The Capsian Escargotières

An interdisciplinary study elucidates Holocene ecology and subsistence in North Africa.

David Lubell, Fekri A. Hassan
Achilles Gautier, Jean-Louis Ballais

The Capsian of the Maghreb is one of a number of broadly similar terminal Pleistocene and Holocene archeological cultures in the circum-Mediterranean region, which are characterized by lithic assemblages of backed blades and bladelets and a diversified hunting, gathering, and collecting subsistence economy in which land snails were an important dietary item.

Capsian sites, called escargotières by most prehistorians (the local name, ramadiya, is derived from the Arabic for ash or ashy color), are characteristically small (20 to 30 meters in diameter), open-air middens composed of ash, fire-cracked rock, flint artifacts, bone fragments, charcoal, occasional human burials, and enormous numbers of land snail shells. These shells are the dominant visual element in most sites.

The Capsian "culture area" has been traditionally considered to lie in the High Constantine Plains of northeastern Algeria and the adjacent Gafsa region of Tunisia (*1*, pp. 414–429; *2*). The name Capsian is derived from the Roman town of Capsa (modern Gafsa). This was first proposed by de Morgan in 1909, the same year in which Pallary suggested the name Gétulien for these archeological materials (*3*). Nomenclatural priority has gone to Capsian.

The distribution of the Capsian is somewhat more extensive than was previously believed. There are no Capsian sites known along the North African littoral, but Capsian assemblages have now been recorded in western Algeria. Interestingly, none have been identified in Morocco (*4*). Furthermore, there appear to be sites that contain Capsian lithic assemblages but few or no land snails along the northern fringes of the Sahara, particularly near oases or chotts in regions such as Négrine and Ouled Djellal (*5*). Both Balout (*1*, p. 428) and Pond (*6*, pp. 159–162) have discussed the possibility of movement (perhaps transhumance) between the High Constantine Plains and the northern Sahara along the major northeast-to-southwest trending synclinal valleys of the Saharan Atlas.

The Capsian is securely dated, according to the radiocarbon method, to between circa 10,000 and 7,000 years ago (*7*). It is generally agreed that it was preceded temporally but not spatially by the Iberomaurusian (sometimes called Oranian), an Epipaleolithic industry that is restricted to the littoral with one possible exception, the site of Columnata in western Algeria (*8*). Locally, the Capsian is succeeded by the Neolithic of Capsian Tradition (7000 to 5000 years ago), which is identified by the addition of ceramics and arrowheads to otherwise largely unchanged *Capsien supérieur* lithic assemblages. There is no conclusive evidence for a fully agricultural economy associated with the Neolithic of Capsian Tradition (*4*).

The number of Capsian sites in northeastern Algeria and adjacent Tunisia is very large. A survey of the Tébessa region by Grébénart (*5*) prior to our work there identified more than 200, and the total left undiscovered may well be twice that. We estimate conservatively that at least one-quarter of the original number of sites in the region has been destroyed by erosion.

Sites appear to have been preferentially located near springs, wadis, or along the base of escarpments. However, this distribution is probably attributable to both preservation and ease of access by prehistorians rather than being an accurate reflection of the original situation. Density of undestroyed sites is high. The average is about one site per 10 square kilometers, and clusters of sites are common. Sites range in size from small mounds (about 10 meters in diameter) to those 100 meters in diameter. Large rock-shelters like Relilaï may contain 5 meters of deposit within an area of about 800 square meters.

Traditionally, the Capsian has been divided into two successive units: the earlier *Capsien typique*, characterized by large tools such as endscrapers, burins, and backed blades; and the later *Capsien supérieur*, in which backed bladelets and geometric microliths predominate. Radiocarbon dates now preclude this interpretation, for they show the two units to be contemporaneous (*9*). Furthermore, the *Capsien typique* and *Capsien supérieur* assemblages are said to be interstratified at Relilaï, one of the sites on which this developmental scheme was based (*5*). In fact, the sequence has only been demonstrated stratigraphically at five sites and is suspected on typological grounds at three more (*10*).

Dr. Gabriel Camps and his colleagues at Aix-en-Provence have reinterpreted the *Capsien supérieur* to include three chronological phases that crosscut five regional facies. In addition, they have argued that the *Capsien typique* was a local variant largely restricted to the Tébessa region (*4*). Our work raises some question about this temporal and spatial sequence.

Our research was designed as an interdisciplinary study of the prehistoric cultural ecology of Capsian escargotières in the Chéria-Télidjène region of northeastern Algeria (Fig. 1). Previous work had demonstrated the abundance of sites there and the chronology was fairly well established, thus obviating the necessity of extensive survey. This has permitted us to turn our attention to a systematic investigation of the modern and prehistoric environment and relate these data to the pattern of Capsian occupation and subsistence practices in the region.

Capsian subsistence has been the subject of considerable speculation but little systematic investigation during the past 40 years. Many prehistorians have concluded that the Capsian diet was based primarily on land snails despite strong admonitions to the contrary from Gobert (*11*), who argued in 1937 that, "Rien n'autorise à l'affirmer ni n'autorise à croire que l'escargot occupait la première place dans la cuisine capsienne." Vaufrey (*12*) characterized the Capsian economy as one in which hunting and plant collecting were equally as important as (and perhaps more important than) snail collecting. Balout (*1*, p. 431) argued that Capsian groups were primarily sedentary gatherers who may have practised some form of subsistence agriculture during the *Capsien supérieur*. Romer (*6*, p. 166) suggested in 1938 that differential frequencies of vertebrate re-

Dr. Lubell is associate professor of anthropology at the University of Alberta, Edmonton, Canada. Dr. Hassan is assistant professor of anthropology at Washington State University, Pullman 99163. Dr. Gautier is chef de travaux, Laboratorium voor Paleontologie, Rijksuniversiteit-Gent, Gent, Belgium. Dr. Ballais is a member of the Départment de Géographie, Université de Caen, Caen, France.

mains in numerous escargotières might be a reflection of seasonal occupation, but subsequent investigators seem to have ignored the implications of this idea. Balout (*1*, p. 121) did suggest at one point that study of the seasonal ethology of the land snails present in the escargotières might be profitable, but until now only Morel (*13*) has pursued the idea.

It has been known for some time that the same species of land snails found in the sites are still extant in the region. Baker (*6*, pp. 190–201) and Morel (*13*) both emphasized the seasonal availability of these animals. Unfortunately, no systematic study of the ecology of North African land snails exists, although there are analogous species elsewhere within the Mediterranean region that are known to be seasonal. Since these species were probably seasonally abundant during the Holocene as well, it seems reasonable to suggest that at least some of the Capsian sites were occupied seasonally. It is possible, for example, that Capsian groups had a seasonal round that included the northern border of the Sahara.

Our research was originally intended to examine this possibility. However, it quickly became apparent that extensive work would have to be undertaken in the High Constantine Plains before results from other regions could be interpreted. Therefore, we concentrated our efforts in the Chéria-Télidjène region where we studied the ecology of modern and prehistoric land snail and plant communities, the geomorphological setting of Capsian sites, the microstratigraphy of these sites and associated Holocene deposits, and the palynology of alluvial sediments. We partially excavated one escargotière to investigate intra-site patterning. Although this research is still in progress, our results so far enable us to present tentative conclusions about the changing nature of Holocene environment and the subsistence adaptations of Capsian populations in the Maghreb.

Environmental Setting

Northeastern Algeria consists of several biogeographical zones. Included within these are the High Constantine Plains, which are bordered on the north by the Atlas Tell, on the west by the Aurès Mountains, and on the south by the Nemenchas. The region includes the major centers of Sétif, Constantine, Biskra, and Tébessa. Average elevation is 1000 meters above sea level, with an undulating topography punctuated by elongate ridges that rise 400 to 500 meters above the plains.

The climate is semiarid with cool, wet winters (BSk under the Köppen classification). Mean annual precipitation at Tébessa is 340 millimeters with the monthly minimum in July (8 millimeters) and monthly maximum in April (44 millimeters). Snow is common in winter. Mean annual temperature is 15°C with a mean monthly low of 5.6°C in January and a mean monthly high of 25.6°C in July (*14*).

The Chéria-Télidjène region lies between two floristic provinces as defined by Quézel and Santa (*15*); to the north are the High Constantine Plains sensu stricto (H2) and to the south the Constantine Saharan Atlas (AS3). Most of the region has been heavily cultivated or grazed during the last 2000 years, and poor conservation practices have led to extensive stream and slope erosion, resulting in wide scale denudation. Modern vegetation consists of a degraded steppe. At lower elevations the vegetation consists predominantly of alfa grass (*Stipa tenacissima*) with artemisia (*Artemisia herba-alba* and *A. campestris*). In more humid habitats (for example, wadi courses), poplar (*Populus alba*), willow (*Salix pedicellata*), tamarix (*Tamarix africana*), oleander (*Nerium oleander*), rushes (*Peganum harmala*), and various thistles all occur. On those slopes where soil remains, occasional stands of pine (*Pinus halepensis*), oak (*Quercus ilex*), and juniper (*Juniperus phoenicea*) still occur.

The High Constantine Plains are primarily farmed for cereal crops now. The Chéria-Télidjène region has a herding economy (sheep and goat) with a variety of cereal and vegetable crops grown in irrigated fields.

Wild animals are rare, consisting primarily of hare, an occasional jackal, a few birds, some reported but very rare antelope or gazelle, and a range of terrestrial microfauna that include gerbils, scorpions, liz-

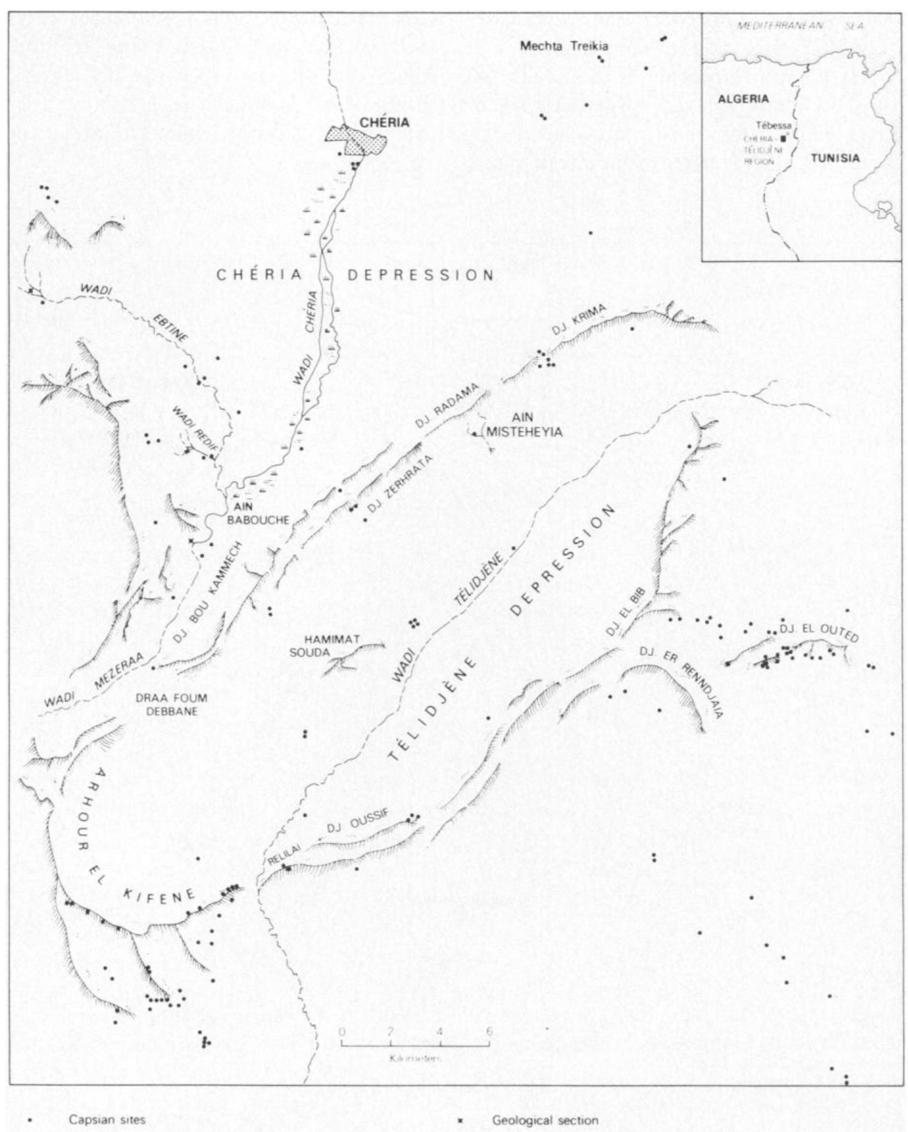

Fig. 1. The Chéria-Télidjène region, with localities mentioned in the text and the density of Capsian sites. [Courtesy of *Libyca*]

ards, snakes, and the same species of land snails found in the escargotières.

Water is relatively plentiful and occurs in springs, spring-fed streams, or artificial wells of up to 20 meters in depth. Shortages do occur in larger towns, especially during summer when antiquated water systems are unable to cope with modern urban population densities. Deep wells at the Roman sites scattered throughout the region are dry, suggesting considerable lowering of the water table during the past 2000 years.

Geomorphological Setting

The Chéria-Télidjène region is characterized by the juxtaposition of large southwest-to-northeast oriented depressions bounded by low narrow djebels (ridges) of uplifted Eocene limestones. A series of four such depressions constitutes the region of contact between the High Constantine Plains and the Nemenchas.

The Chéria Depression is the largest (40 by 22 kilometers) and most complex of these depressions. It is a large lobed syncline that rises steeply to the north where Djebel Dokkane (1712 meters) dominates the marshy Tébessa plain. To the south, the dip increases to form the anticlines of Outa Guibeur and Télidjène that are separated by a narrow syncline complicated by anticlinal folds near Aïn Babouche (Arabic for snail spring). Wadi Chéria/Mezeraa drains south along this syncline (Fig. 1).

The Télidjène Depression (28 by 8 kilometers) is rich in Capsian sites and has been the focus of our investigations. The basin is bounded by an escarpment of jointed Eocene limestone that rises to 1380 meters at Djebel Bou Kammech. In the center of the depression is an isolated "mont derivé," the Hamimat Souda (1183 meters), formed of Lower Cretaceous sandstones and quartzites that dip gently to the east and more steeply to the west where they are affected by several faults. To the southwest of this, the diapiric zone of Draa Foum Debbane is formed of conic hills eroded into Triassic saliferous clays and overlain by jointed dolomitic limestones. In the center of the depression, Wadi Télidjène has cut its bed into variegated marly clays of Upper Cretaceous or Paleocene age.

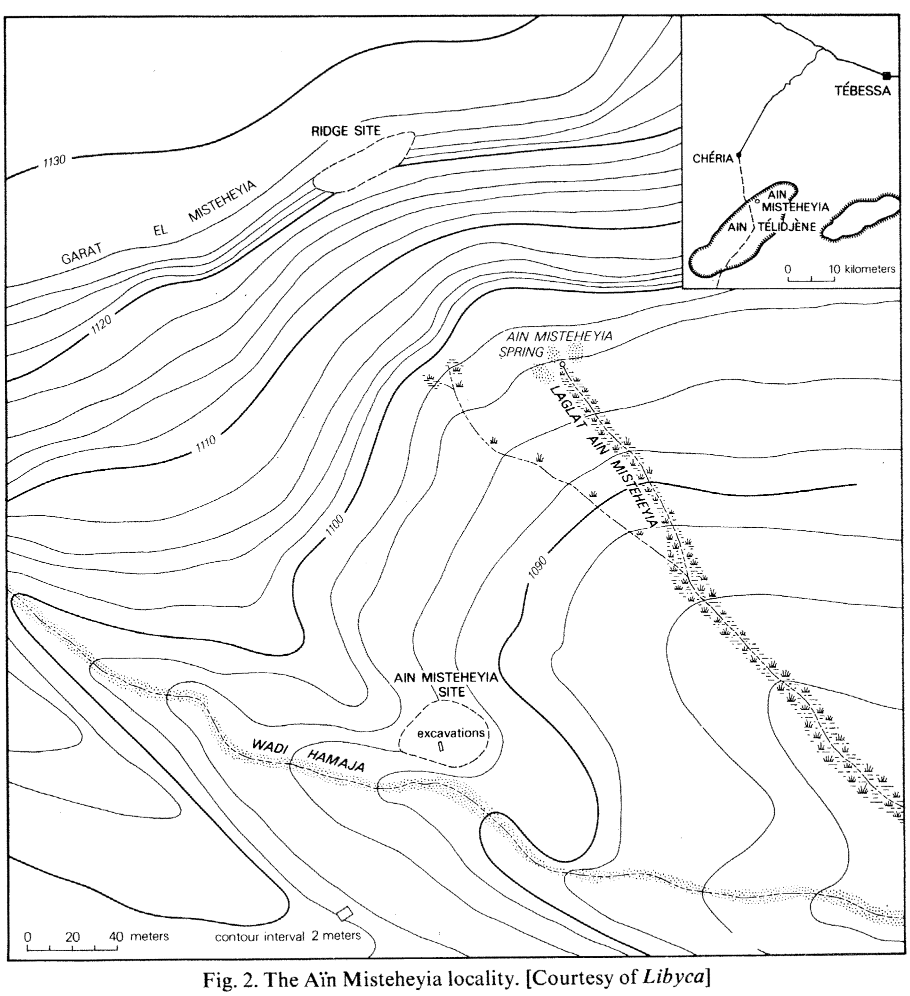

Fig. 2. The Aïn Misteheyia locality. [Courtesy of *Libyca*]

Pleistocene Landforms and Deposits

No deposits before the Middle Pleistocene have been observed (*16*). This appears to have been a period of intense morphogenetic change that destroyed earlier Pleistocene deposits throughout the Maghreb. The Middle Pleistocene deposits form the main relief in the Télidjène Depression and can be traced to the base of the basin as an alignment of asymmetric heights resembling cuestas. Upslope the younger landforms and deposits are dominated by a 30- to 50-meter-high scarp. Away from this, the surface slopes gently downwards and passes beneath Holocene deposits.

The Middle Pleistocene pediment is always recognizable by its thin detrital cover of large rounded pebbles in a white calcareous crust. At Aïn Misteheyia (Fig. 2) it forms a broad plain covered with alfa grass, which passes upslope into an encrusted talus deposit that masks the base of the escarpment. Pebble morphology indicates intense gelifraction during the formation of the detrital cover.

The Upper Pleistocene pediment occurs downslope from the Middle Pleistocene deposits. Near the center of the depression it passes beneath Holocene deposits. Upslope of the contact, the Middle Pleistocene deposit is marked by a break in slope and the appearance of artemisia.

When complete, the Upper Pleistocene pediment is several meters thick and is divided into three units: an upper unit of subangular pebbles in a fine beige matrix; a middle unit of light orange, fine silty sand with unstratified round pebbles 1 to 2 centimeters long; and a lower unit with rare large angular pebbles and occasional reworked blocks from the older pediment. Encrusted slope breccias are commonly associated with the Upper Pleistocene pediment.

Microstratigraphy at Aïn Misteheyia

The most intensively studied Holocene sequence is in the vicinity of the Aïn Misteheyia escargotière in the Télidjène Depression at an elevation of 1100 meters above sea level on the footslope of the Garat el-Misteheyia, an outlier of Djebel Radama. The southern periphery of the site has been truncated by Wadi Hamaja, which joins Wadi Mohamed downslope from the site (Figs. 2 and 3). Both wadis originate at seasonal springs at the base of the Djebel. A perennial spring, Aïn Misteheyia (Arabic for the shy spring) is located between them and is just northeast of the site. It feeds a series of shallow pools (aglat in Arabic) that run midway between the two wadis. Four stratigraphic units have been identified at 16 sections along these wadis (Fig. 3).

Unit I, at the base of the sequence, overlies the variegated Paleocene shales used today for ceramic manufacture. In one section (Hl, Fig. 3) two reddish zones (perhaps paleosols) are exposed. The sediments of unit I consist of abundant unstratified and poorly sorted coarse limestone clasts in an orange clayey and sandy calcareous matrix. These deposits appear to have formed by colluviation and areal sheet deposition in a cold, moist climate with marked seasonal variability and frost weathering. They are probably equivalent to the Upper Pleistocene deposits discussed above and identified throughout the Maghreb (*17, 18*). Near the end of deposition of unit I, a trend to warmer, drier conditions led to extensive erosion and the formation of a very irregular denudational surface.

Unit II is a complex deposit of bright yellowish- to grayish-brown alluvial gravels and silts that lie unconformably on the eroded surface of unit I. Lateral and vertical variation are pronounced, and suggest an erratic fluvial regime with accelerated runoff and a reduced vegetation mat in a semiarid climate with marked seasonality.

Occupation of the Aīn Misteheyia escargotière was concurrent with the deposition of unit II. At the site itself, the cultural deposits are intercalated with alluvial sediments (Fig. 4). In Wadi Mohamed, six dark brown lenses of reworked cultural materials (snail shells, fire-cracked rocks, bone fragments, and artifacts) were observed at the base of unit II. These vary in thickness from 10 to 20 centimeters and are from 30 to 150 centimeters in lateral extent. The presence of a least one intact hearth with in situ charcoal and burnt rubble suggests that they were not transported over a long distance. Radiocarbon dates from the Aīn Misteheyia escargotière, which also date unit II, indicate an age between about 9500 and 7000 years ago for this deposit.

Unit III consists of a dull yellowish-brown sandy silt with an average thickness of 30 centimeters and a maximum thickness of 90 centimeters. It includes scree gravel, scattered artifacts, and other derived cultural materials.

Unit IV is a pale brown sandy silt incorporating large numbers of rolled artifacts, snail shells, and abundant scree gravel. It is discontinuous and varies between 15 and 20 centimeters in thickness.

Units III and IV represent a period of accelerated runoff followed by an erosional episode that may be contemporaneous with the mid-Holocene erosional interval recorded elsewhere in the Maghreb (*19*). Studies of charcoal from archeological sites in Algeria (*20*) suggest a period of increased precipitation (500 to 600 millimeters more than present values) and decreased temperature (3°C less than present values) between 6000 and 4000 years ago, followed by a rapid decrease in precipitation and a rise in temperature.

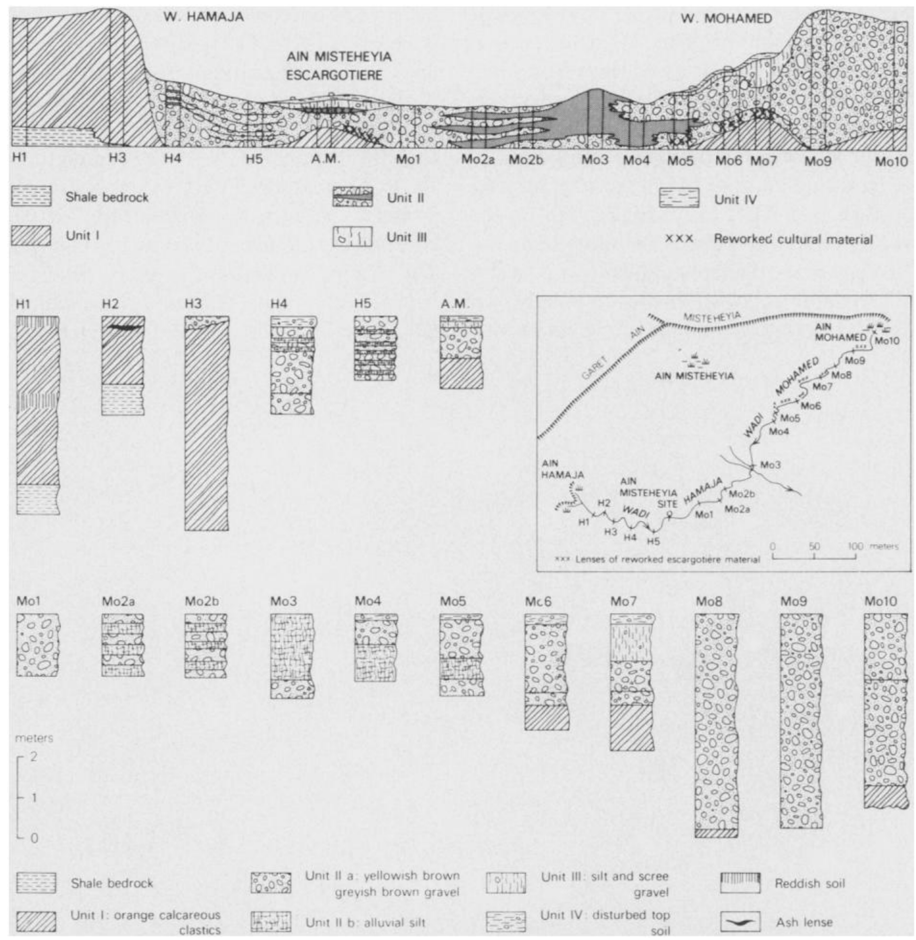

Fig. 3. Schematic cross section of Aīn Misteheyia geology and profiles of 16 sections studied in Wadis Mohamed and Hamaja and their relations to each other. [Courtesy of *Libyca*]

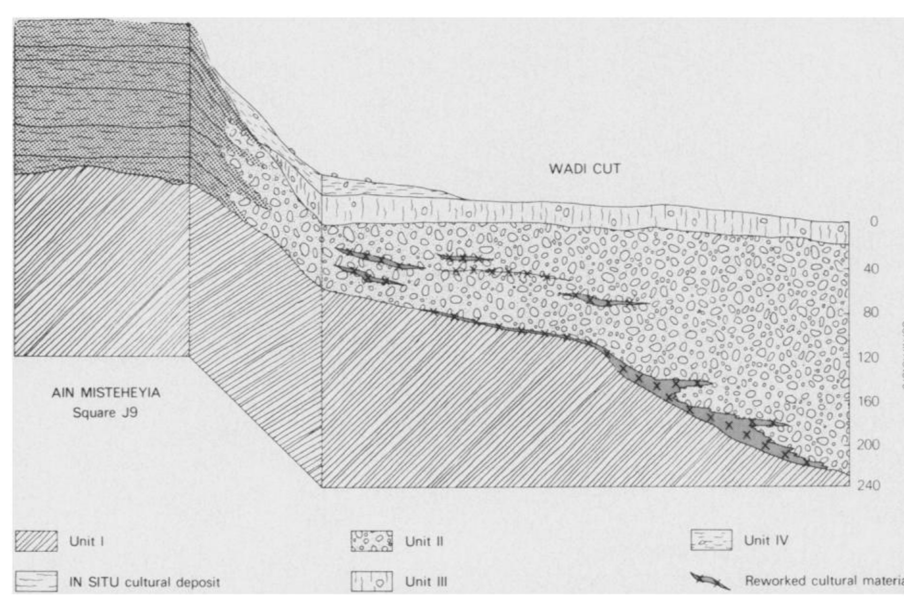

Fig. 4. Schematic block diagram indicating the interstratification of cultural deposits and alluvium at Aïn Misteheyia. [Courtesy of *Libyca*]

A stage of Roman-age alluviation seen elsewhere in the Chéria-Télidjène region is absent in the Aïn Misteheyia area. Instead, the eroded fill is overlain by scree gravel and redeposited archeological materials on which an aridisol has developed.

During the excavation of Aïn Misteheyia one square (J9) was excavated as a stratigraphic control pit as far down as sterile substratum. The 1.5-meter section thus exposed reveals a sequence of six levels that overlie unconformably the deposits of unit I and are interstratified with unit II (Fig. 5). Levels 1 through 5 are generally sandy clay loam of bright gray to grayish-brown hue. They are distinguished on the basis of subtle changes in color, sedimentology, and archeological content. Level 6 is a friable yellowish-brown to pale brown sandy silt with abundant rubble and roots. It is a deflated and mixed deposit. Levels 6, 5, and 4 have been affected by post-depositional pedogenesis; an orthic durorthid aridisol has developed.

Three radiocarbon dates are available for this column. All are based on samples of *Helix melanostoma* shell and calculated on the Libby half-life ($T_{1/2}$ = 5568 years). Level 4 (30 to 35 centimeters below surface) is dated 7280 ± 115 years ago (I-7690); level 3 (70 to 80 centimeters below surface) is dated 8835 ± 140 years ago (I-8378); and level 2 (115 to 125 centimeters below surface) is dated 9280 ± 140 years ago (I-7691). These dates are consistent internally as well as with the established radiocarbon chronology for Capsian sites in this area (*7*). *Helix melanostoma* shell provides dates that are equivalent to those obtained from charcoal samples. We collected two samples from the deposits of an escargotière that had been reworked into the alluvial sediments exposed in section in Wadi Redif. The dates are as follows: *Helix melanostoma* shell, 7690 ± 120 years ago (I-7692) and charcoal, 7340 ± 115 years ago (I-7694).

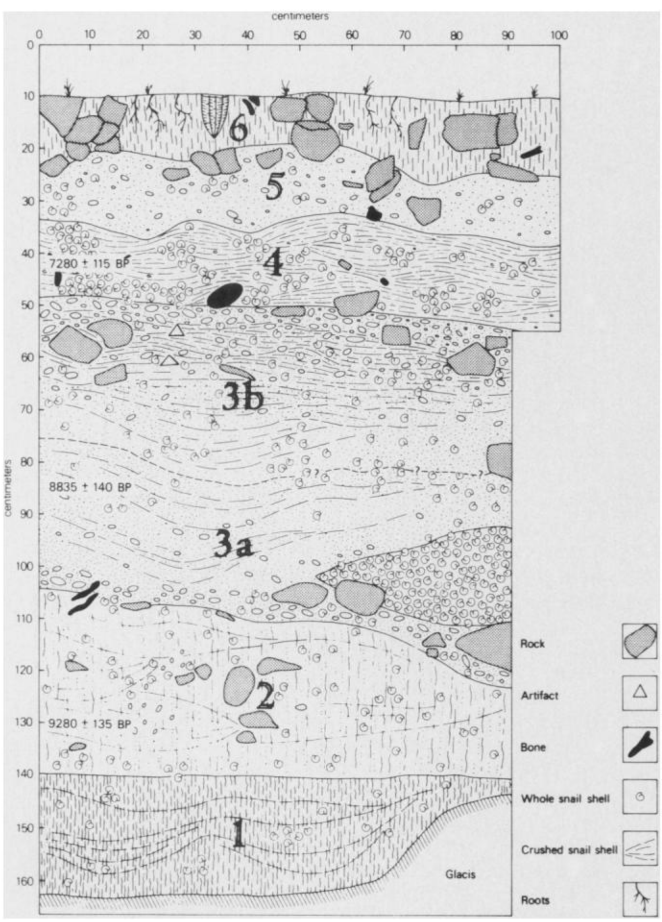

Fig. 5. Profile of the west face of square J9 at Aïn Misteheyia. [Courtesy of *Libyca*]

Additional Holocene Sequences

We have studied four other Holocene sequences in the Chéria-Télidjène region. They are Wadi Redif, Wadi Ebtine, Wadi Chéria/Mezeraa, and Mechta Treïkïa (Fig. 1). These have been described in detail (*21*). While Holocene deposits and landforms are well developed, they are extremely complex and generally lack material suitable for dating. On present evidence it appears that most of the sequences studied postdate the Aïn Misteheyia materials described here, but confirmation of such a tentative correlation must await further investigations.

In general, Holocene deposits seem to unconformably overlie the eroded surface of the Upper Pleistocene deposits. Subsequent deposition indicates a period of intensive mechanical weathering followed by alluviation of sands and gravels that sometimes contain cultural materials reworked from Capsian sites. At least one further episode of downcutting and two periods of renewed deposition follow this. Most sections appear to be capped by post-Roman colluvium.

The Capsian Habitat

Our reconstruction of the Capsian habitat in the Chéria-Télidjène region is based on the study of unit II lithology at Aïn Misteheyia, detailed investigation of the matrix of the escargotière and the fauna recovered within them, and palynological analyses of samples collected in Wadi Chéria/Mezeraa and Wadi Redif. Throughout the period of Capsian occupation (about 9500 to at least 6500 years ago) the environmental setting was characterized by a semiarid climate with open step-

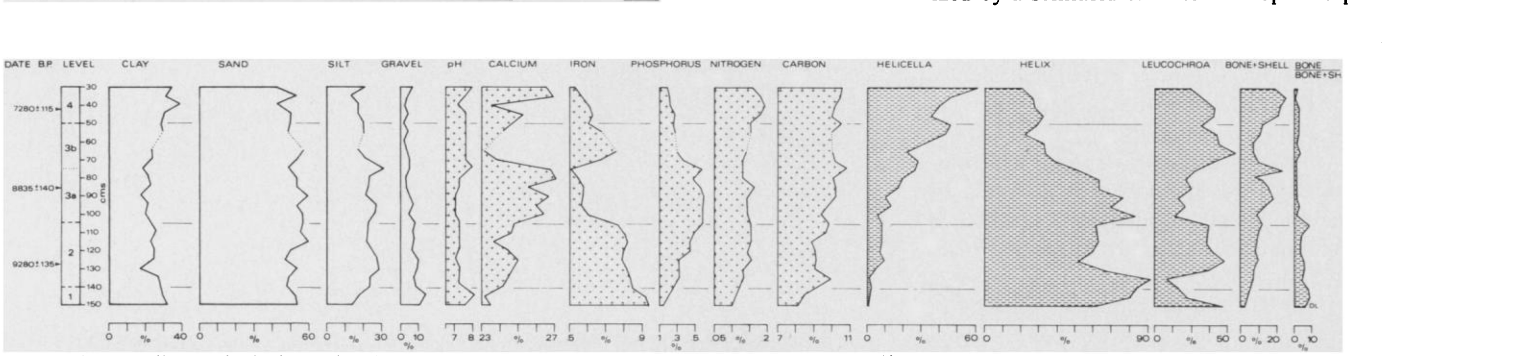

Fig. 6. Sedimentological, geochemical, and faunal composition of cultural deposits of the Aïn Misteheyia escargotière. [Courtesy of *Libyca*]

pic vegetation in the plains and, probably, pine, oak, and pistachio forests on slopes and at higher elevations.

Pollen are very poorly preserved in all samples we have studied. The results, which we discuss elsewhere (*21*), suggest that while the mid-Holocene vegetation pattern was similar to the modern one, it differed in the number, distribution, and biomass productivity of available habitats. Specifically, the moderately increased frequencies of hygrophytic genera such as *Salix, Malvaceae*, and *Liliaceae* in deposits that appear to be contemporaneous with Capsian occupation suggest a greater abundance of localized stream bank habitats during at least part of this period. In general, however, the pollen are consistent with semiarid conditions as suggested by other evidence.

The sediments of the Aïn Misteheyia escargotière generally consist of sandy clay loam with an average clay content between 20 and 30 percent. Vertical change is apparent (Fig. 6). Clay content decreases steadily from an average of 25 percent in level 1 to 20 percent in level 3a, after which it rises steadily to an average of 30 percent in level 4. The curve for sand is inverse to this, and in the samples studied from upper level 2 to lower level 3b, the very fine quartzose sand grains are markedly angular. According to Chorley (*22*), the clay content can be interpreted as reflecting a semiarid climate, which is consistent with Couvert's conclusions based on the study of charcoal from archeological sites (*20*) and our own interpretations of nonarcheological deposits.

The vertebrate remains from Aïn Misteheyia also corroborate this conclusion. The faunal assemblage consists primarily of hartebeest (*Alcelaphus buselaphus*) and horse (*Equus mauritanicus*), both indicative of open steppic plains. There is a rare component of barbary sheep (*Ammotragus lervia*) which inhabits mountain slopes, gazelle (*Gazella* spp.) which were probably not typical of the region but would have been present to the south, and aurochs (*Bos primigenius*) which prefers biotopes with lush vegetation. Aurochs is more frequent in the faunal assemblages from Mechta el-Arbi (*6*, p. 166) and Dra-Mta-El-Ma-El-Abiod (*13*) which may have been located in habitats more favorable to it.

The land snail assemblage from Aïn Misteheyia is common to modern communities in favored (more humid) localities. The only exception is the almost total absence of *Helix melanostoma* (the dominant species in most escargotières) from modern assemblages. Vertical change in species frequencies in the Aïn Misteheyia deposit is pronounced and is illustrated for the three major edible species (*Helix melanostoma, Leucochroa candissima*, and *Helicella setifensis*) in Fig. 6.

These frequency changes are based on analyses of samples taken at 5-centimeter intervals throughout the entire depth of the column exposed during excavation of square J9. The results from other excavation units down to 40 centimeters below surface are comparable. The column can be divided into three molluscan units which correspond closely with levels 2, 3, and 4 as determined by sedimentological analyses. The characteristics of these three units are summarized in Table 1. Material above 20 centimeters below surface (30 centimeters below datum) and below 135 centimeters is excluded because we consider it unreliable due to mixing or preferential destruction of the more fragile *Helicella* (or both).

The modern parameters of *Helix, Helicella*, and *Leucochroa* are summarized in Table 2. The rarity of *Helix melanostoma* in modern assemblages appears to be due to the tendency of this species to bury itself prior to the onset of warm summer conditions. We observed isolated communities in the soil litter of a grove in the town of Chéria and after a day of rain downslope from Aïn Misteheyia in September 1973. The species was apparently still abundant in the region during the 1930's and later (*6*,

Table 1. Vertical changes in land snail frequencies at Aïn Misteheyia. Depth is given in centimeters and range and mean values are percents.

Unit and depth below datum	*Helix melanostoma*		*Leucochroa candissima*		*Helicella setifensis*	
	Range	Mean	Range	Mean	Range	Mean
Unit 3 (70–30)	22.2–40.7	30.8	24.9–45.1	32.9	21.1–45.9	36.3
Unit 2 (100–70)	53.1–84.8	68.8	11.4–21.8	16.7	3.8–25.1	14.5
Unit 1 (145–100)	51.8–93.3	69.5	5.6–38.7	25.2	0.7–9.4	5.2

Table 2. Modern ethological and ecological parameters of edible land snails.

Species	Ecology	Seasonal ethology			
		Winter	Spring	Summer	Fall
Helix melanostoma	Open parkland, garigue, and valley bottoms	Buried	Active	Buried	Active
Helicella setifensis	Humid environments with high vegetation	Hiding near soil?	Active	Aestivating and visible	Active
Leucochroa candissima	Very xerophilous environments, higher elevations	Buried	Active	Aestivating, not always visible	Active
Otala spp.	High elevations with low scrub vegetation	Hiding or buried?	Active	Aestivating and hiding	Active

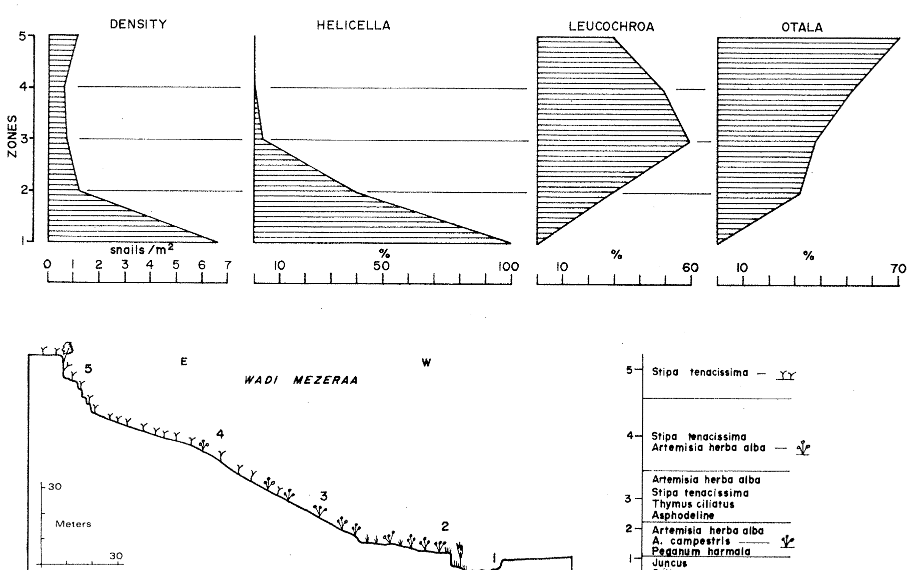

Fig. 7. Transect of Wadi Chéria/Mezeraa with modern habitats and population densities of land snails found in Capsian sites. [Courtesy of *Libyca*]

pp. 190–201; *13*, p. 305). *Helicella setifensis* is superabundant today in moist habitats. In October 1973, we recorded average densities for this species of 6.6 snails per square meter in the channel bank habitat along Wadi Chéria/Mezeraa. The snails were clinging in bunches to vegetation; so much so that we recorded maximum densities of 41.8 snails per square meter. The modern distribution of all three species is controlled by temperature and humidity as functions of elevation, vegetation mat, and insolation (*23*). These relations, along with modern density and species frequencies, are illustrated in Fig. 7.

Our data on modern land snail ecology suggests, at first glance, that the species variation in the Aïn Misteheyia escargotière (especially for *Helicella setifensis*) is a direct reflection of change in climate and hydrographic regime. Geochemical analysis of the stratigraphic column from J9 suggests that this interpretation is erroneous, and that species variation is better explained as a consequence of changing Capsian subsistence practices.

Calcium and phosphorus (Fig. 6) both attain maximums in level 3a, while iron decreases. High *p*H values are inversely correlated with calcium and phosphorus and directly correlated with iron. Low calcium and phosphorus values are interpreted as the result of increased dissolution. This was associated with increased deposition of iron oxides and an alkaline *p*H, all reflecting increased precipitation.

Level 3a seems to represent a period of reduced precipitation. The abundance of *Helicella* in this level cannot, therefore, be attributed to increased precipitation. If it were, we should find two peaks in the curve for this species.

Changes in subsistence practices are suggested by two lines of evidence. First of all, the frequency of microscopic bone and shell remains (Fig. 6) increases steadily from level 1 (less than 5 percent) to level 3a (more than 20 percent), drops off sharply in level 3b (less than 10 percent), and then rapidly increases in level 4. This seems to correspond to a reduction in the intensity of occupation as suggested by parallel decreases in the carbon content of the deposits and the frequency of lithic artifacts. There is, at the same time, a change in the character of the lithic assemblage that will be discussed below.

Secondly, the ratio of bone to bone and shell drops off very sharply at the interface between level 2 and level 3a (Fig. 6). This indicates a decrease in the amount of bone in the deposits and represents a marked change in the subsistence pattern. An earlier pattern with an emphasis on game animals and collection primarily of the larger (and therefore more productive) *Helix melanostoma* was replaced by one in which hunting declined and the previously neglected *Helicella setifensis* was intensively collected.

In sum, the combined results of our sedimentological, geochemical, and zoo-archeological analyses suggest that the Aïn Misteheyia escargotière was occupied during a period of semiarid climate considerably wetter than at present. An intermediate phase of somewhat drier conditions is also indicated.

Archeology

Excavations at Aïn Misteheyia were confined to an area of 4 by 2 meters, dug in 1-meter squares by both arbitrary (5-centimeter) and natural stratigraphic divisions. Square J9 was excavated as a test pit to sterile substratum (Fig. 5), but all other squares were excavated only to the base of level 4 at about 40 centimeters below the suface (Fig. 8).

The excavated assemblage consists of lithic artifacts, a few ostrich egg shell beads and some fragments of ostrich egg shell, two bone awls, and several sherds of shell-tempered pottery. The pottery occurs only in levels 4 and 5. The lithic artifacts, which total 22,682 pieces, consist of tools (6.8 percent), cores (0.6 percent), flakes (12.6 percent), blades (17.8 percent), and manufacturing by-products (62.4 percent). Raw material is the fine-textured light brown to gray flint found in nodular form throughout the region.

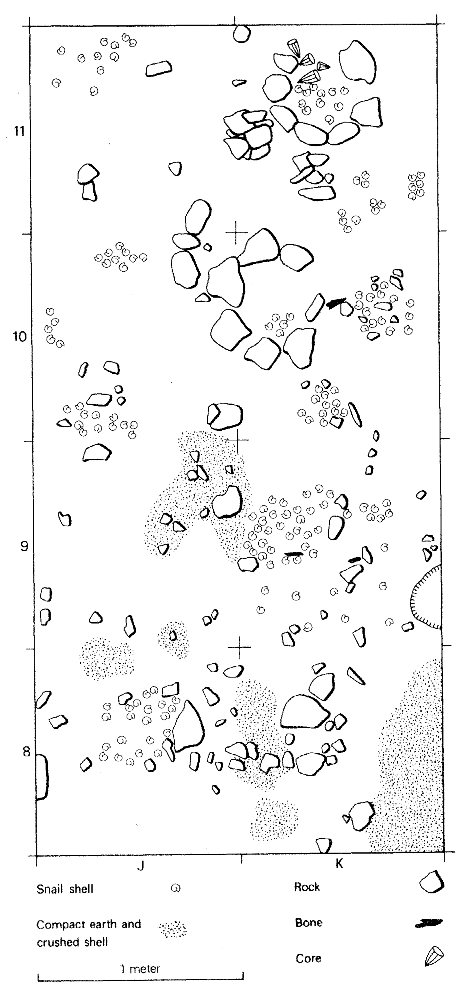

Fig. 8. Plan of the 50 cm below datum level in excavated area of Aïn Misteheyia escargotière with cultural features. [Courtesy of *Libyca*]

More complete data on these artifacts are presented elsewhere (*21*). The discussion below will be limited to the evidence for temporal change in the lithic assemblage that falls within the accepted range of variation for the *Capsien supérieur* (*24*).

Lithic technology is relatively uniform throughout the deposits. Cores are predominantly single platform or opposed platform varieties; 50 percent are blade cores, and most are microlithic. Blades and blade tools are more frequent than flakes or flake tools in every level except 3a. The frequency of microlithic tools never falls below one-third of the sample from any level, and is generally between 40 and 50 percent of the unbroken specimens.

Lithic typology is not uniform. The sample from levels 2, 3a, and 3b contains high frequencies of burins, backed blades or bladelets, and geometric microliths. The sample from levels 4, 5, and 6 is characterized by notches and denticulates, continuously retouched pieces, truncations, and endscrapers (Fig. 9). The lower assemblages can be dated between about 9300 and 8500 years ago, while the upper assemblages are later than about 7300 years ago. Stratigraphy and radiocarbon dates suggest that the site was intermittently occupied. On first glance, therefore, the typological differences might be explained as the result of developmental change. If this were so, one would expect the lower assemblages to fall within the parameters proposed by Camps and Camps-Fabrer (*4, 24*) for phase 1 of the Tébessa Facies of the *Capsien supérieur* (about 8500 to 8000 years ago) and the upper assemblages to fall within phase 2 (about 8000 to 7000 years ago). No such correlation is demonstrable. In fact, although the entire assemblage from Aïn Misteheyia is clearly *Capsien supérieur* in general characteristics, it differs significantly from all other published *Capsien supérieur* and *Capsien typique* assemblages with which we have attempted comparisons (*25, 26*). The reasons for this are not yet clear. Sampling bias is unlikely, unless individual Capsian assemblages are far more activity- or ethnospecific than has previously been suggested. We consider ethnospecificity undemonstrable on present evidence, but activity specificity may well have occurred in certain instances. The few published studies of Capsian faunal assemblages suggest extensive variability among sites which might well be reflected in the lithic tool kit. Certainly this seems a possibility that needs to be considered in any future investigations, given the remarkable coincidence of changes in subsistence practices and changes in lithic typological parameters at Aïn Misteheyia.

Among the more intriguing results of our excavations at Aïn Misteheyia is the exposure of at least two nearly intact small circles of stones at the base of level 4 (Fig. 9). The flat upper surfaces of the stones dip in toward the center to form a bowl-shaped depression. We recovered several sherds of very crude shell-tempered ceramics within the circle in square K 10, and a cache of four blade cores within the circle in square K11. The sherds were slightly above the base of level 4 while the cores were on this surface. The sherds were evidently poorly fired, and have split into two "tables," with an exterior surface that is brick red and smooth, and an inner surface that is gray black and rough. One sherd has a small perforation. To our knowledge this is the first documented in situ association of ceramics with a pre-Neolithic Capsian assemblage in this region (*27*).

The function of these stone circles is unknown. In one case the area immediately surrounding the circle has a low density of cultural debris and artifacts. The interiors of the circles do not contain abnormally large amounts of ash, charcoal, or carbonized plant remains for an escargotière, but the squares in which they occur do contain very high frequencies of fire-cracked lithic artifacts. Unfortunately we neglected to break the stones forming the circles to see if they had been burned and so cannot state unequivocally that they were hearths. It is also possible they were used as supports for vessels into which "pot boilers" were dropped to heat water for cooking. This is the generally hypothesized Capsian cooking method and is inferred from the large amount of fire-cracked rock and ash in most sites (*11, 28*). It has always been assumed that bladders were used as containers but the crude sherds at Aïn Misteheyia suggest alternative possibilities.

We have experimented with various ways to cook the edible land snails found in escargotières. Exposure to heat is essential as a means of loosening the muscles, but direct exposure to heat (that is, roasting) tends to destroy the shell. If boiled, the snail is easily removed with any pointed implement; we used dental probes but a thorn, bone awl, or narrow pointed backed bladelet would do as well. Boiling has little effect on the structure of the shell. We have observed the effects of roasting in a recently burned-over field in Wadi Chéria/ Mezeraa that had been heavily colonized by *Helicella setifensis* and a few *Leucochroa candissima*. Various degrees of burning were observed: (i) brown coloration resulting from incomplete combustion of organic material; (ii) more complete combustion with formation of blackish and bluish-gray zones; (iii) complete oxidation of organic material and formation of very white and powdery calcium carbonate; and (iv) distortion, fissuration, and desquamation of the shell. We observed none of these characteristics in Capsian deposits and doubt that they would have disappeared entirely (*29*).

Capsian Subsistence

Morel (*13*) has recently presented an impressive argument in favor of Gobert's earlier contention that land snails were not the major source of animal protein in the Capsian diet. Our independent results confirm Morel's and have the added advantage of a longer dated stratigraphic sequence which permits us to discuss change in subsistence practices over time. In addition, our microstratigraphic analyses provide information about the estimated biomass exploited by the Capsian occupants of Aïn Misteheyia.

We have calculated the volume of Aïn Misteheyia at 944 cubic meters. With a value of 1.3 for the specific gravity (*30*), we estimate the total mass at 1227 metric

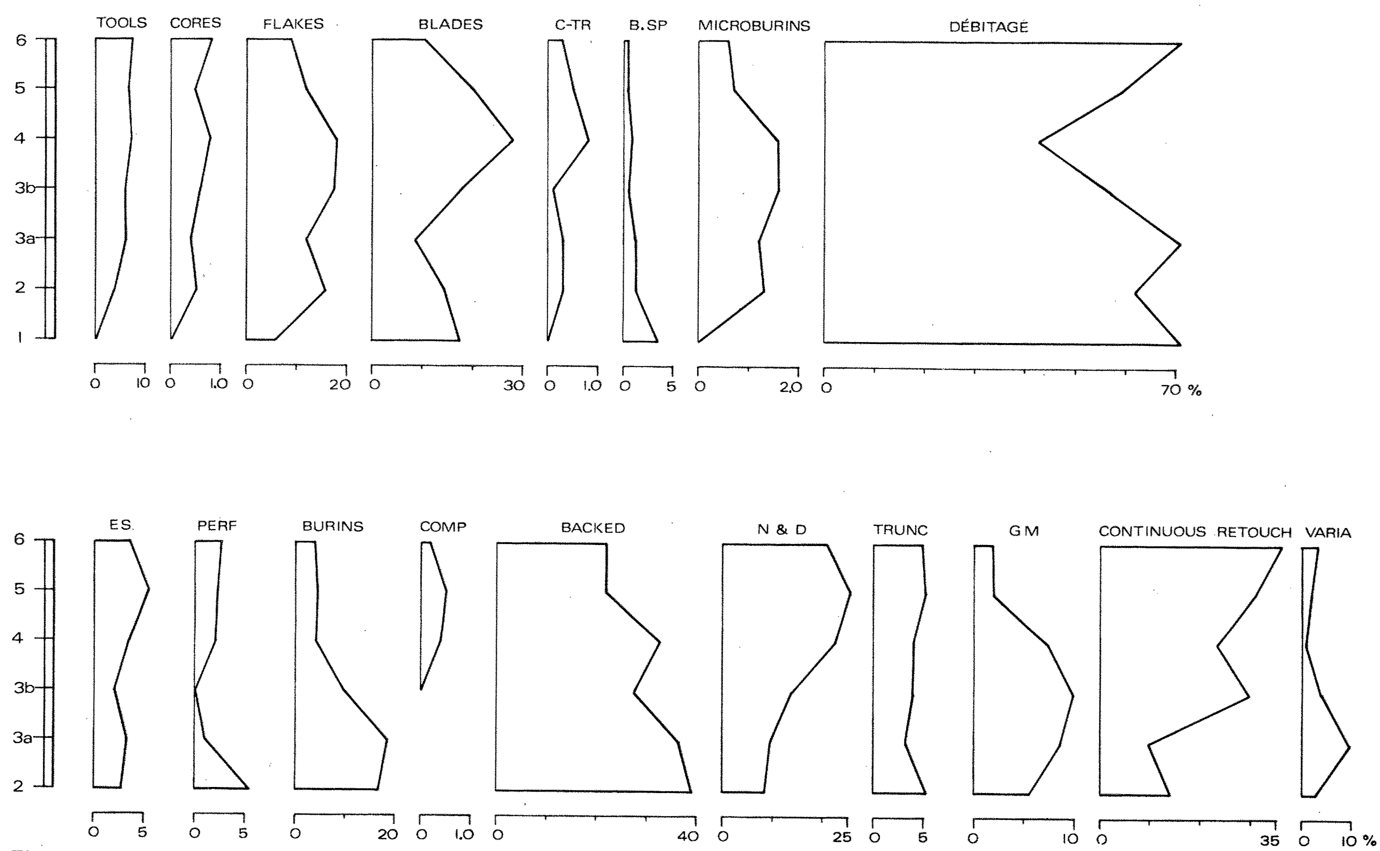

Fig. 9. Composition of the artifact assemblage from the Aïn Misteheyia escargotière (square J9) with temporal changes in technological and typological characteristics. Abbreviations: C-TR, core-trimming pieces; B.SP, burin spalls; ES, endscrapers; PERF, perforators; COMP, composite tools; N & D, notches and denticulates; TRUNC, truncations; and GM, geometric microliths. [Courtesy of *Libyca*]

tons. Whole snail shells average 25,000 per cubic meter and the approximate mean weight of each shell of the three major species is 1.7 grams. This gives an estimate of 40,120 kilograms of whole shell for the site, or 3.3 percent of the deposit by weight. To this we must add the enormous amount of crushed shell which we estimate to contribute at least another 7 percent, bringing the total to approximately 125,000 kilograms of shell.

The total amount of bone recovered during excavation weighs 3.5 kilograms from 5 cubic meters (0.7 kilogram per cubic meter). This gives an estimate of only 660 kilograms of bone for the entire site. However, this estimate is based on material that did not pass through a 0.5-centimeter mesh in the field. Bone recovered during laboratory analyses of bulk samples taken at 5-centimeter intervals during the excavation of square J9 averages 0.44 percent of the deposit by weight. When projected over the entire site, this adds another 5400 kilograms of bone, bringing the total weight of bone to approximately 6000 kilograms.

Among the three major species of edible land snails in the Aïn Misteheyia deposits, the weight of the animal itself is approximately 80 percent of the dry shell weight on average. Therefore, 125,000 kilograms of dry shell represents approximately 100,000 kilograms of edible flesh that is high in protein (about 16 percent) but low in fats (about 1.4 percent) and carbohydrates (about 2 percent). The caloric value is about 90 calories per 100 grams of raw flesh (*31*).

In all likelihood, the bone preserved in the site represents only a fraction of the original amount. Not all bones of hunted animals would have been returned to the site, especially those of the larger vertebrates; the highly alkaline deposits have a deleterious effect on bone preservation; and much of the bone that was returned has been destroyed by crushing and boiling to extract fats and some may have been burned for fuel. We believe, therefore, that the bone preserved represents between 50 and 10 percent of the bones of all animals killed. Considering that dry weight of bone remains represents approximately 6 percent of the live weight of the animal (*32*), we calculate the bone remains to represent between 0.4 and 2 percent of the total live weight of game taken. On this basis, we estimate the total live weight mass of vertebrates at between 300,000 and 1.5 million kilograms. If 60 percent of this was recovered for consumption, the total edible vertebrate flesh would have been between 180,000 and 900,000 kilograms. For convenience, we will assume that about 500,000 kilograms were consumed. Therefore, it is unlikely that snails contributed more than one-sixth (17 percent) of the animal flesh in the Capsian diet at Aïn Misteheyia.

Estimates for modern hunter-gatherers in semiarid environments suggest that approximately one-third of the diet is composed of meat (*33*) which provides 1.8 times the protein available from plants (about 16 percent as opposed to 5 percent). This seems a reasonable estimate for the Capsian as well. The estimated 100,000 kilograms of snail flesh would provide 16,000 kilograms of protein and 90 million calories. The 500,000 kilograms of vertebrate meat would provide about 80,000 kilograms of protein and 1.74 billion calories. The total available food value from animal sources would have been approximately 96,000 kilograms of protein and 1.83 billion calories over a period of about 3000 years.

Now, let us assume the average Capsian band was roughly equivalent to modern hunter-gatherers, about 20 individuals per group per site (*34*). Each person would require an average of 50 grams of protein and 2200 calories per day. If meat supplied 65 percent of the protein (32.5 grams) and 50 percent of the calories (1100 calories), allowing for nutritional contributions from plant sources, the group of 20 would require a total of 650 grams of protein and 22,000 calories from animal sources every day. On this basis, the animal remains in the site would provide approximately 147,000 man-days of protein support (96,000/0.65) and 83,000 man-days of calorific support ($1.83 \times 10^8/22{,}000$). The former figure may well be in error given the generally higher protein value of wild carcasses as opposed to domesticated ones (*35*). Nonetheless, this suggests that the site was only occupied for between 230 and 400 years (2700 to 4800 months) over approximately 3000 years (*36*). These figures imply either annual occupation for several weeks each year, or periodic occupation for several months interspersed with long periods of vacancy.

Such a model helps to explain the high density of Capsian sites in the Chéria-Télidjène region. Within a 5-kilometer radius of Aïn Misteheyia there are 13 other escargotières (excluding the six lenses observed in Wadi Mohamed) of which five are more than 30 meters in diameter, five are between 20 and 30 meters, and three are less than 20 meters. Most are estimated to have at least 1 meter of deposit remaining. Within a 10-kilometer radius there are 40 other sites with a similar range of size. There are 20 escargotières within the northeastern two-thirds of the Télidjène Depression, an area that might easily have been used as the catchment basin for the occupants at Aïn Misteheyia (*5*) (Fig. 1). Our field observations suggest that the remaining sites represent no more than three-quarters of the original number. We lack adequate chronological precision for these but it is unlikely, in any event, that more than a fraction were occupied simultaneously (even on a sporadic basis) if population densities for successful modern hunter-gatherers in semiarid environments (0.5 to 1 person per square kilometer) are applicable to their prehistoric counterparts (*34*).

While land snails may not have been the primary source of animal protein in the Capsian diet, they were certainly important. The modern ethology and ecology of the edible land snails found in the escargotières suggests that this source would have been unavailable during the winter and scarce during the summer. Furthermore, our one systematic attempt at snail collecting, in Wadi Chéria/Mezeraa during October 1973, demonstrated that recolonization by snail communities is slow. We therefore project the necessity of fallow periods within any one collection area as part of the Capsian subsistence and settlement strategy. We hypothesize, accordingly, that Capsian groups moved their camps frequently to take advantage of periods of land snail abundance and to avoid excessive predation of local land snail populations. Hygienic considerations may have also played a part in this pattern, since food refuse was apparently discarded on or near living areas.

Snails would have been available in quantity during spring and fall, but their relative abundance on a species basis would have been differential with respect to microenvironmental conditions. We cannot propose a seasonal subsistence pattern on present evidence, especially considering the lack of evidence for the kinds of plants consumed. Modern hunter-gatherer diets are composed largely of plant foods, and the Capsian habitat was rich in a variety of grasses, acorns, pine nuts, and pistachio nuts. Cones of ***Pinus halepensis*** are known from a few sites, but there is no incontrovertible evidence for consumption of the nuts despite the presence of grinding stones in some Capsian sites. Nuts and acorns would have been an autumn resource and if they were eaten there should be some evidence in the form of charred shells or kernels (or both). Earlier investigators have made no mention of this, and while they might have missed some of the evidence, we doubt they would have missed all of it. As a check, we processed about 100 kilograms of matrix from Aïn Misteheyia by flotation and recovered no macrofloral remains other than small fragments of charcoal. Subsequently, one of us discovered some charred bulbs in the collections from the 1930 Logan Museum Expedition at the University of Minnesota. These have been identified as *Allium* sp. (possibly *A. ascalonicum*, the shallot) (*37*). While our failure to recover macrofloral remains might be a sampling problem, it is nonetheless probable that the absence of nuts in Capsian sites (and especially Aïn Misteheyia) is an indication of spring occupation. Perhaps some groups moved south at other times of the year. At any rate, they do not appear to have harvested nuts in the autumn.

Capsian Cuisine

Further evidence that Capsian cooks prepared snails by boiling is provided by the condition of vertebrate bone. Microscopic examination of matrix from Aïn Misteheyia and other sites reveals large quantities of degraded cancellous tissue that, to the untrained eye, resembles microfaunal remains (*38*). Similar phenomena have been observed in soil from bone boiling pits at a prehistoric site in central Alberta (*39*), and there is abundant ethnographic and archeological evidence from a number of regions and time periods to suggest that the practice of crushing and boiling bone to extract fats has a considerable antiquity. In view of the low fat content of land snails as well as the generally lower caloric value of wild carcasses, it seems reasonable to postulate similar practices by Capsian cooks.

The Capsian diet was, in all likelihood, composed of a stew containing meat, snails, and some plants, perhaps accompanied by a gruel made from boiled grasses, garnished with nuts, and perhaps seasoned with wild herbs and shallots which are somewhere between garlic and onion in flavor. It was, to be sure, a far cry from escargots de bourgogne, but equally satisfying under the circumstances.

Summary and Conclusions

Capsian occupation in the Chéria-Télidjène region of northeastern Algeria coincides with a phase of alluviation (about 9500 to 6500 years ago) with a semiarid climate that was cooler and more humid than today. These conditions were interrupted briefly at about 8800 years ago by an erosional interval with a warmer and drier climate similar to present conditions. Independent studies of charcoal from Capsian sites elsewhere in Algeria confirm this sequence in general outline, suggesting it may have more than purely local significance.

Vegetation cover throughout the period of Capsian occupation in this region appears to have consisted of open steppe in the depressions and on the plains with pine, oak, and pistachio forests at higher elevations. There may have been some change in the extent and character of these communities during the Holocene, but the general pattern appears to have been relatively constant according to present evidence.

Capsian subsistence was based on a combination of hunting (gazelle, aurochs, and hartebeest), land snail collecting, and presumably plant gathering. While land snails and vertebrates were favored sources of high quality protein, the contribution of the former was apparently no greater than one-sixth of the animal protein in the diet. The three land snail species predominant in most escargotières are still extant in the region today and each is restricted to a different biotope. Differential exploitation of these species appears to have been a function of both site location and local environmental conditions at any particular time.

Partial excavation of the Aïn Misteheyia escargotière has provided a number of insights into Capsian subsistence, settlement, and diet. The faunal assemblage from this site is consistent with semiarid conditions, but there is evidence for change in the subsistence base coincident with the brief period of increased aridity. Sedimentological and geochemical studies show that the onset of somewhat drier conditions is associated with an increase in the frequency of the hygrophyllic land snail *Helicella setifensis*. We interpret this increase, in light of the synchronous decrease in the frequency of vertebrate bone in the site, as due to a reduction in vertebrate biomass during the drier episode and a consequent attempt by the Capsian group at Aïn Misteheyia to maintain their standard of living by increasing the exploitation of *Helicella setifensis* which had been neglected previously, probably due to its small size.

The artifact assemblage from Aïn Misteheyia falls within the established general parameters for the *Capsien supérieur*. However, typological variability within the assemblage does not conform to the finer geographical and temporal distinctions recently proposed for this industrial complex. Furthermore, there is a clear change in the Aïn Misteheyia tool kit, coincident with the onset of more arid conditions and change in the subsistence base, which suggests that much of the variability observed in and among other *Capsien supérieur* assemblages may be due to local resource availability rather than cultural distinctions among groups. Future research should focus on links between changing subsistence group boundaries, population movements (for example, seasonal rounds), and stylistic and utilitarian aspects of the Capsian tool kit.

The amount of food refuse accumulated at Aïn Misteheyia over a span of about 3000 years indicates that the net period of occupation for groups of about 20 individuals cannot have been greater than about 230 to 400 years. Apparently the occupation of this site (and presumably other escargotières as well) was sporadic. We envision a general pattern of rotating settlement with intermittent residency at any one site. Such a pattern explains the remarkable density of Capsian escargotières in northeastern Algeria far better than previous suggestions that Capsian groups were sedentary. This rotational pattern may have been in part hygienic, since food debris was discarded within living areas. However, it should also be noted that this practice would have conserved local resources (especially land snails) and mitigated against overpredation of both vertebrates and invertebrates.

In sum, we interpret the Capsian subsistence adaptation as innovative, conservationist, and highly successful—so much so, in fact, that despite the appearance of Neolithic economic practices in neighboring regions by about 7000 years ago, the Capsian pattern in the Maghreb appears to have remained basically unchanged for a further two millennia.

References and Notes

1. L. Balout, ***Préhistoire de l'Afrique du Nord*** (Arts et Métiers Graphiques, Paris, 1955).
2. J. Tixier, *Typologie de l'Epipaléolithique du Maghreb* (Mémoire No. 2, Centre de Recherches Anthropoligiques, Préhistoriques et Ethnographiques, Alger, 1963).
3. J. de Morgan, *Les Premières Civilizations* (Leroux, Paris, 1909), pp. 135 and 136; P. Pallary, *Instructions pour les Recherches Préhistorique dans le Nord-Ouest de L'Afrique* (Mémoire No. 3 de la Société Historique Algérienne, 1909).
4. G. Camps and H. Camps-Fabrer, in *Die Anfänge des Neolithikums vom Orient bis Nordeuropa*, J. Lüning, Ed. (Böhlau, Köln, 1972), pp. 19–59.
5. D. Grébénart, *Le Capsien des Régions de Tébessa et d'Ouled Djella Algérie* (Editions du l'Université du Provence, Aix-en-Provence, 1975).
6. A. W. Pond, L. Chapuis, A. S. Romer, F. C. Baker, *Prehistoric Habitation Sites in the Sahara and North Africa* (Logan Museum, Beloit, Wisconsin, 1938).
7. G. Camps, G. Délibrias, J. Thommeret, *Libyca* **16**, 9 (1968); *ibid.* **21**, 65 (1973).
8. C. Brahimi, *ibid.* **20**, 49 (1972).
9. The traditional model was first stated by R. Vaufrey [*L'Anthropologie* **43**, 456 (1933)] and slightly revised by him later [*Swiatowit* **16**, 15 (1936)]. The new interpretation is contained in Camps *et al.* (*7*).
10. See distribution map in (*2*).
11. E. G. Gobert, *Rev. Afr.* **81**, 640 (1937).
12. R. Vaufrey, *Préhistoire de l'Afrique*, Tome 1: *Le Maghreb* (Masson, Paris, 1955), p. 413.
13. J. Morel, *L'Anthropologie* **78**, 299 (1974).
14. A. N. Lebedev, *The Climate of Africa* Part 1: *Air Temperature, Precipitation* (Israel Program for Scientific Translation, Jerusalem, 1970).
15. P. Quézel and S. Santa, *Nouvelle Flore d'Algérie et des Régions Désertiques Méridionales* (Centre National de la Recherche Scientifique, Paris, 1962), p. 12.
16. We have used Middle Pleistocene and Upper Pleistocene instead of Tensiftian and Soltanian because the latter, which were originally proposed for Morocco by G. Choubert, F. Joly, M. Gigut, J. Marçais, J. Margat, R. Raynal [*C.R. Acad. Sci.* **243**, 504 (1956)] are no longer accepted by many workers because the type sections were poorly chosen. See G. Beaudet, G. Maurer, A. Ruellan, *Rev. Géogr. Phys. Géol. Dyn.* **9**, 269 (1967).
17. R. van V. Anderson, *Bull. Geol. Soc. Am.* **43**, 847 (1932); C. Vita-Finzi, *Man* **2**, 205 (1967).

18. K. W. Butzer, *Environment and Archaeology* (Aldine, Chicago, 1971), pp. 24–26.
19. R. Coque, *La Tunisie Présaharienne: étude gémorphologique* (Colin, Paris, 1962). For a summary, see (*18*, p. 320).
20. M. Couvert, *Libyca* **20**, 45 (1972).
21. A full discussion is forthcoming in D. Lubell, J-L. Ballais, A. Gautier, F. A. Hassan, *Libyca*, in press.
22. R. J. Chorley, in *Introduction to Fluvial Processes*, R. J. Chorley, Ed. (Methuen, London, 1969), pp. 53–73.
23. Data collected in 1972 and 1973. For similar observations on analogous species in other regions, see K. Schmidt-Nielsen, C. R. Taylor, A. Shkolnik, *J. Exp. Biol.* **55**, 385 (1971); P. A. Randolph, *Ecology* **54**, 933 (1973); C. A. Reed, *Postilla* **66**, 1 (1962).
24. G. Camps, in *La Préhistoire: problèmes et tendances*, F. Bordes and D. de Sonneville-Bordes, Eds. (Centre National de la Recherche Scientifique, Paris, 1968), pp. 87–101; J. Tixier, in *Background to Evolution in Africa*, W. W. Bishop and J. D. Clark, Eds. (Univ. of Chicago Press, Chicago, 1967), pp. 771–820.
25. The range of inter- and intraassemblage diversity appears to be much greater among *Capsien supérieur* assemblages than has been recognized so far. We have attempted low-level statistical comparisons using published typological indices for approximately a dozen assemblages and only in a very few instances are strong similarities observable. Further work will be published shortly.
26. See P. Vermeersch, *L'Anthropologie* **79**, 215 (1975) for additional observations on variation in Capsian lithic assemblages.
27. For a discussion of the Neolithic of Capsian Tradition and other Neolithic assemblages in the Maghreb, see (*4*); A. Gilman, thesis, Harvard University (1973); and C. Roubet, *Le Gisement du Damous el Amar et sa place dans le Néolithique de Tradition Capsienne* (Travaux du Centre de Recherche Anthropologique, Prehistoriques et Ethnographiques, Alger, 1968).
28. E. G. Gobert and R. Vaufrey, *Notes et Documents* (Direction des Antiquités et Arts, Tunis, 1950), No. 12, pp. 1–47; J. Roche, in *Die Anfänge des Neolithikums vom Orient bis Nordeuropa*, J. Lüning, Ed. (Böhlau, Köln, 1972), p. 98.
29. They have been observed in other Paleolithic sites. See, for example, G. Falkner, *Dtsch. Forschungsgem.* **15**, 112 (1969).
30. S. F. Cook and A. E. Treganza, *Am. Antiq.* **13**, 135 (1947).
31. A. Bowes and C. F. Church, *Food Values for Portions Commonly Used* (Lippincott, Philadelphia, 1966).
32. Based on data in M. Kubasiewicz, *Zachodnio-Pomerskie* **2**, 235 (19 T. E. White, *Am. Antiq.* **18**, 396 (1953).
33. R. B. Lee, in *Man the Hunter*, R. B. Lee and I. DeVore, Eds. (Aldine, Chicago, 1968), pp. 30–48.
F. A. Hassan, *Curr. Anthropol.* **14**, 535 (19 H. M. Wobst, *Am. Antiq.* **39**, 147 (1974).
35. J. T. Worgan, in *Proteins in Human Nutrition*, J. W. G. Porter and B. A. Rolls, Eds. (Academic Press, New York, 1973), p. 56.
36. We have calculated the average accumulation rate at Aïn Misteheyia at 4.2 centimeters per 100 years of overall occupation; that is, net occupation plus vacancy. The rate from the bottom date to the middle date is about 10 centimeters per 100 years, and from the middle date to the top date about 2.5 centimeters per 100 years. This suggests an overall span of about 3500 years.
37. Identification of this material was provided by Dr. W. Stewart, Department of Botany, University of Alberta.
38. Correct identifications of this material were provided by Dr. C. S. Churcher, University of Toronto.
39. T. C. Losey, *Archaeol. Soc. Alberta Newsletter (Edmonton)*, **28** (1971), and personal communication.
40. Supported by the Wenner-Gren Foundation for Anthropological Research (1972) and the Canada Council (1973–74) through grants to D.L., whose participation was facilitated by a sabbatical leave from the University of Alberta. R. Ouahes, Direction of Scientific Research, Algiers, authorized this research, which was aided by the cooperation of M. Mammeri, Director of Centre de Recherches Anthropologiques Préhistoriques et Ethnographiques, Algiers, and his colleagues G. Aumassip, M. Couvert, C. Roubet, and the late F. Roubet. D.L. was responsible for overall direction and archeology, F.A.H. for local geomorphology and paleoecology as well as reconstruction of the subsistence regime, A.G. for modern and prehistoric faunal studies, and J.-L.B. for regional geology and geomorphology. We thank A. Close and C. Chippindale of Cambridge University and J. Elmendorf of George Washington University for their enthusiastic collaboration during the field season. Palynological analyses were supervised by T. Habgood of the University of Alberta and sedimentological analyses were run by the Soils Department, University of Alberta. Figures 1 to 5 and 8 were drawn by I. Wilson, Cartographic Services, Department of Geography, University of Alberta. D.L. takes this opportunity to publicly thank F.A.H., Close, Chippindale, and Elmendorf for remaining in the field and completing work under way when he and A.G. were forced to leave due to illness. We thank K. W. Butzer and J. Tixier for advice and encouragement.

Californium-252 Plasma Desorption Mass Spectroscopy

Nuclear particles are used to probe biomolecules.

R. D. Macfarlane and D. F. Torgerson

An impressive array of modern analytical instruments and techniques is being used with increasing efficiency and detail, to identify and characterize complex biomolecules. Among these is the mass spectrometer, which can serve for analytical measurements and can give structural information as well from fragmentation patterns. Mass spectroscopy has had limited application, however, because it requires volatilization and ionization of the sample. Molecules, such as hormones, enzymes, peptides, and nucleic acids, that play a role in biochemical pathways or regulation are generally complex and exhibit strong intermolecular interactions in aqueous solutions and in the solid state. Solid samples of these compounds generally have low vapor pressures, which means that too few ions can be formed to obtain a mass spectrum. The simplest method for increasing the vapor pressure is to heat the sample. Thermally labile molecules, however, decompose when subjected to elevated temperatures, so that this method is not applicable to these compounds. One approach to the solution of the problem is to increase the sensitivity of the mass spectrometer so that measurable ion currents can be detected even at extremely low vapor pressures. McIver *et al.* (*1*) have developed a trapped ion cyclotron resonance mass spectrometer that can detect vapor pressures down to 10^{-10} torr, a factor of 10,000 better than an electron impact mass spectrometer with direct sample introduction.

R. D. Macfarlane is professor of chemistry at Texas A & M University, College Station 77843, and D. F. Torgerson is a senior scientist in the Cyclotron Institute at Texas A & M University.

Another approach is to enhance the rate of volatilization of the molecule while minimizing the rate of decomposition. Polar groups on the molecule, which produce the strong intermolecular interactions in the solid state that reduce volatility, can be modified chemically to nonpolar substituents, and the derivative will have a higher vapor pressure than the original molecule. This technique is widely used in mass spectroscopy and has the added attraction that the vaporized derivative can be analyzed by both gas chromatography and mass spectroscopy in a coupled mode (*2*). Beuhler *et al.* (*3*) showed that if a solid film of a peptide is deposited on a nonreacting surface such as Teflon, the vapor pressure of the peptide is effectively enhanced and vaporization can be effected at lower temperatures.

Heats of vaporization of biological molecules deposited on a solid surface are also reduced in the presence of a strong electric field gradient. This results in a "field desorption" of molecules and was first used by Beckey *et al.* (*4*) in mass spectroscopic studies of involatile biomolecules. A variation of this method was recently reported by Simons *et al.* (*5*), who were able to field-desorb molecular ions of sucrose and proline from liquid surfaces.

Volatilization with minimal decomposition is the objective in mass spectroscopic studies of biomolecules. The first step in the thermal decomposition of a molecule adsorbed on a surface is unimolecular fragmentation, which takes place when excitation to an unstable vibrational state results in bond cleavage. The rate of decom-