative to the vPDB standard, and the $\delta^{15}N$ values are reported relative to the AIR standard. Measurement errors on both the $\delta^{13}C$ and $\delta^{15}N$ values are ± 0.2 ‰ at 1 σ.

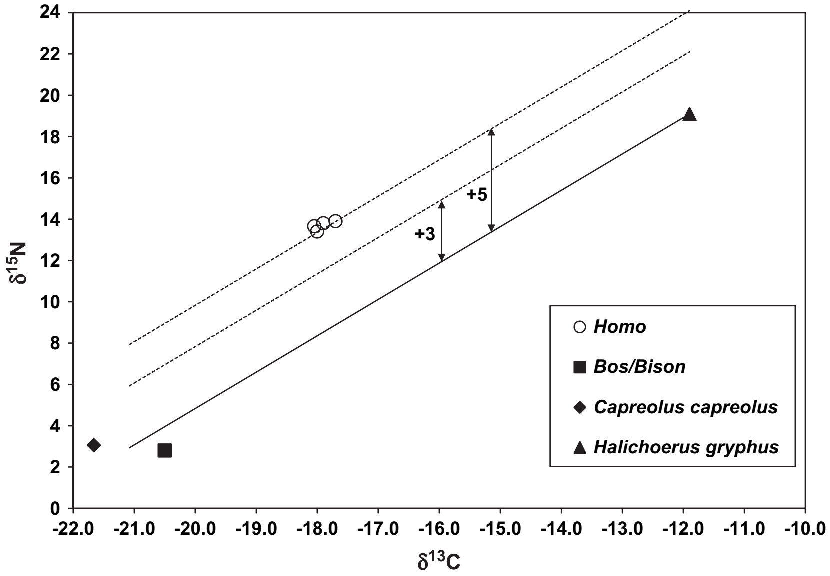

Fig. 1. $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen extracted from humans and fauna from Kendrick's Cave and Great Orme's Head, Wales, and Oronsay, Scotland. Also plotted are theoretical mixing lines between two resources, using the faunal data as end points, with both a +3 and +5 ‰ $\delta^{15}N$ enrichment indicated.

fish, may be due to the excavation methods rather than an actual absence from the site. However, if Dawkins was correct in interpreting the cave as a burial site, rather than an occupation site, then we would not necessarily expect to find faunal food remains associated with the burials.

Bone collagen was extracted following procedures outlined in Richards and Hedges (1999) with the addition of an ultrafiltration step (Brown et al., 1988). The isotopic data is given in Table 1. Figure 1 is a plot of the human isotopic data, including the four humans and a *Bos/Bison* sample from the cave. Also plotted are the values of a *Capreolus capreolus* sample identified as being from the larger Great Orme's Head region but is likely also from the site of Kendrick's Cave. As there are significant shifts in faunal $\delta^{15}N$ values over the last 40,000 years in Northern Europe (Richards and Hedges, 2003) and little published data from directly radiocarbon dated samples, we chose to only compare the human data to these two contemporary fauna from the same immediate region. Richards and Hedges (2003) found a decrease in herbivore $\delta^{15}N$ values for specimens directly AMS radiocarbon dated to this time period in Northern Europe (e.g. compared to $\delta^{15}N$ of *ca.* 6 ‰ for Holocene herbivores), and the herbivore samples from Kendrick's cave also exhibit these lower $\delta^{15}N$ values. As no marine mammal or fish bones were recovered from this site, the closest geographical and temporal comparative isotopic data available is from a grey seal from the island of Oronsay, Scotland, dated to *ca.* 5600 years BP (Richards and Mellars, 1998). The isotopic value of the seal bone is similar to other seals from the North Atlantic and indeed to seals from other locations (Richards and Hedges, 1999).

To interpret the isotopic data we have used theoretical end points of $\delta^{13}C = -21$ ‰ for a 100% terrestrial protein diet (based on the two contemporary herbivore values) and $\delta^{13}C = -12$ ‰ for a 100% marine protein diet (using the seal value). With these values, the human $\delta^{13}C$ values would indicate a diet where approximately 30% of dietary protein was from marine resources. Mammal bone collagen $\delta^{15}N$ values are approximately 3-5 ‰ higher than average dietary protein (Schoeninger and DeNiro, 1984; Kelly, 2000; Katzenberg, 2000; Sealy, 2001). We have plotted in Fig. 1 theoretical mixing lines between the two faunal resources (the two herbivores and the seal), with both a theoretical +3 and +5 ‰ $\delta^{15}N$ enrichment indicated. The humans lie on the +5 ‰ mixing line, which, based on this specific comparative faunal data, would indicate that the human values may be explained as indicative of a mix between protein from terrestrial herbivores such as *Cervus elaphus*, and marine mammals, such as seals. If, on the other hand, the marine contribution was from shellfish or fish, the $\delta^{15}N$ values would be much lower, as fish and shellfish are at lower trophic levels than seals and have corresponding lower $\delta^{15}N$ values (e.g. *ca.* 12 ‰ for piscivorous fish, *ca.* 8 ‰ for shellfish, Richards and Hedges, 1999).

There is little comparative human isotopic data from the late Upper Palaeolithic. Hayden et al. (1987) measured $\delta^{13}C$ values of late Upper Palaeolithic humans from France, but did not find evidence for the significant consumption of marine foods, apart from one individual from Cap Blanc whose $\delta^{13}C$ value of −18.8 ‰ may indicate some marine protein consumption. Richards et al. (2000b) measured the isotopic values of humans and fauna from the sites of Gough's Cave and Sun Hole Cave, inland sites in the Mendip region of Southwest England. Those sites are roughly contemporary with Kendrick's, dating to between *ca.* 11,700 to 12,400 BP. No evidence for the consumption of marine foods was found, and instead the isotope data was interpreted as indicating a diet where dietary protein derived from animal foods, likely herbivore meat. This shows that at least two different dietary adaptations coexisted in the UK in the late Upper Palaeolithic, although both adaptations relied on the consumption of animal protein as their main source of dietary protein. It may be that we are observing contrasting coastal/inland (Kendrick's) and inland (Gough's, Sun Hole) dietary strategies. This interpretation arises from our argument that the animal protein at Kendrick's came from the hunting and consumption of marine mammals in addition to terrestrial herbivores. The isotopic data unfortunately cannot further identify the season of the year that marine mammals were hunted at Kendrick's. A diet where marine protein was consumed exclusively for one third of the year, perhaps when seals were calving, results in the same isotopic signature as the regular periodic consumption of marine mammals over the course of a year, where the average amount of marine protein would be 30% of the yearly protein intake. Therefore, we cannot use these data to further pinpoint the nature of this dietary strategy as either a seasonal (e.g. mobile) or year-round (e.g. sedentary) use of marine foods.

We have presented here the first direct evidence of the significant consumption of marine foods, and particularly marine mammals, by late Palaeolithic modern humans. Our results foreshadow the increasing reliance on marine foods found at later Mesolithic sites in coastal Europe. This, then, is a clear detection of one dietary trajectory that led to increasing reliance on narrow resource bases such as marine foods, and which in some regions eventually led to a reliance on the single resource base of domesticated plants and animals at the onset of the Neolithic (Richards et al., 2003).

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