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Pleistocene and Holocene herbivore diets and palaeoenvironments in the Gebel Akhdar (Libya): Implications for past human populations

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ABSTRACT

The Gebel Akhdar massif in Cyrenaica, northeast Libya, has yielded a long record of human occupation going back at least 100,000 years. To date, there is only a limited understanding of how the landscape of the region varied in response to the climatic fluctuations of the last glacial–interglacial cycle, and the implications of these changes for local human populations remain largely unexplored. This study provides an isotope-based interpretation of past environments directly linked to the archaeological record. Tooth enamel stable carbon isotope ratios ($\delta^{13}C$) from herbivore species hunted by past human populations are used to infer the isotopic characteristics of past diet and vegetation, and in turn the likely environmental conditions that prevailed during periods when humans were active within the landscape. To provide a baseline from which to interpret the archaeological $\delta^{13}C$ data, modern samples are considered in relation to their diet and environmental origin. Archaeological samples come from 2 cave sites, Haua Fteah and Hagfet ed Dabba, and span a period from oxygen isotope stage 4 to the mid-Holocene. Whilst results indicate a more arid environment in the Pleistocene and an increase in humidity at the onset of the Holocene, the overall picture is one of relative environmental stability. The biggest landscape change observed in the data occurs during the mid-Holocene Neolithic, when C_4 plant species become evident in the herbivore diet for the first time. There is little evidence to suggest that this occurred at a time of any large-scale climate variation, and thus the contribution of anthropogenic influences to vegetation change is considered likely.

1. Introduction

The Gebel Akhdar massif in Cyrenaica, northeast Libya (Fig. 1), possesses an archaeological record that extends back to at least oxygen isotope stage (OIS) 5 (ca. 128–74 ka) (McBurney, 1967; Barker et al., 2007; Douka et al., 2014) and likely to OIS 6 (ca. 195–128 ka) on the evidence of unpublished OSL dates from the Haua Fteah cave (pers. comm. Z. Jacobs). Across this time period numerous oscillations in climate occurred at a wide range of spatial and temporal scales, which in North Africa were predominately manifested as shifts between wetter and drier conditions (Cacho et al., 2000; Sierro et al., 2005; Enzel et al., 2008; Kwiecien et al., 2009; Castañeda et al., 2010; Sprovieri et al., 2012). Concurrently, archaeological archives from across the region appear to display varying periods of population expansions and contractions, some of which occurred in step with environmental changes (Hoelzmann et al., 2001; Garcea, 2006, 2012a; Castañeda et al., 2009; Scerri, 2013). In particular, people appear to have been absent from many areas within North Africa during times when hyper-arid conditions prevailed across much of the region (Clark, 1980; Petit-Maire, 1991; Cremaschi et al., 1998; Cancellieri and di Lernia, 2013; Foley et al., 2013). In contrast, the archaeology of the Gebel Akhdar, a coastal area of varied topography (Fig. 1), alludes to a different population history, with people being present in the region during each OIS of the last interglacial–glacial cycle, albeit likely in varying numbers and not necessarily continuously (McBurney, 1967; Barker et al., 2010, 2012; Jones et al., 2011). This raises the question of whether favourable environmental conditions in the Gebel Akhdar made the region attractive for occupation during periods when other areas of North Africa appear to have been largely abandoned.

Rising to a maximum elevation of ~780 m the Gebel Akhdar is today cooler and more humid than the surrounding desert regions (El-Darier and El-Mogaspi, 2009). The local mean annual precipitation ranges from <250 mm to >600 mm and the mean annual temperatures from 16 to 21 °C (Elfadli, 2009; El Kenawy et al., 2009; Ageena et al., 2014). Presently, the area has the richest vegetation and highest floral diversity of any area in Libya. Maquis scrubland dominates the local vegetation, with common species including *Juniperus phoenicea*, *Quercus coccifera*, *Pistacia lentiscus*, and *Ceratonia siliqua*, whilst steppe species such as

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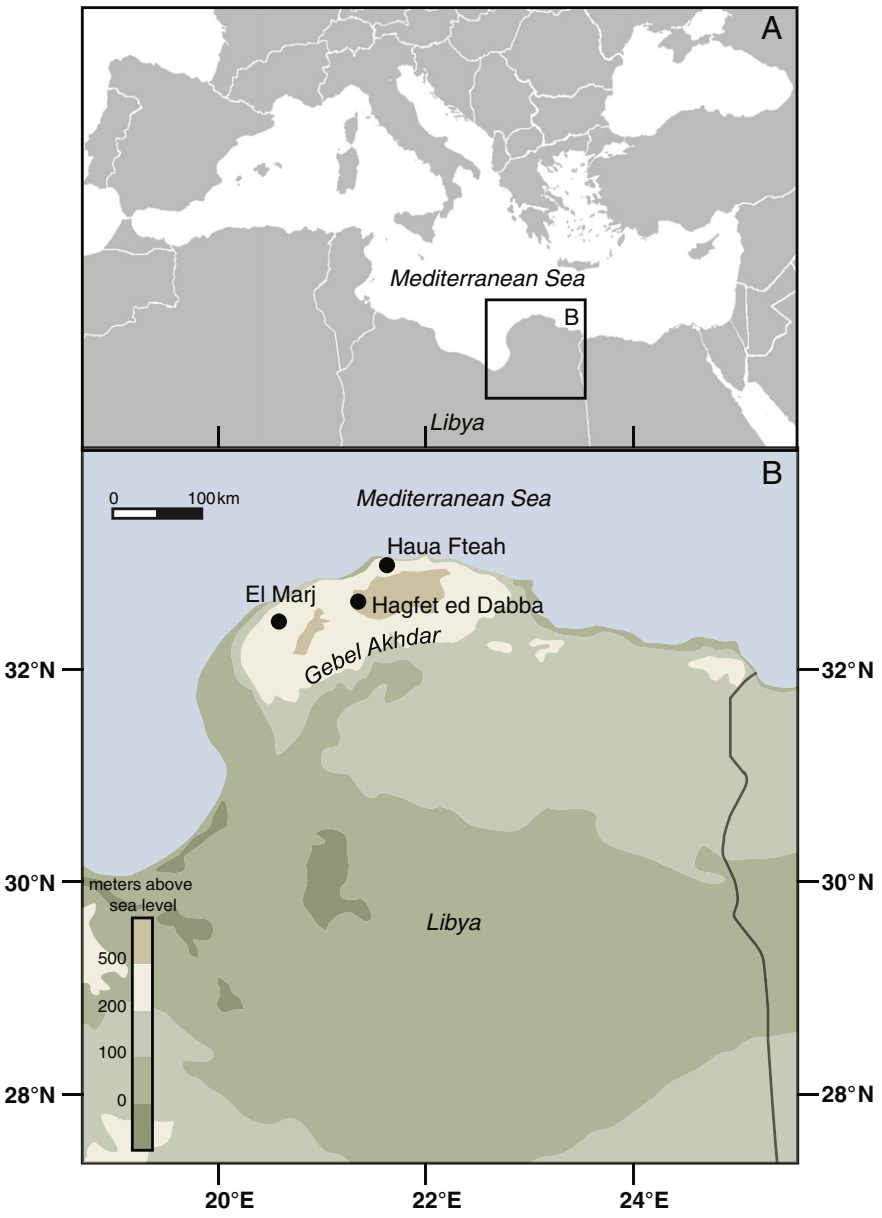

Fig. 1. A: Map showing the position of the Gebel Akhdar (square) in the eastern Mediterranean. B: Map of northeast Libya showing the location of sites mentioned in the text, situated within the Gebel Akhdar.

Sarcopoterium spinosum, and *Artemisia* sp. are also common (Al-Sodany et al., 2003; El-Darier and El-Mogaspi, 2009). A high degree of floral endemism suggests that the Gebel Akhdar may have been biogeographically isolated for an extended period of time (Hegazy et al., 2011), and combined with its geographical setting may indicate that in the past, as is the case today, the Gebel Akhdar provided an environment notably different from adjacent more desertic regions of North Africa.

Palaeoenvironmental research to date has indicated that the Gebel Akhdar experienced relatively low magnitude variations in temperatures and rainfall amounts over the last ~100,000 years (Inglis, 2012; Reade et al., 2015a; Prendergast, et al., submitted for publication). Alluvial, tufa, and dune deposits are all found within the region suggesting that the amount of moisture in the landscape varied with time, but a lack of precise chronological understanding of these deposits hinders comparisons with the archaeological record (Hey, 1955). Sediments in the Haua Fteah cave, which contain archaeological material, indicate periods of increased climate instability, particularly during OIS 3 (ca. 59–24 ka) (Inglis, 2012). However, whilst these archives are sensitive to landscape-scale environmental conditions they are also heavily influenced by sedimentary and taphonomic processes within the cave, making environmental interpretations complex (Hunt et al., 2010; Inglis, 2012). Mollusc isotope data from the cave suggests an increase in aridity during OIS 2 (ca. 24–12 ka) (Prendergast et al., submitted for publication). There is currently only a limited understanding of the impacts of these climatic variations on the local landscape. Differences in the species composition of mammalian and molluscan assemblages in the Haua Fteah and other archaeological sites have been used to infer shifts in the composition of woodland/steppic environments, although as these assemblages are the result of human procurement, the sensitivity of the archives to natural variations may be reduced (Higgs, 1967; Klein and Scott, 1986; Hunt et al., 2011). Thus there remains a need to gain further palaeoenvironmental insights from archives, which are linked to, but not directly influenced by, human activity.

Here we focus on estimating past vegetation and environmental conditions in the Gebel Akhdar through stable isotope analysis of mammalian faunal remains from two cave sites, Haua Fteah and Hagfet ed Dabba. The carbon isotope ($\delta^{13}C$) composition of tooth enamel apatite