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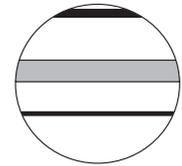
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Abstract

Climatic fluctuations that occurred in North Africa during the early and middle Holocene had a profound impact on the environment of the region and would have required human populations in the area to adapt their subsistence and economic strategies in equally significant ways. Capsian groups, located in eastern Algeria and southern Tunisia from approximately 10,000 to 6000 cal. BP, were among the last North African foragers at a time when other groups were abandoning food collection to engage in food production in the form of pastoralism. Capsian foragers relied heavily on land snails, but we have little information on their use of plant resources, which can be an important indicator of economic adaptation to environmental change. In this study we use phytolith analyses at the Capsian site of Ain Misteheyia in eastern Algeria to track the changes in subsistence strategies throughout much of the middle-Holocene climatic transitions. Our results show that Capsian foragers exploited plants such as sedges and small-seeded grasses from wetland microenvironments within their home ranges which allowed them to demonstrate robust and resilient resource procurement strategies, and maintain a foraging lifestyle resistant to major fluctuations in climate.

Keywords

broad spectrum foragers, Capsian archaeology, desertification, human adaptations, Maghreb, middle Holocene climate change, North Africa, phytoliths

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Introduction

The spread of farming and pastoralist economies in the circum-Mediterranean during the early and middle Holocene heralded one of the most significant transitions for human societies and paved the way for the development of complex societies in the region. These processes occurred at the same time as marked environmental fluctuations in the region including significant moist episodes, the well-known 8.2 kyr climatic event and the shift to secular drying conditions at the beginning of the late Holocene. In an effort to understand the role of environmental change and shifting human adaptations, we examined changing subsistence practices among one group of early-to mid-Holocene foragers in northwest Africa. Capsian groups, located in eastern Algeria and southern Tunisia from approximately 10,000 to 6000 cal. BP, were among the last North African foragers (Rahmani, 2004). Neolithic economic practices began to appear in the Maghreb from around 6000 cal. BP (Linstädter, 2008; Lubell, 2001; Roubet, 2001), but the extent to which the economy of later Capsian groups was transformed remains unresolved. The appearance, at *c.* 6800 cal. BP, of non-indigenous domestic ovicaprids associated with a Neolithic of Capsian Tradition occupation at Grotte Capéletti in the Aurès Mountains (Roubet, 2001), suggests that at least some mid-Holocene foraging groups in the Maghreb became pastoralists and may have practiced transhumance.

Most Capsian groups appear to have remained mobile foragers throughout the mid Holocene, with a subsistence regime that relied even more heavily on land snails than elsewhere in the circum-Mediterranean region (Lubell, 2004a, 2004b). In order to explain the longevity of the Capsian foraging adaptation we need to obtain more information on the types of plants and animals that were consumed. However, owing to the lack of macrobotanical evidence from Capsian sites, we have little knowledge of the role of plants in Capsian subsistence strategies.

Phytoliths are important indicators of plant use, especially in the absence of macrobotanical remains in archaeological deposits. They preserve well (Piperno, 2006), and are common in archaeological sites, a context in which plants have been densely concentrated. This study is an attempt to gain insight into the role of plants in Capsian subsistence by examining phytoliths from Ain Misteheyia (Lubell et al., 1975, 1976, 1982–1983, 2009), with the aim of improving our understanding of why Capsian populations persisted with broad-spectrum hunting and gathering thousands of years longer than other North African groups.

Climate of North Africa in the early to mid Holocene

The persistence of the Capsian tradition can be attributed in part to a successful adaptation strategy and also to favorable environmental conditions. The former were described by Lubell (1984, 2001) while paleoclimatic data and references to other sources can be found in recent publications by Jackes and Lubell (2008), Linstädter (2008) and Zielhofer and Linstädter (2006).

The paleoclimate of North Africa has been reconstructed using a number of different lines of proxy evidence, with some of the most important being paleo-lake levels, pollen, and isotopic

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records from tufas. This evidence provides a clear picture of conditions that were much wetter than today across the expanse of the Sahara from *c.* 10,000 to 5000/4000 cal. BP. These moister conditions began at *c.* 15,000–14,500 cal. BP, well after the Late Glacial Maximum, with an increase in summer solar radiation contributing to the strengthening of southern monsoons. The tropical monsoons shifted northwards into the Saharan zones. This moister episode came to an abrupt end with the beginning of the Younger Dryas cool/dry period from *c.* 12,600 to 11,600 cal. BP as seen in the Greenland ice cores. Stronger monsoonal activity renewed with warming at the beginning of the Holocene, *c.* 11,600 cal. BP (Gasse, 2000, 2002; Gasse and Van Campo, 1994; Street-Perrott and Perrott, 1990).

Evidence for early- to mid-Holocene moist episodes can be seen in the paleohydrological record across North Africa, however, the evidence for rising lake levels is not simultaneous across the region, and for the most part, does not begin immediately after the Younger Dryas. Lake records show increasing levels beginning from *c.* 10,500 to 9500 cal. BP (Cremaschi et al., 2010; Gasse, 2002). Gasse (2000) found evidence for two Holocene lake expansion phases, the first from 10,500 to 8500/8000 cal. BP, and the second from 7500 to 4500 cal. BP. A short-term drying episode from 8400 to 8000 cal. BP is recorded in the lakes, and roughly corresponds to the 8.2 ky cool/dry event identified in the Greenland ice cores (Alley and Ágústsdóttir, 2005), although it appears to last longer than the *c.* 200 years of the 8.2 ky event. After the maximum wet period, an overall drying trend is characterized by a series of dry/wet fluctuations, and finally, the lakes began to rapidly decline between 5000 and 4000 cal. BP. Gasse (2002: 763) highlights the rapidity of the wet/dry pulses by remarking that water availability could fluctuate significantly within the timeframe of a human lifespan. This clearly would have had a profound impact on hunter/gatherers, pastoralists or incipient cultivators living in this region and would call for rapid changes in adaptive strategies.

Climatic indicators from tufas bear a striking resemblance to the patterns obtained from the study of lake levels. The formation of tufas is dependent upon both abundant water, and also the presence of a stable soil cover. The high-precipitation conditions necessary for tufa formation in SW Fezzan, Libya continued from 9600 to 7600 yr BP (U/Th date), but no tufa formation occurred after this time. Tufa-forming conditions were significantly reduced at *c.* 8100 cal. BP, coinciding with the 8.2 ky event. Low $\delta^{13}\text{C}$ values in early-Holocene tufa in this region indicate high soil productivity resulting from dense vegetation cover (Cremaschi et al., 2010).

Climatic and hydrological fluctuations had an impact on vegetation which in turn required human adaptational changes. More humid-loving vegetation began to expand northward into the Sahara zone after *c.* 12,000 cal. BP and reached a maximum density from 10,000 to 8000 cal. BP. The patterns of individual plant distributions suggest that elements of Saharan, Sahelian and Sudanian all existed together, rather than a situation where a single geobotanical zone was dominant. This was a direct effect of the North African humid episode, and the result was a significant increase in biodiversity (Lézine, 2009; Watrin et al., 2009). Pollen data from Libya indicate a mix of savannah and parkland vegetation, along with plants requiring standing fresh water such as *Typha* and *Scirpus* during the early Holocene, from *c.* 11,000 to 9200 cal. yr BP. From *c.* 9000 to 8500 cal. yr BP diversification of vegetation decreased with increasing aridity (Watrin et al., 2009). The more tropical plant species declined around 5000 cal. BP, as the Saharan plant communities adjusted to increasing drought. The rise in biodiversity during the early through mid Holocene would have been a significant advantage for hunter-gatherer groups living in this region, yet the decreasing diversity in the later middle Holocene would have necessitated new adaptive strategies.

Given this general environmental picture, our study of phytoliths from Ain Misteheyia was designed to reconstruct some of the microenvironments available to the Capsian populations of this region. Another goal of this research was to provide insights into aspects of Capsian ecology and subsistence economies including patterns of plant exploitation and transhumance. One characteristic of Capsian adaptation to the semi-arid environment of the region might have been variations in seasonal mobility patterns, which is a longstanding research problem for this time and region (e.g. Lubell et al., 1975). Our ultimate aim was to further the understanding of why the Capsian persisted with broad-spectrum hunting and gathering strategies thousands of years later than other prehistoric North African groups.

Capsian subsistence economies

Most Capsian sites are found in concentrations in eastern Algeria and southern Tunisia near the modern towns of Tebessa and Gafsa (Figure 1), and across a wide range of ecological zones (Lubell, 1984; Rahmani, 2004). The Capsian territory extends from around Tiaret, Algeria on the west, stretching eastward to about 50 km east of Gafsa (Lubell et al., 1976). In general Capsian sites are not found along the Mediterranean coast although the recent work at Hergla in Tunisia (Mulazzani, 2010, 2012; Mulazzani et al., 2010) requires a revision of this scenario. The main Capsian occupation area is on the high, undulating plains in northeast Algeria/southern Tunisia, where thousands of open-air sites typically are found near springs or passes. A smaller number of sites are located in caves and rock shelters along limestone escarpments. This region, especially around Tebessa in Algeria, is surrounded on the north, south, and west by the Atlas and Aurès Mountains.

The deposits of most Capsian sites consist of ash, fire-cracked rock, lithic debris, vertebrate remains, bone tools, human burials, engraved as well as undecorated ostrich egg shell, and occasionally small stone carvings and shell beads (Camps, 1975; Lubell, 2001; Rahmani, 2004). They are characterized by vast amounts of land snail shell (Lubell, 2004a, 2004b), hence the name *escargotières* although the local name is *rammadiya*, meaning ashy ground in Arabic (Gobert, 1937). There are also sites in the southern Capsian area, on the northern fringe of the Sahara near Biskra, that lack snail shells (Lubell et al., 1975; Tixier et al., 1976). Unfortunately, the deposits at the open-air sites are often deflated and compacted, making the stratigraphy difficult to reconstruct. The rock shelter sites have intact stratigraphy and better preservation (Camps, 1975; Jackes and Lubell, 2008; Lubell et al., 1982–1983; Mulazzani, 2012).

Varying lithic and faunal assemblages at Capsian sites have produced some uncertainty as to the development of Capsian subsistence strategies. However, it is generally accepted that at around 8000/8200 yr cal. BP there was a shift in subsistence strategies, which coincides with the transition from Typical to Upper Capsian in lithic and faunal assemblages, and generally occurs around the time period of the arid climatic episode known as the 8.2 ky event (Alley et al., 1997; Jackes and Lubell, 2008; Street-Perrott and Perrott, 1990). The Typical Capsian toolkit contains larger tools, such as backed blades, burins and scrapers, as well as crescent-shaped microliths. In comparison, Upper Capsian toolkits include more bladelets, along with geometric microliths and microburins, as well as a rich worked bone component. Pressure flaking was introduced during this period (Rahmani, 2004; Sheppard, 1987).

Faunal assemblages also changed at around 8000/8200 cal. BP. The majority of the animal protein in the Capsian diet came from vertebrates (especially hartebeest) and land snails, but there are also remains of many other animals including large herbivores such as aurochs and zebra. In Upper Capsian components, higher frequencies of smaller game such as gazelle and lagomorphs are present (Lubell, 2001; Lubell et al., 1976). In general, the Typical Capsian is characterized by the remains of larger species of

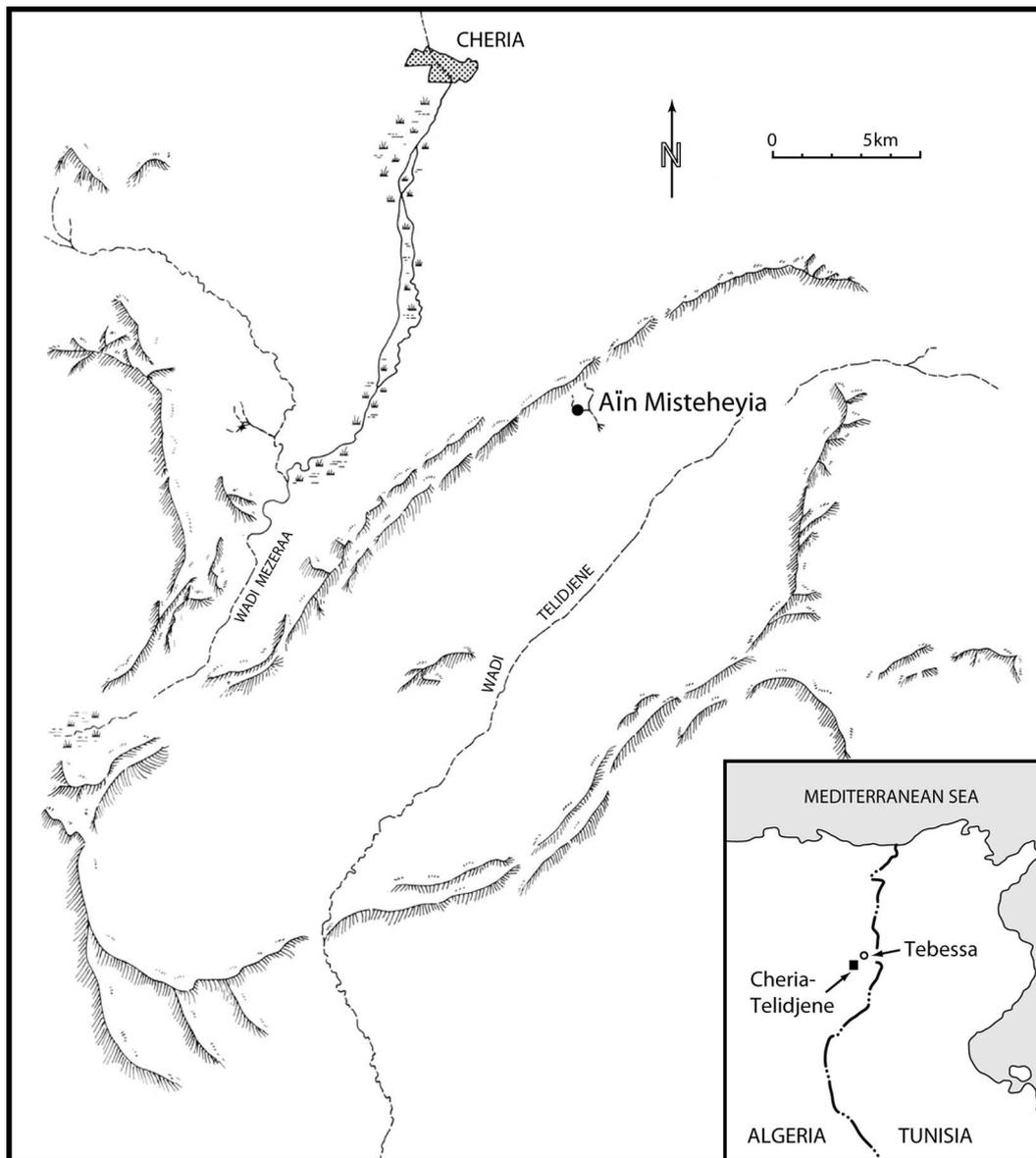


Figure 1. Location of Ain Misteheyia within the Telidjene Basin of the Tebessa-Cheria region of eastern Algeria.

mammals and molluscs than the Upper Capsian. This subsistence change is most likely related to fluctuating climate, general drying trends and middle-Holocene environmental change possibly including the 8.2 ky event (Alley et al., 1997; Courty and Vallverdu, 2001; Jackes and Lubell, 2008; Street-Perrott and Perrott, 1993) which is recognized in many studies of the North African Holocene (Linstädter, 2008). The mid-Holocene desiccation is also a significant episode of environmental change (Hassan, 2002, 2003–2004; Marshall and Hildebrand, 2002) which certainly would have impacted Capsian societies. The animal species consumed, toolkits, and occupation territory of the Capsian all appear to have changed in response to episodes of drying environmental conditions.

Lithic and faunal assemblages are well-represented in the Capsian archaeological record, but almost nothing is known about floral changes and Capsian plant exploitation in response to these environmental changes. Very few remains of charred seeds or tubers have been recovered from Capsian sites (Lubell, 2001) despite the abundance of ash and wood charcoal in the deposits (Couvert, 1977). Only a single charred bulb of *Allium* sp. was retrieved from one Capsian site (Lubell et al., 1976) but little else. Although the correlation between climatic events and culture

change is employed with caution, phytolith evidence from Ain Misteheyia adds new information on the shifts in microenvironments at one Capsian site as well as changes in plant exploitation strategies.

Ain Misteheyia

Ain Misteheyia is located on the northern flank of the Telidjene Basin, a truncated anticline in the Tebessa-Cheria region of eastern Algeria (Figure 1). The modern climate is a temperate, Mediterranean one. Average temperature in the Tebessa region ranges from 6°C in the winter to 25°C in the summer, with an average of 15°C. Average annual rainfall is about 300 mm. The site is an open air escargotière, 40 m in diameter. It was excavated in 1973 and 1976 (Lubell et al., 1975, 1976, 1982–1983) as part of an interdisciplinary study of Capsian cultural ecology.

There were no macrobotanical remains recovered from the site, but the excavators collected abundant remains of vertebrates and land snails. The vertebrate assemblage consists of large bovids (possible *Bos primigenius*), hartebeest (*Alcelaphus buselaphus*), Barbary Sheep (*Ammotragus lervia*), Dorcas and Atlas Gazelle (*Gazella dorcas* and *G. cuvieri*), zebra (*Equus*

mauritanicus), Golden Jackal (*Canis aureus*), and lagomorphs (*Lepus capensis* and *Oryctolagus cuniculus*), as well as some rare bones from birds, lizards, and rodents. Hartebeest is the most common large game animal. The land snail assemblage consists of four edible species, all still present in the region today. These are, from largest to smallest: *Helix melanostoma*, *Otala* sp., *Leucochroa candissima*, and *Helicella setifensis*.

Despite having been subjected to extensive deflation and compaction which made stratigraphic distinctions difficult to identify (Lubell et al., 1982–1983: 60–63), detailed geoarchaeological and zooarchaeological analyses coupled with studies of the lithic assemblage and a series of 11 radiocarbon dates on land snail shell, have allowed definition of a stratigraphic sequence that includes Typical Capsian in the lower levels and Upper Capsian above, separated by an hiatus. The distinction between the upper and lower occupations occurs at about 120 cm below datum. The levels from 120 cm to sterile substrate are dated from c. 9800 to 9500 cal. BP, while those above date from c. 8000 to at least 7200 cal. BP and probably later (Lubell et al., 2009). These are estimates using a 1000 year correction for land snail shell (Evin et al., 1980; Goodfriend, 1987; Mastronuzzi and Romaniello, 2008; Quarta et al., 2007) and calibrated with CALIB Rev. 5.0.1. (Reimer et al., 2004; Stuiver and Reimer, 1993).

The earlier levels have more hartebeest, zebra and aurochs, and *H. melanostoma*, along with a Typical Capsian lithic assemblage. The later levels indicate an increase in lagomorphs, smaller snails, and an Upper Capsian lithic assemblage. This change in the faunal remains and lithic technology correlates to a radiocarbon date of about 8000–8200 cal. BP, which agrees with the archaeological and zooarchaeological evidence from Kef Zoura D, a rock shelter site in the Telidjene Basin, where the chronology is based on charcoal dates using AMS (Jacks and Lubell, 2008).

Oxygen and carbon isotope analysis of land snails excavated at Aïn Misteheyia indicate that one of the various climatic fluctuations which occurred during human occupation was an abrupt cool/dry period at the site around 8000–8200 cal. BP (Faber et al., 2007, 2008). Various snail species exhibit a general decrease in $\delta^{18}\text{O}$ at this time. The data appear to correspond with Greenland ice cores, which record an abrupt decrease in $\delta^{18}\text{O}$ around 8200 cal. BP (Alley and Ágústsdóttir, 2005).

Phytoliths

Phytoliths provide evidence for the presence and use of plants at archaeological sites, making them a valuable tool for investigations in palaeoecology and human adaptations. Phytoliths at archaeological sites can be indicative of diet, climate and environment, use of space, farming techniques, seasonality (Rosen, 1999), and use of fuel (Albert et al., 2000).

Formation and morphology

Phytoliths are formed when plants uptake soluble silica, or monosilicic acid, that is present in different amounts in ground water, which then becomes solid silicon dioxide. Plants deposit the silica in the epidermis-cell lumen, or the space in between cells. Silica is either actively or passively acquired by the plant. During active absorption, plants place the silica in certain predetermined cells such as hair cells. Some plants exercise both active and passive uptake, depending on the plant part in which the silica is deposited (Piperno, 1988, 2006; Rosen, 1997, 1999).

The amount of silica in the soil and groundwater is correlated with the amount of silica absorbed by the plant (Piperno, 2006). The acidity of the soil, moisture content, and texture, as well as the amount of aluminum and iron oxides affects the concentration of soluble silica in the soil. The higher the evapotranspiration rate, the more plant silicification occurs, creating more multi-cell

phytoliths. Multicell forms, as opposed to single cells, have been the most promising for plant identification to genus or species of the plant (Piperno, 2006; Rosen, 1999). At Aïn Misteheyia, the plants represented by our phytolith assemblages grew within a wetland context in which sediment and environmental conditions encouraged the passive uptake of abundant silica. Hence, the phytoliths include large numbers of multicell forms.

Not all plants produce phytoliths. Monocotyledons, or sedges, grasses, and palms, produce the most phytoliths and are therefore the most widely used plants for phytolith analyses (Piperno, 1988). Crenates, bilobes, rondels, crosses, and saddles, or short-cell phytoliths, are produced in grasses and are useful in environmental reconstruction (Barboni et al., 1999; Pearsall, 1989; Piperno, 1988, 2006; Rosen, 1997; Twiss et al., 1969). Comparing grasses that have different photosynthetic pathways may indicate rainfall, temperature, and elevation (Piperno, 2006; Rosen, 2001). For example, grasses in the Poooid subfamily of gramineae are C3 plants and the presence of those phytoliths indicates a temperate environment. The Panicoid subfamily contains C4 grasses that grow in warm and moist environments. Sedges (Cyperaceae Family) produce cone-shaped phytoliths whose presence indicates a wetland microenvironment (Rosen, 2001).

A comparative approach is typical within phytolith studies. A species of plant may produce variations of the same morphotypes. For example, maize produces a variety of rondel morphotypes (Piperno, 2006). Conversely, different types of plants may produce similar phytoliths. Phytolith morphotypes produced by dicotyledons, or woody plants, are hairs, hair bases, silica aggregates, sclereids, spherical phytoliths, platy phytoliths, and polyhedral and anticlinal epidermal types (Piperno, 1988: 443). Most dicot phytoliths are only indicative of the presence or use of trees and shrubs rather than family, tribe, or species as can be the case with monocots. Platy phytoliths are found in wood ash and are a good indicator of hearths (Rosen, 2000). Silica aggregates are the most common woody phytoliths (Albert et al., 2000).

Laboratory method

The sediment samples for this investigation come from the 1973 and 1976 excavations at Aïn Misteheyia. Five of the 18 excavated squares are represented, all of which had samples collected from every 5 cm of the entire profile sequence. The exception was one sample that came from one of two probable hearths at 50 cm below datum. Fragments of fired clay from this feature have been dated by TL/OLS to 4230 ± 370 BP (Lubell et al., 2009: 181). All of the samples were processed in the field through nested geological sieves and the < 2 mm fraction retained for further analyses. Here we report on 20 of these samples including the hearth. Each of the excavation squares and soil profile units is represented by at least three samples. Our investigations were aimed at analyzing temporal rather than spatial variability in order to understand environmental and cultural changes over time.

The procedure phytolith extraction followed Rosen's protocol (Rosen, 1999). The sediment was sieved through 0.25 mm mesh to separate the larger particles from the samples, and then weighed to obtain an aliquot of approximately 1 g. The sediment was treated with a 10% HCl solution to remove carbonates, and then washed and centrifuged several times. Sodium hexametaphosphate, or Calgon, was added to the samples to deflocculate and aid in clay removal. Sand and silt were allowed to settle in a measured beaker of distilled water, and the clay in suspension was poured off. Once the sample dried, it was placed in a muffle furnace at 500°C for 2 h to burn off remaining organic material.

In order to separate the phytoliths from other minerals, the sample was floated in a high density solution of sodium polytungstate and distilled water, with a density of 2.3 sp.gr. The phytoliths in

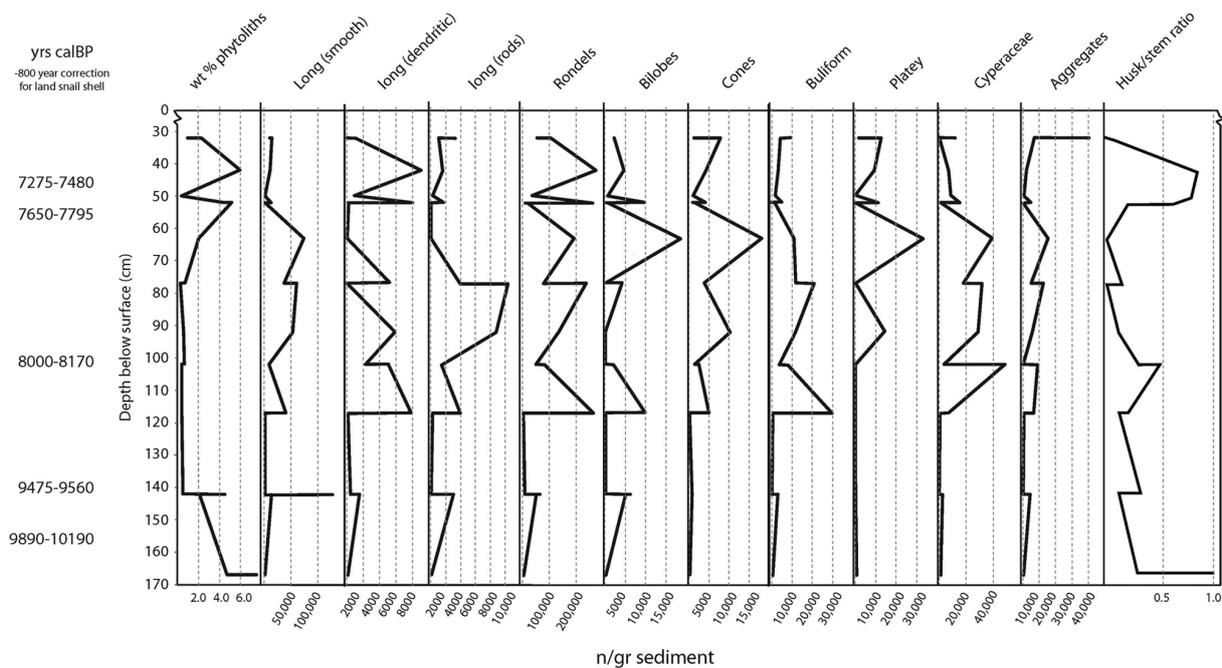


Figure 2. Number of relevant phytolith morphotypes per gram sediment by depth of excavation. Please note the varying scales between morphotypes.

suspension were transferred to other centrifuge tubes where they were again washed and centrifuged several times. The phytoliths were then pipetted onto a surface to dry before mounting. Finally, the phytoliths were mounted with Entellan (Merck).

Capsian escargotières contain ash-rich deposits, which typically have high phytolith densities (Rosen, 1999). This was the case for Aïn Misteheyia. The single-cell phytoliths were counted to 300 and the multicell phytoliths to 100 for each sample, generating a count of 400 phytoliths per sample. The number of phytoliths per gram sediment is determined, as this makes an absolute rather than a relative standard for which to compare samples across contexts (Rosen, 1999). Phytoliths were counted using a transmitting light microscope at 400 \times magnification.

Discussion of results

Environment

Short cell phytoliths are used as indicators of grassland types (Barboni et al., 1999; Pearsall, 1989; Piperno, 1988; Rosen, 1997; Twiss et al., 1969). The most numerous short cell phytolith morphotypes present in the Aïn Misteheyia deposits are rondels (Figure 3a) which generally derive from Pooid grasses (Figures 2, 3a), and employ a C3 photosynthetic pathway. The presence of C3 rather than C4 grasses is indicative of greater rainfall and more temperate climatic conditions.

Other short cells included a much smaller number of bilobate morphotypes indicative of C4 Panicoid grasses which favor warm moist microenvironments, and cones from sedges (Cyperaceae) (Figure 2). The majority of the multicell phytoliths identified were also from sedges, and most of these were from the stems of these plants (Figure 3b). Sedges are a wetland plant, and their presence suggests that the spring at the site was continually active. This is also in keeping with other environmental proxies from the site such as snail species, $\delta^{18}\text{O}$ and faunal remains, which indicate greater rainfall and lower evapotranspiration rates (Jackes and Lubell, 2008). These phytolith data are also consistent with other lines of proxy evidence for North Africa in the early to mid Holocene, which indicate that conditions were significantly wetter

than the later Holocene, and wetter than at present (Linstädter, 2008; Street-Perrott and Perrott, 1993). This environmental setting provided a favorable and productive habitat for Capsian foraging activities (Lubell, 1984).

Seasonality

The seasonality of Capsian sites is not entirely clear due in large part to the lack of environmental evidence. In most cases, vertebrate remains are too fragmentary or generally inconclusive. Since charred plant remains are almost unknown, seasonality has been inferred from the presence of species of snails that aestivate at certain times of the year, and the ratios of the different species of snails (Lubell et al., 1975).

By comparing the frequency of smooth long cells from the stems of grasses, to dendritic long cells from grass-seed husks, we can ascertain the season of plant collection and use. Since the husks are formed in spring and summer, the presence of a greater amount of dendritic husk phytoliths rather than stem phytoliths at Aïn Misteheyia would indicate a spring occupation. In general, in most of the lower sampling depths (below the levels dating to 8000/8200 cal. BP), the ratio of dendritic to smooth long cells is low, which suggests that the site was not occupied in the spring. However, in the upper levels between the depths of 42–52 cm below datum, the husk/stem ratio increases greatly in some samples indicating a larger number of grass husks, and suggesting both a shift to a spring occupation as well as increased exploitation of grass seeds (Figure 2).

Fuel

Silica aggregates are the most common phytolith type from woody plants (Albert et al., 2000) and were abundant in the samples from Aïn Misteheyia (Figure 2). Platey phytoliths were also present in the assemblage (Figure 3c). This type is derived from wood ash (Rosen, 2000), and is consistent with the large amount of ash in the deposits, possibly as a result of burning wood in fires.

Many multicell sedge phytoliths were present in the hearth sample which had a high ratio of multicell to single cell phytoliths.

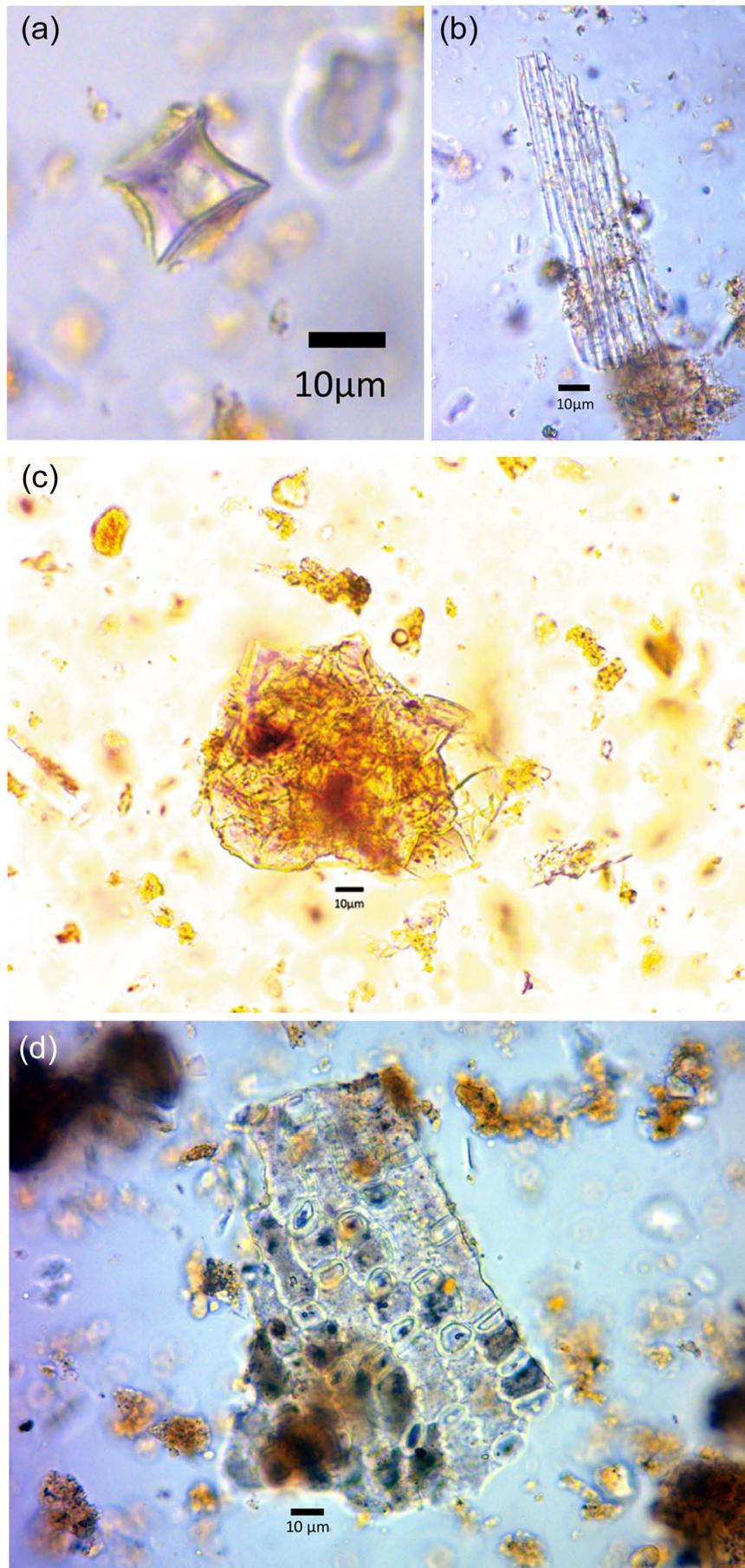


Figure 3. Photographs of selected phytolith morphotypes. (a) A rondel phytolith, generally derived from C3 Pooid grasses. (b) A multicell phytolith from the stem of a sedge (Cyperaceae). (c) A platey phytolith morphotype from the wood of a dicotyledon (woody plant or tree). (d) A multicell phytolith from a grass husk, comparing favorably to phytoliths from Halfa grass (c.f. *Desmostachya bipinnata*).

Every other sample had a ratio of 0.02–0.6, but the hearth had a ratio of multi/single cells of 2.69. The majority of multicell phytoliths were from sedges (Cyperaceae) which grow in marshy environments. The wetland plants that grew near the spring may have been dried and used for fuel, possibly as kindling for the fires. The large amount of multicell sedge phytoliths in the hearth may also be in part attributed to objects made of sedges, such as bedding, matting, and baskets (Rosen, 1999) being discarded into the fire.

Diet

Significantly, as mentioned above, there appears to be an increase in grass husk phytoliths, specifically a type that compares favorably to Halfa grass (*Desmostachya bipinnata*) husks (Figure 3d) in the upper part (from 35 to 65 cm) of the Aïn Misteheyia deposits (Figure 2). This very likely indicates a shift in plant resource priorities towards a more intensive exploitation of grass seeds. Winterhalder and Golan (1997) discuss just such a subsistence and resource ranking change among hunter/gatherers in situations of climatic stress. With the reduction in shrubs and woodland vegetation in favor of grasslands, highly ranked resources such as nuts, or in this case perhaps sedge tubers, will often give way to lower ranked resources such as grass seeds (Rosen, 2010; Rosen and Rivera-Collazo, 2012; Winterhalder, 1990; Winterhalder and Golan, 1997). Although there are no grinding stones at Aïn Misteheyia, the grass husks might very well indicate an increase in the exploitation of grass seeds, and a low level grass exploitation technology in which seeds are consumed as gruel rather than bread.

Typical and Upper Capsian occupations

The frequency and types of phytoliths are grouped into an upper and lower assemblage, as are the faunal and lithic assemblages at Aïn Misteheyia (Figure 2). Significantly, the changes in the assemblages at Aïn Misteheyia occurred after 7650/7795 cal. BP. There are fewer phytoliths present in the samples within the upper 65 cm of the deposits, while the occupation levels from about 65 to 115 cm below datum have a noticeably higher density of phytoliths. The most notable aspects of the phytolith record are the shift from large numbers of sedges (Cyperaceae) and low numbers of grass husk phytoliths in the lower portion of the record (65–115 cm) to a drop in sedges and an increase in grass husk phytoliths in the upper part of the record (35–65 cm) which may be related to drying environmental conditions. This corresponds to the shift between the Typical and Upper Capsian levels, and very likely represents a change in subsistence strategy from an emphasis on sedge tubers to more intensive use of grass seeds. The shift from sedges to grasses is one explanation for the change in phytolith density, since sedges generally have higher yields of phytoliths than grasses.

Conclusion: Towards an understanding of the late Capsian by examining changing subsistence strategies

The significance of this investigation lies in its contribution towards further understanding Capsian subsistence strategies at Aïn Misteheyia and how they changed with shifting environmental conditions. Despite debates concerning the chronological and geographical relationship between Typical and Upper Capsian, it is agreed that there was a change in lithic toolkits, the species of animals that were exploited, richness of the shell and bone industries, and territory, all at around 8000/8200 cal. BP. We have

shown here that there was probably a change in plant exploitation strategies after this time as well. This change from a traditionally high-ranked resource such as possibly sedge tubers to a traditionally lower-ranked resource such as grass seeds is a common strategy among hunter/gatherer societies as a response to drying conditions in semi-arid environments (Gremillion, 2004; Kennett and Winterhalder, 2006; Rosen, 2010; Rosen and Rivera-Collazo, 2012; Winterhalder and Golan, 1997). It is an adaptation that allows these societies to maintain a successful foraging lifestyle by reducing risk within a less-predictable environmental regime. Perhaps this significant adjustment in subsistence strategies was one of the factors that allowed Capsian groups to maintain their lifestyle as other North African groups turned to pastoralism. The Neolithic of Capsian tradition emerged about 6000 cal. BP, making the Capsian the last hunter-gatherers of the Maghreb (Camps, 1975; Lubell, 1984; Rahmani, 2004; Roubet, 2001). The phytolith evidence from Aïn Misteheyia adds to an understanding of Capsian ecology, which is integral to furthering our understanding of Capsian culture change.

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References

- Albert RM, Weiner S, Bar-Yosef O et al. (2000) Phytoliths in the middle Palaeolithic deposits of Kebara Cave, Mount Carmel, Israel: Study of the plant materials used for fuel and other purposes. *Journal of Archaeological Science* 27: 931–947.
- Alley RB and Ágústssdóttir AM (2005) The 8k event: Cause and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews* 24(10–11): 1123–1149.
- Alley RB, Mayewski PA, Sowers T et al. (1997) Holocene climatic instability: A prominent, widespread event 8200 yr ago. *Geology* 25: 483–486.
- Barboni D, Bonnefille R, Alexandre A et al. (1999) Phytoliths as paleoenvironmental indicators, west side Middle Awash Valley, Ethiopia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 152: 87–100.
- Camps G (1975) The prehistoric cultures of North Africa: A radiocarbon chronology. In: Wendorf F and Marks AE (eds) *Problems in Prehistory: North Africa and the Levant*. Dallas: Southern Methodist University, pp. 181–192.
- Courty M-A and Vallverdú J (2001) The microstratigraphic record of abrupt climate changes in cave sediments of the western Mediterranean. *Geoarchaeology: An International Journal* 16(5): 467–500.
- Couvert M (1977) *Atlas d'Anatomie des Charbons de Foyers Préhistoriques Afrique du Nord Tempérée*. Algiers: Mémoires du CRAPE 26.
- Cremschi M, Zerboni A, Spötl C et al. (2010) The calcareous tufa in the Tadrart Acacus Mt. (SW Fezzan, Libya): An early Holocene palaeoclimate archive in the central Sahara. *Palaeogeography, Palaeoclimatology, Palaeoecology* 287(1–4): 81–94.
- Evin J, Marechal J, Pachiaudi C et al. (1980) Conditions involved in dating terrestrial shells. *Radiocarbon* 22: 545–555.
- Faber M, Yapp CJ and Lubell D (2007) Stable isotope composition of land snails from an ~8ka B.P. archaeological site in eastern Algeria. *GSA Abstracts – GSA 2007 Annual Meeting*. Denver.
- Faber M, Yapp CJ and Lubell D (2008) Oxygen and carbon isotope compositions of land snail shells from ~8ka B.P. archaeological sites in interior Algeria. *GSA Abstracts – GSA 2008 Annual Meeting*. Houston.

- Gasse F (2000) Hydrological changes in the African tropics since the Last Glacial Maximum. *Quaternary Science Reviews* 19(1–5): 189–211.
- Gasse F (2002) Diatom-inferred salinity and carbonate oxygen isotopes in Holocene waterbodies of the western Sahara and Sahel (Africa). *Quaternary Science Reviews* 21(7): 737–767.
- Gasse F and Van Campo E (1994) Abrupt post-glacial climate events in West Asia and North Africa monsoon domains. *Earth and Planetary Science Letters* 126(4): 435–456.
- Gobert E-G (1937) Les escargotières: Le mot et la chose. *Revue Africaine* 81: 639–645.
- Goodfriend GA (1987) Radiocarbon age anomalies in shell carbonate of land snails from semi-arid areas. *Radiocarbon* 29: 159–167.
- Gremillion KJ (2004) Seed processing and the origins of food production in eastern North America. *American Antiquity* 69: 215–233.
- Hassan FA (2002) Conclusion: Ecological changes and food security in the later prehistory of North Africa: Looking forward. In: Hassan FA (ed.) *Droughts, Food, and Culture: Ecological Change in Africa's Later Prehistory*. London: Kluwer Academic.
- Hassan F (2003–2004) *Climatic Changes and Cultural Transformations in Farafra Oasis, Egypt*. Archaeology International UCL, pp. 35–39.
- Jackes M and Lubell D (2008) Environmental and cultural change in the early and mid Holocene: Evidence from the Télijdjène Basin, Algeria. *African Archaeological Review* 25(1–2): 41–55.
- Kennett DJ and Winterhalder B (2006) *Behavioral Ecology and the Transition to Agriculture*. Berkeley: University of California Press.
- Lézine A-M (2009) Timing of vegetation changes at the end of the Holocene Humid Period in desert areas at the northern edge of the Atlantic and Indian monsoon systems. *Comptes Rendus Geosciences* 341(8–9): 750–759.
- Linstädter J (2008) The Epipalaeolithic–Neolithic transition in the Mediterranean region of northwest Africa. *Quartär* 55: 41–62.
- Lubell D (1984) Paleoenvironments and Epi-Paleolithic economies in the Maghreb (ca. 20,000 to 5000 B.P. In Clark JD and Brandt SA (eds) *From Hunters to Farmers: The Causes and Consequences of Food Production in Africa*. Berkeley: University of California Press, pp. 41–56.
- Lubell D (2001) Late Pleistocene–early Holocene Maghreb. In: Perrigine PN and Ember M (eds) *Encyclopedia of Prehistory, Volume 1: Africa*. New York: Kluwer/Plenum Publishers, pp. 129–149.
- Lubell D (2004a) Prehistoric edible land snails in the circum-Mediterranean: The archaeological evidence. In: Brugal J-J and Desse J (eds) *Petits Animaux et Sociétés Humaines. Du Complément Alimentaire Aux Ressources Utilitaires. XXIVe rencontres internationales d'archéologie et d'histoire d'Antibes*. Antibes: Éditions APDCA, pp. 77–98.
- Lubell D (2004b) Are land snails a signature for the Mesolithic–Neolithic transition in the circum-Mediterranean? In: Budja M (ed.) *The Neolithization of Eurasia – Paradigms, Models and Concepts Involved*. Neolithic Studies 11, Documenta Praehistorica XXXI, pp. 1–24.
- Lubell D, Ballais JL, Gautier A et al. (1975) The prehistoric cultural ecology of Capsian escargotières: Preliminary results of an interdisciplinary investigation in the Cheria-Telidjène region (1972–1973). *Libyca* 23: 44–121.
- Lubell D, with contributions by Feathers J and Schwenninger J-L (2009) Post-Capsian settlement in the eastern Maghreb: Implications of a revised chronological assessment for the adult burial at Ain Misteheyia. *Journal of African Archaeology* 7(2): 175–189.
- Lubell D, Hassan FA, Gautier A et al. (1976) The Capsian escargotières. *Science* 191(4230): 910–920.
- Lubell DA, Gautier ET, Leventhal M et al. (1982–1983) Prehistoric cultural ecology of Capsian Escargotières II: Report on investigations conducted during 1976 in the Bahiret Telidjène, Tebessa Wilya, Algeria. *Libyca* 30/31: 59–142.
- Marshall F and Hildebrand E (2002) Cattle before crops: The beginnings of food production in Africa. *Journal of World Prehistory* 16(2): 99–143.
- Mastroruzzi G and Romaniello L (2008) Holocene aeolian morphogenetic phases in southern Italy: Problems in ¹⁴C age determinations using terrestrial gastropods. *Quaternary International* 183: 123–134.
- Mulazzani S (2010) *L'Habitat Epipaléolithique de Shm-1 et les sites environnants au bord de la Sebkhah-Lagune de Halk El Menjel (Hergla – Tunisie) entre le VIIe et le VIe Millénaire cal BC*. Thèse de Doctorat, Université Paris 1 – Panthéon-Sorbonne.
- Mulazzani S (ed.) (2012) *Le capsien de Hergla (Tunisie). Culture, environnement et économie*. Reports in African Archaeology. Frankfurt: Africa Magna Verlag.
- Mulazzani S, Le Bourdonnec F-X, Belhouche L et al. (2010) Obsidian from the Epipalaeolithic and Neolithic eastern Maghreb. A view from the Hergla context (Tunisia). *Journal of Archaeological Science* 37: 2529–2537.
- Pearsall DM (1989) *Palaeoethnobotany: A Handbook of Procedures*. San Diego: Academic Press.
- Piperno DR (1988) *Phytolith Analysis: An Archaeological and Geological Perspective*. San Diego: Academic Press.
- Piperno DR (2006) *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*. New York: Altamira Press.
- Quarta G, Romaniello L, D'Elia M et al. (2007) Radiocarbon age anomalies in pre- and post-bomb land snails from the coastal Mediterranean Basin. *Radiocarbon* 49: 817–826.
- Rahmani N (2004) Technological and cultural change among the last hunter-gatherers of the Maghreb: The Capsian (10,000–6,000 B.P.). *Journal of World Prehistory* 18(1): 57–105.
- Reimer PJ, Baillie MGL, Bard E et al. (2004) IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46: 1029–1058.
- Rosen AM (1997) Phytoliths evidence for cereal cultivation at Horvat Galil and Nahal Beset. *Tel Aviv* 24(2): 229–236.
- Rosen AM (1999) *The Practical Impact of Science on Near Eastern and Aegean Archaeology*. Weiner Laboratory Publication 3 (Pike, Scott and Seymour Gitin, eds). London: Archetype Press, pp. 86–92.
- Rosen AM (2000) *Phytolith Report for Tseganka 8*. <http://www.faculty.sbc.edu/cchang/Kaz%20web/TS8Phyto.htm>
- Rosen AM (2001) Phytolith evidence for agro-pastoral economies in the Scythian period of southern Kazakhstan. In: Meunier JD, Colin F and Faure-Denard L (eds) *The Phytoliths: Applications in Earth Science and Human History*. Aix en Provence: CEREGE, pp. 183–198.
- Rosen AM (2010) Natufian plant exploitation: Managing risk and stability in an environment of change. *Eurasian Prehistory* 7(1): 117–131.
- Rosen AM and Rivera-Collazo I (2012) Climate change, adaptive cycles and the persistence of foraging economies during the Late Pleistocene/Holocene transition in the Levant. *PNAS* 109(10): 3640–3645.
- Roubet C (2001) Neolithic of Capsian: Neolithique de Tradition Capsienne *sensu stricto*. In: Perrigine PN and Ember M (eds) *Encyclopedia of Prehistory, Volume 1: Africa*. New York: Kluwer/Plenum Publishers, pp. 197–219.
- Sheppard P (1987) *The Capsian of North Africa: Stylistic Variation in Stone Tool Assemblages*. Oxford: British Archaeological Reports, International Series 353.
- Street-Perrott FA and Perrott RA (1990) Abrupt climatic fluctuations in the tropics: The influence of Atlantic Ocean circulations. *Nature* 343: 607–612.
- Street-Perrott FA and Perrott RA (1993) Holocene vegetation, lake-levels and climate of Africa. In: Wright HEJ, Kutzbach JE, Webb T et al. (eds) *Global Climates since the Last Glacial Maximum*. Minneapolis: University of Minnesota, pp. 318–356.
- Stuiver M and Reimer PJ (1993) Extended ¹⁴C data base and revised CALIB 3.0 ¹⁴C age calibration program. *Radiocarbon* 35: 215–230.
- Tixier J, Marmier F and Trécolle G (1976) *Le Campement Préhistorique de Bordj Mellala (Algérie)*. Paris: Éditions du Cercle de Recherches et d'Études Préhistoriques.
- Twiss PC, Suess E and Smith RM (1969) Morphological classification of grass phytoliths. *Proceedings of the Soil Science Society of America* 33(1): 109–115.
- Watrín J, Lézine A-M and Hély C (2009) Plant migration and plant communities at the time of the 'green Sahara'. *Comptes Rendus Geosciences* 341(8–9): 656–670.
- Winterhalder B (1990) Open field, common pot: Harvest variability and risk avoidance in agricultural and foraging societies. In: Cashdan E (ed.) *Risk and Uncertainty in Tribal and Peasant Economies*. Boulder: Westview, pp. 67–87.
- Winterhalder B and Golland C (1997) An evolutionary ecology perspective on diet choice, risk and plant domestication. In: Gremillion KJ (ed.) *People, Plants, and Landscapes: Studies in Paleoethnobotany*. Tuscaloosa: University of Alabama, pp. 123–160.
- Zielhofer C and Linstädter J (2006) Short-term mid-Holocene climatic deterioration in the West Mediterranean region: Climatic impact on Neolithic settlement pattern? *Zeitschrift für Geomorphologie N.F., Suppl.* 142: 1–17.