Journal of Archaeological Science (2000) **27,** 1–3
Article No. jasc.1999.0520, available online at http://www.idealibrary.com on IDEAL®

FOCUS: Gough's Cave and Sun Hole Cave Human Stable Isotope Values Indicate a High Animal Protein Diet in the British Upper Palaeolithic

M. P. Richards and R. E. M. Hedges

Research Laboratory for Archaeology and the History of Art, University of Oxford, 6 Keble Road, Oxford, OX13QJ, U.K.

R. Jacobi, A. Current and C. Stringer

Department of Palaeontology, Natural History Museum, Cromwell Road, London, SW7 5BD, U.K.

We undertook stable isotope analysis of Upper Palaeolithic humans and fauna from the sites of Gough's Cave and Sun Hole Cave, Somerset, U.K., for palaeodietary reconstruction. We were testing the hypothesis that these humans had a mainly hunting economy, and therefore a diet high in animal protein. We found this to be the case, and by comparing the human $\delta^{15}N$ values with those of contemporary fauna, we conclude that the protein sources in human diets at these sites came mainly from herbivores such as *Bos* sp. and *Cervus elaphus*. There are a large number of *Equus* sp. faunal remains from this site, but this species was not a significant food resource in the diets of these Upper Palaeolithic humans.
© 2000 Academic Press

Keywords: PALAEODIET, UPPER PALAEOLITHIC, STABLE ISOTOPES, CARBON, NITROGEN, GOUGH'S CAVE.

Introduction

Gough's Cave is one of a series of caves with Palaeolithic deposits in the Cheddar Gorge, Somerset. It has been excavated a number of times throughout the last century and most of the excavated material has come from the 1920s and 1930s excavations. There have been more recent (1980s) excavations of previously untouched deposits by Roger Jacobi, Andy Currant and Chris Stringer, which have helped clarify the stratigraphy and produce new material (Currant, Jacobi & Stringer, 1989). A series of Accelerator Mass Spectrometer (AMS) dates was carried out on human and faunal material at the Oxford Radiocarbon Accelerator Unit (ORAU) in the 1980s and 1990s (Stringer, 1990).

Gough's Cave has the largest assemblage of Upper Palaeolithic artefacts and faunal remains of any Upper Palaeolithic site in Britain. Pollen analysis of contemporary deposits from the nearby Sun Hole Cave points to an open landscape in higher levels, but wooded in lower levels. The most abundant faunal remains at Gough's Cave are horse, followed by red deer, and many bones show signs of butchery, including removal of the tendons. Seasonality estimations based on tooth eruptions place occupation of this site in both the summer and winter.

Human remains were found at both Gough's and Sun Hole Caves, and at Gough's there are clear cut marks on the human bones indicating deliberate removal of flesh, but it is unclear whether these are indicators of cannibalism or not (Currant, Jacobi & Stringer, 1989).

Upper Palaeolithic peoples are often pictured as nomadic foragers who move around the landscape seasonally and have a mainly hunting economy. The evidence for a hunting economy is based on finds of butchered animal bones from Upper Palaeolithic sites, but as plant remains are not often recovered from Palaeolithic sites, there is no way of knowing how important plant foods were in their diet. Evidence from lithic assemblages also supports the hunting hypothesis and "Creswell/Cheddar" points from sites such as Gough's Cave have been interpreted as spear or projectile points (Morrison, 1980:100).

Stable Isotope Analysis

Unlike analysis of faunal and plant remains from archaeological sites, stable isotope analysis provides a direct measure of past human diets. Measurements of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope values in bone collagen can tell us about the long-term (*c.*

0305–4403/00/010001+03 $35.00/0
© 2000 Academic Press

Table 1. Human and faunal bone collagen stable isotope values from Gough's Cave and Sun Hole Cave

Sample	Species	Age/sex	^{14}C years (BP)	$\delta^{13}C^{b}$	$\delta^{15}N^{c}$	C:N
Sun Hole 2	*H. sapiens*	?	12210 ± 160 (OxA-535)	− 19·8	7·2	3·4
GC2[a]	*H. sapiens*	Adult	11820 ± 120 (OxA-2795)	− 18·9	7·1	3·3
GC6	*H. sapiens*	Adult male	11700 ± 100 (OxA-2236)	− 19·1	5·4	3·2
M23·1/2	*H. sapiens*	?	12300 ± 100 (OxA-2237)	− 18·6	6·5	3·3
GC 87/190	*H. sapiens*	Adult male?	12380 ± 110 (OxA-2796)	− 18·5	7·1	3·4
OxA-465	*Equus ferus*		12360 ± 170	− 19·9	0·7	3·1
OxA-466	*Cervus elaphus*		12800 ± 170	− 19·5	2·7	3·1
OxA-587	*Equus ferus*		12530 ± 150	− 20·1	0·7	3·2
OxA-588	*Bos*		12030 ± 150	− 19·4	2·8	3·1
OxA-1200	*Vulpes lagopus*		12400 ± 110	− 19·8	4·9	3·2

[a] Average of two separate isotope measurements on two different bones.
[b] Measured relative to the Vienna PeeDee Belemnite (VPDB) standard, measurement errors are ± 0·3‰.
[c] Measured relative to the Atmospheric N_2, Ambient Inhalable Reservoir (AIR) standard, measurement errors are ± 0·4‰.

the last 10 years of life) protein sources in human and faunal samples (Schwarcz & Schoeninger, 1991; Ambrose, 1993). The $\delta^{13}C$ values indicate the amounts of marine foods in past human diets, from a value close to − 20%, indicating no marine protein, to a value of − 12%, indicating almost 100% marine protein. The $\delta^{15}N$ value indicates the trophic level of the major protein sources in the diets. Human (and faunal) $\delta^{15}N$ values are 2–4% higher than the $\delta^{15}N$ values of the protein they consume (Schoeninger & DeNiro, 1984). Therefore, humans that consume mainly plant foods will have lower $\delta^{15}N$ values than humans that derive the majority of their protein from animal products.

To test the hypothesis that Upper Palaeolithic peoples had a mainly hunting (and therefore animal protein) economy, we undertook analysis on radiocarbon-dated human and faunal bones from Gough's Cave, as well as one human sample from Sun Hole Cave. Measurements were made at the Stable Isotope Laboratory of the Research Laboratory for Archaeology and the History of Art, Oxford. Samples were prepared following standard methods outlined elsewhere (Richards, 1998; Richards & Hedges, 1999). There are a number of different aged deposits at Gough's Cave, but here we only looked at material directly radiocarbon dated to between 13,000 and 11,000 BP. The human and faunal isotope values are presented in Table 1 and Figure 1, along with their associated radiocarbon ages.

Results and Discussion

Three of the human values have more positive $\delta^{13}C$ values (> − 19‰) than would be expected for Holocene humans with a purely terrestrial food diet. Could it be that these Gough's Cave humans, although they lived inland, had some marine foods in their diet? This is unlikely, as they do not have the elevated $\delta^{15}N$ values that are observed with a marine protein input in the diet. There were changes in atmospheric $\delta^{13}C$ at this time (Leuenberger, Siegenthaler & Langway, 1992) which are reflected in plant $\delta^{13}C$ values (Leavitt & Danzer, 1992) and also in the fauna, with collagen $\delta^{13}C$ values approximately 1‰ greater than in the Holocene (Richards, 1998). The Gough's/Sun Hole human and faunal $\delta^{13}C$ values probably also reflect this change in atmospheric $\delta^{13}C$.

The human and faunal $\delta^{15}N$ values from Gough's Cave are surprisingly low compared to Holocene values. Without the associated fauna, one could have erroneously assumed, based on comparisons with $\delta^{15}N$ values of Holocene fauna, that the Gough's and Sun Hole Cave humans subsisted mainly on plants. However, it seems that these samples date to a period of low plant and animal $\delta^{15}N$ values. The reason for the relatively low $\delta^{15}N$ values at this time is unknown, and may relate to lowered plant $\delta^{15}N$ values due to climate or soil formation processes.

By comparing the human and faunal values, it actually seems that the humans were consuming mainly animal protein, as their average $\delta^{15}N$ of *c.* 6·8‰ is much greater than the associated herbivore $\delta^{15}N$

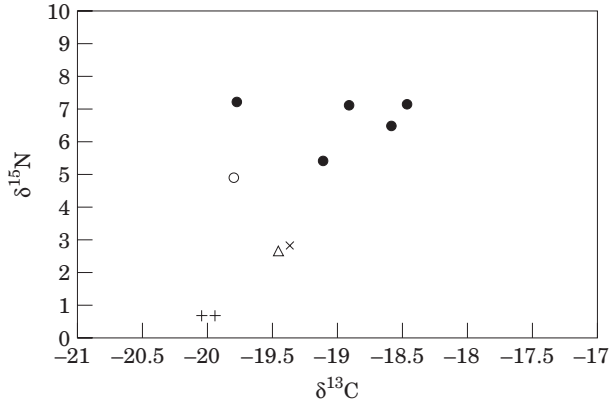

Figure 1. Plot of human and faunal stable isotope values from Gough's and Sun Hole Caves. (●), Humans; (○), arctic fox; (△), *Cervus elaphus*; (×), *Bos* sp.; (+), *Equus* sp.

values. The human values are higher than the single carnivore value, from an arctic fox, which indicates that humans were consuming animal protein at a higher trophic level than the fox.

If the humans hunted and consumed mainly horse, then their δ^{15}N values should be *c.* 3–5‰ (*Equus* δ^{15}N value of 0·7‰+enrichment of 2–4‰). Instead, their δ^{15}N values make more sense if they lived mostly off *Bos* and *Cervus elaphus* (*Bos* and *Cervus* values of *c.* 3‰+enrichment of 2–4‰=the observed values *c.* 6–7‰). It is also possible that other species, including *Rangifer tarandus*, were consumed by these individuals. *Rangifer tarandus* has δ^{15}N values similar to *Cervus elaphus* (Richards, 1998), and has more positive δ^{13}C values, which may explain the observed slight enrichment in the human δ^{13}C values. A number of artefacts made from *Rangifer tarandus* have been found at Gough's, but there is no other evidence that this species was being exploited for food.

The extensive cut marks on the bone could indicate that these people were not the hunters at Gough's, but perhaps the hunted. The above conclusions about the diet of these individuals would not change if this were the case, but instead of telling us about the diets of the supposed hunters at Gough's, we could be looking at the diet of another human group living in southern Britain at this time.

Conclusions

This limited stable isotope study proposes that Late Upper Palaeolithic hunters in southern Britain had a hunting economy and that their protein was mainly derived from the woodland species *Bos* and *Cervus elaphus*, while *Equus* was only consumed periodically. If the human bones measured here are from the hunters at Gough's and Sun Hole, one could then envisage Gough's and Sun Hole Caves as being specialist sites for hunting horse at certain times of the year, but the animal meat was only a supplement to a year-round diet based mainly on hunted woodland mammals.

Acknowledgements

We would like to thank Paul Pettitt, Tamsin O'Connell and G.J. Van Klinken for useful discussions on the data. We would also like to thank Ken Neal for assistance in preparing the stable isotope samples.

References

Ambrose, S. H. (1993). Isotopic analysis of paleodiets: methodological and interpretive considerations. In M. K. Sandford (Ed.) *Investigations of Ancient Human Tissue: Chemical Analyses in Anthropology*. Langhorne, Pennsylvania: Gordon and Breach Science Publishers, pp. 59–130.

Currant, A. P., Jacobi, R. M. & Stringer, C. B. (1989). Excavations at Gough's Cave, Somerset 1986–7. *Antiquity* **63,** 131–136.

Leavitt, S. W. & Danzer, S. R. (1992). δ^{13}C variations in C_3 plants over the past 50,000 years. *Radiocarbon* **34,** 783–791.

Leuenberger, M., Siegenthaler, U. & Langway, C. A. (1992). Carbon isotope composition of atmospheric CO_2 during the last ice age from an Antarctic ice core. *Nature* **357,** 488–490.

Morrisson, A. (1980). *Early Man in Britain and Ireland*. London: Croom Helm.

Richards, M. P. (1998). *Palaeodietary studies of European Human Populations using Bone Stable Isotopes*. Thesis, University of Oxford.

Richards, M. P. & Hedges, R. E. M. (1999). Stable isotope evidence for similarities in the types of marine foods used by Late Mesolithic humans at sites along the Atlantic coast of Europe. *Journal of Archaeological Science* **26,** 717–722.

Schoeninger, M. & DeNiro, M. (1984). Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta* **48,** 625–639.

Schwarcz, H. & Schoeninger, M. (1991). Stable isotope analyses in human nutritional ecology. *Yearbook of Physical Anthropology* **34,** 283–321.

Stringer, C. (1990). British Isles. In (R. Orban, Ed.) *Hominid Remains: an Up-Date*. Brussels: Université Libre de Bruxelles, pp. 2–41.