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Year-round shellfish exploitation in the Levant and implications for Upper Palaeolithic hunter-gatherer subsistence

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A B S T R A C T

Recent studies have shown that the use of aquatic resources has greater antiquity in hominin diets than previously thought. At present, it is unclear when hominins started to habitually consume marine resources. This study examines shellfish exploitation from a behavioural ecology perspective, addressing how and when past hunter-gatherers from the Levant used coastal resources for subsistence purposes. We investigate the seasonality of shellfish exploitation in the Levantine Upper Palaeolithic through oxygen isotope analysis on shells of the intertidal rocky shore mollusc *Phorcus (Osilinus) turbinatus* from the key site Ksâr 'Akil (Lebanon). At this rockshelter, multi-layered archaeological deposits contained remains of both marine and terrestrial molluscs in relatively large quantities, which were consumed and used as tools and ornaments by the occupants of the site. Our results indicate that at the start of the Initial Upper Palaeolithic (IUP), there is no evidence for shellfish consumption. Humans started to take fresh shellfish to the rockshelter from the second half of the IUP onward, albeit in low quantities. During the Early Upper Palaeolithic (EUP) shellfish exploitation became increasingly frequent. Oxygen isotope data show that shellfish exploitation was practised in every season throughout most of the Upper Palaeolithic (UP), with an emphasis on the colder months. This suggests that coastal resources had a central role in early UP foraging strategies, rather than a seasonally restricted supplementary one. Year-round shellfish gathering, in turn, suggests that humans occupied the rockshelter at different times of the year, although not necessarily continuously. Our oxygen isotope data is complemented with broader-scale exploitation patterns of faunal resources, both vertebrate and invertebrate, at the site. The inclusion of coastal marine resources signifies a diversification of the human diet from the EUP onward, which is also observed in foraging practices linked to the exploitation of terrestrial fauna.

1. Introduction

Recent archaeological discoveries indicate that the exploitation of aquatic resources has a long history among various hominin species. The earliest evidence of the exploitation of freshwater fish was documented from Koobi Fora, Kenya about 1.95 million years ago (Braun et al., 2010) for *Homo ergaster/erectus*, who made Oldowan tools. *Homo erectus* individuals may have consumed freshwater molluscs from approximately ≥ 400 thousand years ago (kya) in Trinil (Java, Indonesia) (Joordens et al., 2014). During Marine Isotope Stages (MIS) 6 and 5 (roughly 190–125 kya and 125–80 kya, respectively), Middle Stone Age (MSA) *Homo sapiens* exploited shellfish at several South African coastal sites (e.g. Klein et al., 2004; Avery et al., 2008; Jerardino and Marean, 2010; Langejans et al., 2012; Clark and Kandel, 2013; Kyriacou et al., 2015; Jerardino, 2016). In the Mediterranean region, marine molluscs were exploited during the Middle Palaeolithic both by *H. sapiens* and *Homo neanderthalensis* from MIS 5 onward (e.g., Emiliani et al., 1964; Klein and Scott, 1986; Stiner, 1999; Finlayson et al., 2006, 2008; Colonese et al., 2011; Cortés-Sánchez et al., 2011; Barker et al., 2012; Fa et al., 2016).

Thus, aquatic resources played a role in early hominin diets, although their contribution has been considered as marginal for most of

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the Palaeolithic (e.g., Erlandson and Moss, 2001; Colonese et al., 2011; Clark and Kandel, 2013; Jerardino, 2015). This is especially true when optimal foraging models are used, which primarily consider the caloric value and energy intake of foodstuffs (see also Grayson and Delpech, 1998; Stiner, 2001, 2010). However, from a nutritional ecology perspective, shellfish are a rich source of many essential nutrients, including vitamins (i.e., A, B12, C, D, and E), iron, folate, potassium, calcium, and omega-3 fatty acids (e.g., Hockett and Haws, 2003; Haws and Hockett, 2004; Cunnane and Crawford, 2014; Kyriacou et al., 2015). Due to their high polyunsaturated (or omega-3) fatty acid content in the form of docosahexaenoic acid and its importance for brain development, shellfish and aquatic food sources in general are thought to have been important in human brain expansion and evolution (e.g., Brenna and Carlson, 2014; Cunnane and Crawford, 2014; Joordens et al., 2014; Kyriacou et al., 2014). With regard to nutritional ecology, Hockett and Haws (2003) (Haws and Hockett, 2004) suggest that broader and nutritionally rich diets increase hominid fitness, aid to reduce child mortality, and inter-birth intervals. This in turn, would allow for population increase as for example the increase in population density thought to coincide with the start of the UP (e.g., Mellars and French, 2011; French, 2015).

Most of the above-mentioned essential nutrients can also be obtained in reasonable quantities through the consumption of animal organs and/or plant foods, with the possible exceptions of vitamins D and omega-3 fatty acids, which are more difficult to obtain from other, terrestrial, sources. However, due to their limited visibility in the archaeological record, it is often hard to assess the role that organ meat and plant foods played in hominin diets. Whereas shellfish are convenient 'food packages', providing an array of essential nutrients not combined in other food sources and, if available, are ideal to assess the nutritional breadth of the diet. Here we use oxygen isotope analysis as a tool to determine the nature and seasonal timing of UP shellfish exploitation. Seasonality of shellfish exploitation data, derived from oxygen isotope analysis, allow us to explore questions about whether coastal environments were used as a supplementary resource in lean times, or if they occupied a more central-place in past foraging strategies and accessed throughout the year. We further investigate whether shellfish gathering was a result of intensification of food resources with increased residency and or population pressure (e.g., Stiner et al., 2013; Marean, 2014) through comparisons with exploitation patterns of other faunal resources.

Moreover, data on the periodicity of mollusc collection are helpful for gaining a fuller understanding of coastal foraging strategies (e.g., Mannino et al., 2007, 2014; Colonese et al., 2009; Prendergast et al., 2016) and allow us to address questions regarding behavioural ecology. For example, how prehistoric hunter-gatherers moved in the landscape or how they used their surroundings for raw material procurement (e.g., bivalves of *Glycymeris* sp. for the manufacture of utilitarian objects or perforated shells for personal ornamentation) or foraging. In addition, these data can be used as a proxy for the timing of site occupation (e.g., Shackleton, 1973; Mannino et al., 2011). Here we investigate seasonality of shellfish exploitation by modern humans in the eastern Mediterranean UP using the Ksâr 'Akil (Lebanon) shell assemblage as a case study. To do this we conducted oxygen isotope analysis of the most common edible marine mollusc, *Phorcus turbinatus*. These data on coastal foraging are complemented with broader patterns of faunal resource and habitat exploitation.

2. Ksâr 'Akil and its palaeoenvironmental setting

The Ksâr 'Akil rockshelter is situated close to the eastern Mediterranean coast, approximately 10 km north of Beirut, Lebanon (Fig. 1). Its multilayered sequence is 23 m deep and spans the Middle Palaeolithic (MP) to the Epipalaeolithic (EPI) (e.g., Ewing, 1947; Mellars and Tixier, 1989). It yielded several human fossils (Ewing, 1960; Bergman and Stinger, 1989; Tillier and Tixier, 1991) that are associated with rich archaeological assemblages (Fig. 2). Virtually all mollusc remains were found in UP deposits (van Regteren Altena, 1962; Inizan and Gaillard, 1978). The UP sequence at Ksâr 'Akil comprises roughly the upper 16 m of sediments. In this study, the sequence is subdivided following the division in archaeological layers by Williams and Bergman (2010); see also Tixier and Inizan, 1981; Azoury, 1986; Marks and Volkman, 1986; Bergman and Goring-Morris, 1987; Kersten, 1987; Bergman, 1988; Bergman and Stinger, 1989; Mellars and Tixier, 1989; Ohnuma and Bergman, 1990; Douka et al., 2013; Leder, 2014; Bosch et al., 2015a). Calibrated age estimates (after Bosch et al., 2015a; see also Mellars and Tixier, 1989; Douka et al., 2013, 2015; Bosch et al., 2015b) are provided at the 68.2% probability level. The lowermost UP Layers XXV–XXI comprise so-called Initial Upper Palaeolithic (IUP) assemblages sensu Kuhn et al. (1999), and date to at least 44,600–43,000 cal BP, however the base (i.e., Layers XXV–XXIV) of the IUP remains undated, due to lack of shells or other datable materials from those layers. The IUP is followed by the Early Upper Palaeolithic (EUP) or early Ahmarian deposits (Layers XX–XIV) dating to 43,300–42,800 cal BP. These are overlain by two "unnamed UP phases" (Layers XI–XIII and IX–X, respectively) sensu Williams and Bergman (2010) the lithic assemblages of which show both early Ahmarian and (Levantine) Aurignacian affinities. These two phases are grouped into a broader "UP", because of the lack of consensus over their archaeological attribution (e.g., Bergman and Goring-Morris, 1987; Williams and Bergman, 2010). The subsequent Layers VIII–VII are classic (Levantine) Aurignacian and together with the two previous "unnamed UP" phases, this part of the sequence dates between 41,900 and 32,800 cal BP. Layer VI has been attributed to the Atlitian by Williams and Bergman (2010) and has an age range of 32,700–31,900 cal BP. The top Layers V—I have been described as Epipalaeolithic. The lowest of these layers (i.e., Layer V) is dated to 30,200–29,700 cal BP and a reassessment of the lithics may be prudent in relation to this date.

Ksâr 'Akil is located about 3 km from the present-day coast, on the northern limestone slope of the Antelias Valley at an elevation of approximately 80 m above sea level (Ewing, 1947; Wright, 1962). In prehistoric times, the south-facing rockshelter would have been protected by a hill in the centre of the valley that was quarried away in historic times (Bergman et al., 2012). From the site, hunter-gatherers would have had access to a range of different landscapes, from the mostly rocky shores of the Bay of St. George and its small coastal plain to the steep slopes of the Lebanon Mountains; the top of the mountain range leads to the open highlands of the El Beqaa Valley. Freshwater was available from the stream running down the Antelias Valley and presumably from local springs (Ewing, 1947).

The recovered faunal assemblage includes both terrestrial and aquatic molluscs, as well as terrestrial vertebrates (including avian, microfaunal, and macrofaunal taxa) and provides us with additional information on the available habitats surrounding Ksâr 'Akil (Table 1).

The occurrence of terrestrial snails suggests that there were wooded (e.g., *Buliminus labrosus, Pene syriacus, Cristataria porrecta,* and *Helix pachya*) as well as open- to half-shaded habitats (e.g., *Pomatias elegans, P. olivieri, Oxychilus syriacus, Metafructicola berytensis, Monacha nummus,* and *M. syriaca*) in the vicinity of the site (Bosch et al., 2015c). Freshwater molluscs are rare and comprise *Theodoxus jordani, Melanopsis buccinoidea,* and *Potamida littoralis*. The latter adapted to lower-energy regimes (i.e., slow-flowing and/or stagnant water bodies). There is no brackish water component among the assemblage. A bivalve fragment (RGM-639547) thought to belong to *Cerastoderma glaucum* was misidentified and is actually a juvenile of *Acanthocardia tuberculata* (Bosch et al., 2015c). Additionally, marine intertidal rocky shore, soft and hard substrate subtidal taxa were recovered (van Regteren Altena, 1962; Bosch et al., 2015c). Taphonomic signatures on the shells suggest that most marine taxa, excluding those from intertidal rocky shores, were collected as beached specimens, either from active beaches or from fossil beach deposits.

Avian taxa, studied by Kersten (1991), include open woodland (e.g.,