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Paleoclimatic inference of the mid-Holocene record of monk seal (*Monachus monachus*) in the Cantabrian Coast

A.B. Marín [a,*], M.R. González-Morales [b], J. Estévez [c]

[a] Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, Fitzwilliam Street, Cambridge CB2 1QH, United Kingdom
[b] Instituto Internacional de Investigaciones Prehistóricas de Cantabria, Universidad de Cantabria, 39005 Santander, Spain
[c] Laboratorio de Arqueozoología, Universidad Autónoma de Barcelona, Bellatera, Barcelona, Spain

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ABSTRACT

The mid-Holocene has been widely used to test the performance of the numerical models that are commonly employed to estimate the future evolution of world climate. This period, as the pollen record shows, was characterized by higher temperatures than present in northern and Central Europe, while cooler conditions occurred in the south of the continent. This pattern is challenging numeric algorithms that widely fail to replicate the paleoclimate data of southern Europe. Here we report the discovery of a fragmented bone of a temperate water phocid (*Monachus monachus*) dated to 5540 ± 40 BP that was hunted and consumed on the Cantabrian Coast during that period. This find implies a hitherto unnoted phase of warm conditions associated with strengthened advention of subtropical waters to the region. As a consequence, the possibility that the oceanographic regime from that time in the Bay of Biscay was similar to the current one is reinforced, a fact that could modify our view of mid-Holocene climate in the Iberian Peninsula and have important implications in climate change studies.

1. Introduction

Paleoclimatic reconstructions are essential in our understanding of past human evolution and the predictions of future ecological developments. Physical and biological indicators, such as ice cores, speleothems, pollen, foraminifera and invertebrate and vertebrate faunas, have all been used in the past to build temperature curves (Dansgaard et al., 1993; Genty et al., 2003; Grootes et al., 1993; Guiot et al., 1996; Ruddiman, 1992) leading to an intense debate on the effects of climate change on human evolution (Behrensmeyer, 2006; Foley, 1994; Ruff, 2005; Trauth et al., 2007). In addition, they have been commonly applied to test the performance of climate numerical models and to identify the role of natural versus anthropogenic influence on climate (Brovkin et al., 1999; Claussen et al., 2002; Crucifix et al., 2002; Ganopolski and Rahmstorf, 2001; Jones et al., 1998; Weber, 2001). Some periods provide an outstanding opportunity for doing so. This is the case with the mid-Holocene climatic optimum, which occurred at around 6000 years BP, involving substantial changes in mean global temperature within a trend of steady warming without the presence of large ice sheets (Harrison et al., 1998; Steig, 1999).

As a climate proxy of that period, here we report the identification of *Monachus monachus* (monk seal) remains in the Bay of Biscay, a currently endangered and almost extinct phocid associated with warm subtropical waters that has been dated approximately to the mid-Holocene. A fragmented bone, identified as an ulna of this species and showing clear signs of human butchery, was recovered from La Fragua Cave, a small hunting camp on the present Cantabrian shore in northern Spain. This is the first time such a specimen has been retrieved in this region, which is widely known for its complete and abundant archaeological record during the Upper Palaeolithic and Mesolithic.

Apart from the zooarchaelogical relevance of the find, it also has an interesting climate significance. Thus, the thermal reconstruction commonly used for southwest Europe in the mid-Holocene, mainly based on the pollen record (Cheddadi et al., 1997; Davis et al., 2003), suggests that temperatures were lower than at present. However, the climate models that are currently available tend to encounter problems in achieving a good fit to those evidences (Bonfils et al., 2004; Brewer et al., 2006).

The fact that a temperate water phocid was found in the Cantabrian Coast during that period enables the possibility that the regime of sea currents was similar to the present one, including the predominant advection of warm waters from the subtropical Atlantic towards northern latitudes. This mechanism could have tempered the Holocene climate in southwest Europe as it does nowadays (Visbeck, 2002). If this was the case, climate models

* Corresponding author. Tel.: +44 07767 784982; fax: +44 01223 764710.
E-mail addresses: abm38@cam.ac.uk (A.B. Marín), moralesm@unican.es (M.R. González-Morales), jordi.estevez@uab.es (J. Estévez).

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ought to take this into account, avoiding an unjustified bias towards cooler temperatures in that part of the continent, and thus, improving their general performance.

2. Materials and methods

La Fragua Cave is located at 125 m above sea level on the southeastern slope of Mount Buciero, in Santoña (eastern Cantabrian Spain) (see Figs. 1 and 2). The cave is relatively small – roughly 10 m long by 3 m wide at most – but is well sheltered and favorably oriented against winter conditions. Archaeological excavations carried out at the site between 1990 and 1996 revealed the existence of continuous human occupation from the late upper Magdalenian to the Neolithic (González Morales, 2000), making it one of the few Late Glacial sites on the Bay of Biscay coast to have survived the steady rise in sea level (González Morales et al., 1992).

From the subsistence point of view, this site has been described as a secondary camp for the exploitation of resources in its immediate surroundings (Marín and González-Morales, 2007), within a territorial system that would have included the whole Asón valley, with large habitation sites like El Mirón (Marín, 2008, 2009) located in the interior area. Thus, the taxonomic composition of the recovered faunal assemblage is typical of a specialized hunting strategy focused on temperate fauna, mostly red deer and ibex although some wild boar and roe deer remains are also present. This taxa representation is coherent with the general pattern of the Cantabrian Coast during the Holocene and follows the progressive displacement of Arctic fauna observed during the Late Pleistocene (Straus, 1992). The seasonality of the site indicates that the cave was mainly occupied during later summer and autumn, when food were stored in considerable quantities in anticipation of the coming winter season (Marín, 2004). Further-

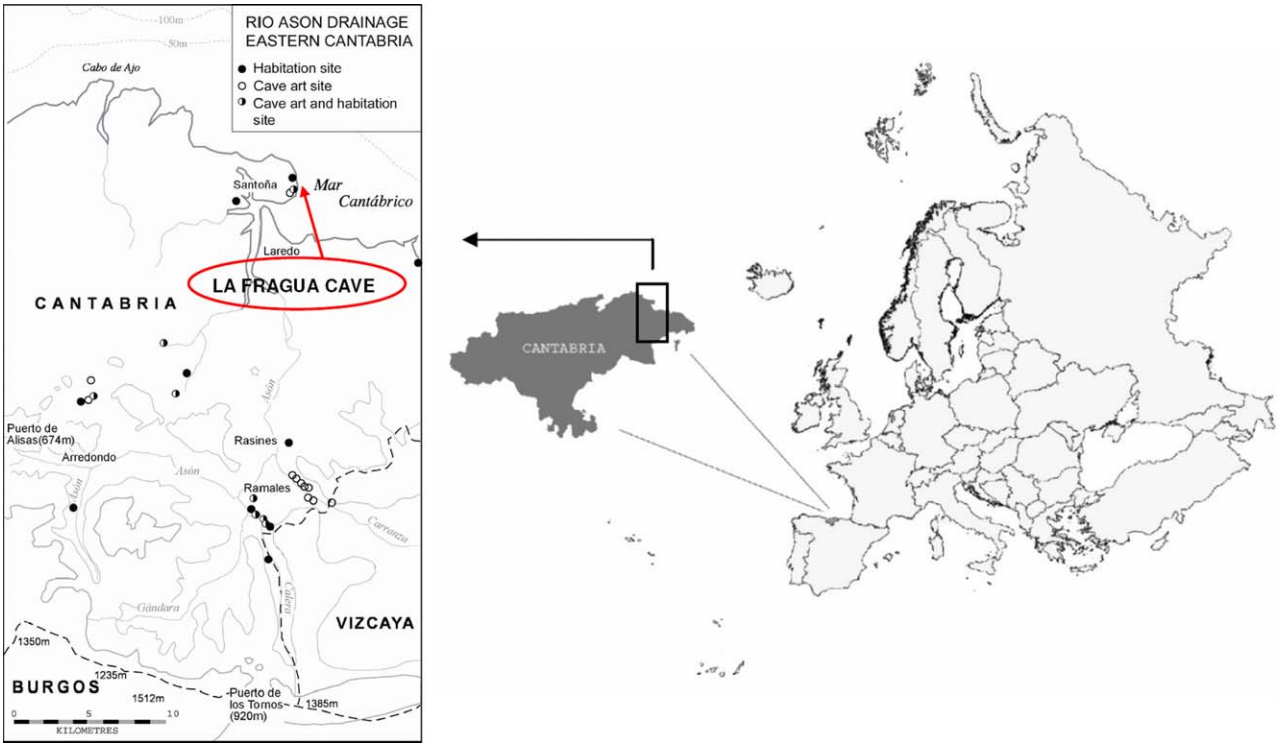

Fig. 1. Location of La Fragua Cave in the river Asón drainage basin in eastern Cantabria Province in Spain.

Fig. 2. General view of Monte Buciero and the river Asón drainage basin from Laredo (right) (Photograph: Gutierrez Zugasti). Photograph of the southeast side of Monte Buciero showing La Fragua Cave (the red arrow shows the present location of the cave) (left).