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Dating and redating Capsian skeletons 3A-4 and 3A-7, Aïn Berriche (Algeria)

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ABSTRACT

Aïn Berriche (also called Site 12) is a Capsian site, but Skeleton 3A-7 had been dated to thousands of years after the assumed end of the Capsian period. Questions about the date focussed on two features: 1. The skeleton appeared to have characteristics of the mortuary practices associated with the Algerian Capsian tradition; and 2. The skeleton was preserved with shellac after excavation, a possible source of contamination. Analyses were therefore undertaken to determine the extent to which the shellac penetrated the bone and to establish whether ultrafiltration of the collagen would help eliminate contaminants. In addition to re-dating 3A-7, we dated Skeleton 3A-4 which had a different mortuary treatment and was stratigraphically higher. Results are presented within the context of previous work on the Capsian.

1. Introduction

The Capsian is one of the several late Pleistocene-early Holocene archaeological industries identified in the Maghreb (modern Tunisia, Algeria and Morocco). It is dated between ca. 10,000 and 6000 cal BP, found primarily in eastern Algeria and Tunisia, and characterized by sites known as either *escargotières* or *rammadiya* because of their very high content of both land snail shells and ash (Lubell, 2001; Jackes and Lubell, 2008). Capsian groups are described as one of the last hunter-gatherer populations in northwest Africa (Rahmani, 2004). The stone tool industry is distinguished by two facies, the earlier Typical Capsian and later Upper Capsian, the change occurring around the time of the 8200 cal BP cold event, after which primary pressure technique was used for the production of blades and bladelets (Rahmani and Lubell, 2012). Although most Capsian sites are open-air, there are a substantial number also found in rock shelters. The majority of sites are found on the high interior plateau, but recent work in Tunisia (Mulazzani, 2013) has demonstrated the presence of coastal occupations as well.

Capsian sites frequently have burials, sometimes numerous, of people often called Mechtoids after the eponymous site of Mechta el-Arbi which was excavated during the first third of the 20th century. The mortuary practices at these sites can be complex (Aoudia-Chouakri, 2013; Jackes and Lubell, 2014).

It is important to emphasize here that the chronology and physical characteristics of these skeletons has led to continuing debate for nearly a century. Were Capsian populations indigenous to the region or intrusive (Lubell et al., 1984; Holliday, 2015)? Do all the burials found in Capsian sites actually date to the Capsian (Jackes and Lubell, 2014; Lubell et al., 2009; Pond et al., 1938)? While the data we will present here do not allow us to provide definitive answers for questions such as these, they do provide additional context for the discussion.

In this paper we provide new data on two individuals from Site 12, a large open-air Capsian escargotière, located at 35° 53′ 31.2″ N, 7° 22′ 21.8″ E in eastern Algeria near the town of Berriche (Jackes and Lubell, 2014; Fig. 1). The site is also known as Aïn Berriche due to its proximity to a spring (*aïn* in Arabic). It was excavated jointly in 1930 by two teams, one from the Logan Museum at Beloit College, Wisconsin led by Alonzo Pond and one from the University of Minnesota in Minneapolis led by Albert Jenks. While the teams collaborated, they excavated separate trenches (Jackes and Lubell, 2014; Jackes et al., 2014a).

We will deal only with the eight skeletons excavated by the Minnesota team, seven of which were on loan until late 2014 to DL and MJ. The location of the skeletons excavated by the Beloit team are at present unknown. Some details of these skeletons have been described elsewhere (Haverkort and Lubell, 1999; Jackes and Lubell, 2014). Here we will discuss the implications of dating for two of them, skeletons 3A-4 and 3A-7. The context provided is necessary to understand the limitations of our information, particularly for Skeleton 3A-7, as well as the importance of correct dates.

2. Previous attempts at dating

In 2004 and 2005, Sandra Garvie-Lok (University of Alberta) processed five rib samples for collagen. The uneven results highlighted problems with Site 12 human remains (Table 1).

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Table 1
Collagen yield data for the first series of samples.

U of A #	Burial	Collagen %	Comments by S. Garvie-Lok
MJ10	3A-1	12.7	Good sample quality
MJ06	3A-2	8.9	
MJ11	3A-3	0.0	Dissolved during processing
MJ17	3A-5	1.7	Very poor quality, results will be questionable
MJ05	3A-6	0.0	Degraded sample, dissolved in standard NaOH rinse

Three of these samples and an additional one from Skeleton 3A-7 were sent for AMS radiocarbon dating at IsoTrace (University of Toronto) and stable isotope analyses at the Environmental Isotopes Laboratory (EIL), University of Waterloo (Table 2).

The collagen extraction for the 3A-7 sample was done at IsoTrace. It was not included in the original analyses because multiple traumatic changes to the upper and lower post-cranial skeleton would have limited mobility (Jackes et al., submitted for publication) and could have led to atypical dietary values. We have observed similar instances in Portuguese Mesolithic skeletons: Arruda N and Samouqueira H2 (Jackes and Lubell, 1999: 29; Lubell et al., 2007: 212). Unfortunately, the atomic % C:N ratio of 3.10 for TO-12196 that we published (Jackes and Lubell, 2014; Jackes et al., 2014a, Table 2) was incorrect. We have now received the correct elemental % composition (pers. comm. R. Heemskerk, EIL, U. of Waterloo, 26/02/2015) and recalculated the accurate atomic % C:N ratio as 7.38 (Table 2). This is far outside the acceptable range of 2.9–3.6 and thus this date, which we described as "not concordant" (Jackes and Lubell, 2014: 104) with other evidence from the site, must be ignored. We provide the data here for information purposes only.

3. The context of 3A-7

Skeleton 3A-7 was excavated at the end of the field season and was neither sketched nor photographed. In contrast to the other skeletons, we have only the description in Wilford's field notes (Wilford, 1930a, crossed out text in original, metric measurements added in square brackets):

> Skeleton #7
> Found May 16 — Adult
> Surroundings — A dividing line of dirt between 1st level + middle level, a few inches thick. Below this a thick layer of shell with comparatively little dirt extended to floor dividing middle level from lowest level. This sk. was buried in the shell, and the dirt layer above it was unbroken, but the few inches above the sk. was dirt instead of shell.
> Location. (measured from upper end of spinal column)
>
> 51–5 E x 43–6 S
> Depth below surface — 4–11 [1.5 m]
> Depth below floor above 1–8 [0.51 m]
> Depth above floor below 2–2 [0.66 m]
> Depth above floor escargotière 5–3 [1.6 m]
> Position — Spinal column in E + W line — upper end east.
> Pelvis — 1 ft [.305 m] NW of spinal column tilted up on front side, femora in sockets and pointing SE across spine
> Scapulae, side by side, under leg on N side (left leg) one rt humerus under left leg, left humerus crossing over to rt femur where latter crossed the spine.
> Left forearm on outside of pelvis
> Rt forearm along right femur.
> Head, both tibias + both fibulas missing. Some lumbar vertebra with pelvis. Atlas vert. present, stained with red ochre. Red ochre found with burial.
> ~~Preservation Fair~~

Beyond this description of the disposition of the bones, we also have Wilford's account of his activities that day, during which he was profiling the trench: he wrote "At a time when we are so busy I hope we don't find too many skeletons" (Wilford, 1930b). Brown's notes for the day (Brown, 1930) include the following: "The men had finished the first level dirt down to the new floor. I, in providing them with dirt from the middle level discovered a skeleton… In the afternoon Lloyd worked on the skeleton, whose head seems to be missing…" The next day Brown wrote: "In the afternoon finished numbering and shellacking skeleton 7…" Wilford was sick that night. It is evident from this that little time was spent on recording and excavating Skeleton 3A-7. The records make clear that the next days were mostly employed in final sieving and sorting, cleaning, packing, as well as some labour troubles with the local men. This is very unfortunate because the skeleton itself is unusually interesting (Jackes et al., submitted for publication).

3.1. Skeleton 3A-7: burial disposition

Our re-examination of the skeleton has shown that there are many fragments — marked 3A-7 and exhibiting clean modern breaks — of which a number could be refitted. It is evident that the initial finding, or the subsequent excavation, caused extensive damage to the skeleton (perhaps explaining the strike-through of the "fair preservation" comment). Fig. 1 provides an interpretation of Wilford's description of the skeleton quoted above.

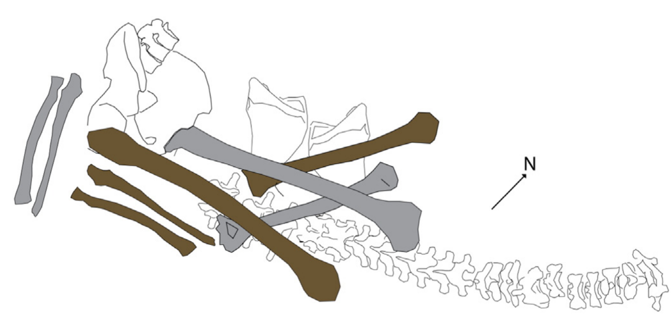

Fig. 1. Sketch to elucidate Wilford's description of how the bones of 3A-7 lay (darker long bones right, lighter left).

Table 2
Radiocarbon dates and stable isotope values for the first series of samples (2005).

Skeleton	U of A #	EIL #	IsoTrace # ^{14}C date BP	Collagen %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C %	N %	Atomic % C:N
3A-1[a]	MJ10	107877		12.7	−19.18	6.32	49.07	16.64	3.44
3A-2	MJ06	84085[b]	TO-12,195 7890 ± 100	8.9	−19.06	6.93	43.18	15.08	3.33
3A-5	MJ17	107882		1.7	−28.95		56.95		
3A-7[a]		109858[c]	TO-12,196 3090 ± 160	1.1	−24.02	9.02	31.34	4.95	7.38

[a] cf. Jackes and Lubell (2014).
[b] Average of two runs (Heemskerk pers. comm. 25/08/2004).
[c] Average of three runs (Heemskerk pers. comm. 26/02/2015).

Fig. 2. Skeleton 3A-4 on 10th April 1930, showing the lateral extended burial posture of about 180 cm length. All teeth were present (Logan Museum of Anthropology, Beloit College, negative 30-115a).

The curious circumstance that skull, tibiae and fibulae are recorded as missing, and the bones of the arms and shoulder girdle are clearly misplaced, is not unusual for this site (Jackes and Lubell, 2014). For some Site 12 skeletons the pelvic basin was maintained as an articulated unit, sitting either upright or with the ventral surface down. Large long bones might be missing and the bones of the forearm placed near the pelvis. Skulls were also sometimes missing, or placed beside or on pelves, or on the lumbar spine. The description provided by Wilford does not make it clear whether the vertebrae lay in ventral or dorsal decubitus: our reconstruction in Fig. 1 provides the most logical solution, given the description of the pelvis, and follows the pattern seen in 3A-1 (Jackes and Lubell, 2014), the most fully documented skeleton found in 1930.

Skeleton 3A-1 was recorded in detail because it was unusually complete, was dug by experienced excavators, and was one of the earliest and most interesting finds. Photographs show the vertebral column lay with the ventral surface down. The 3A-7 reconstruction is further supported by information on a comparable burial from Mechta el-Arbi, 112 km from Site 12, as the crow flies. The 1923 excavation there (Debruge, 1925: 130–133) revealed a skeleton which had the lower limb bones separated from the pelvis and still flexed partially upright as in 3A-5 (Jackes and Lubell, 2014). The skull, mandible, limb bones and podials lay beyond the pelvis, while the vertebral column extended forward from the intact pelvis, with both vertebrae and pelvis placed on their ventral surfaces. Ribs are not mentioned for 3A-7, but in both 3A-1 and the Mechta el-Arbi skeleton the ribs were retained generally in place below the vertebrae without slumping (Debruge, 1925: Fig. 4; Jackes and Lubell, 2014: Fig. 3). Found 1.4 m below the surface, the Mechta el-Arbi skeleton can be considered Capsian, lying on *Helix aspersa* (now called *Cornu aspersum*) shells and associated with charcoal and ash, and presumably with ochre. The skull and mandible from this burial, described and illustrated by Lagotala (1925) as Crâne masculin No. 1 H and known as the "type skull", are now at the University of Minnesota: three of the four maxillary incisors were evulsed.

The burial pattern at Site 12 seems to have involved post-mortem manipulation of the skeletons — almost certainly after the initial primary burial — combined with harvesting of long bones, especially of adults, sometimes for use as tools (Jackes and Lubell, 2014). On the basis of his records of other skeletons, we know that Wilford took note of the location of ochre: for 3A-7 he specified that the atlas had ochre. The atlas is no longer present with the skeleton, and it is possible that, in his haste, Wilford wrote "atlas" for axis. In the case of 3A-1, for example, the atlas was with the skull beside the pelvis, rather than with the axis which was in position cranial to the otherwise complete vertebral column. The 3A-7 axis does not have cut marks (Haverkort and Lubell, 1999: Table 1), but it does have ochre (there is also a faint smear of ochre on the superior lateral right clavicle, but not on the hyoid). The ochre on the axis is very restricted, found only on the dens, on the facet for the transverse ligament. This implies that the more heavily ochred atlas must have been there originally during the post-mortem manipulation, perhaps even before excavation (the atlas is shown in Fig. 1), and we might suggest that the atlas, the cranial base and the mandible could have had cut marks (a small fragment of a mandibular horizontal ramus is present among the bones marked 3A-7). The scapulae and both clavicles, two ribs and lumbar vertebrae have cut marks and the first sternal body has one or two very fine cuts. One cut on the medial end of the right clavicle is unusually deep (Haverkort and Lubell, 1999: Fig. 16). Given our knowledge of the method of digging and the circumstances of the find, we must consider whether Brown might have hit the clavicle with a shovel as he brought down sediment from the vertical excavation face to provide the local men employed on the site with work, shifting soil and sieving, but in this case excavation trauma can probably be excluded.

Dental evulsion is a marker of the Capsian tradition for adult burials, with the removal of various numbers of incisors in both males and females, including those at Site 12 (Humphrey and Bocaege, 2008). The skull having been removed, we are unable to use this as an identifier. In the absence of a reliable date, the Capsian attribution of 3A-7 must depend on the post-mortem manipulation and removal of bones.

The inclusion of fragments of mammalian fauna with the human bones, given catalogue markings by the excavators, is characteristic of the Minnesota trench Site 12 burials. It is of interest to determine whether dates for the faunal material confirm or refute our interpretation of continuing disturbance of the original burial over an extended period of time.

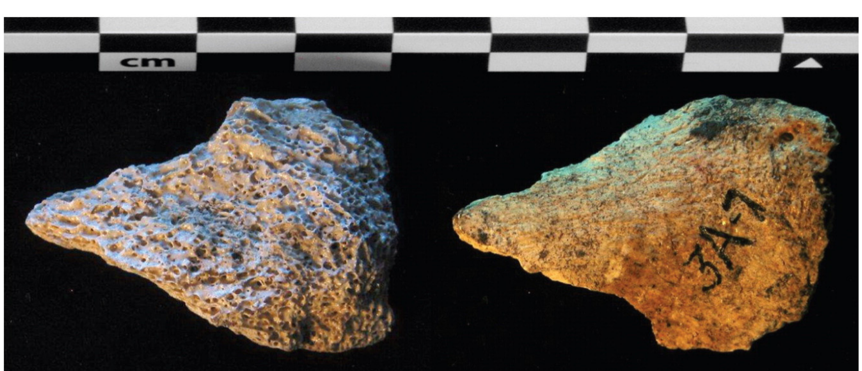

Fig. 3. Two views of the 3A-7 anterior distal right femur fragment used for date TO-12,196.

Fig. 4. 3A-7 left twelfth rib (3A-7.01).

3.2. Skeleton 3A-4: burial disposition and location

Skeleton 3A-4 was an extended burial. Such burials were commonly found during the 1930 Logan Museum excavations both at Site 12 and at other sites in the area. They were interpreted as "Arab" burials, or mediaeval burials (Pond et al., 1938: 105–107), but none has ever been dated. Skeleton 3A-4 was the only one of these burials found in the Minneapolis trench, but it shared the characteristics of others considered to be intrusive: complete extended burials (Fig. 2), lying fully or partly on the right side, higher stratigraphically, without incisor evulsion or apparently any association with ochre. Brown's diary for 15th March (Brown, 1930) records the immediate reaction when the first of these burials was found in the Beloit Main Trench: "The skeleton in Mr. Pond's trench being intrusive was not of such great importance". The cultural differences from the Capsian burial practices seem clearly evident but the stratigraphic position and dating of some other complete skeletons from the site are problematic.

The most proximal portions of 3A-4 and 3A-7 were about four feet [1.22 m] apart horizontally, in an area where the mound surface sloped down about a foot [30 cm] from the location of 3A-7 to the location of 3A-4. Skeleton 3A-7 was 4′11″ [1.5 m] below the surface, while 3A-4 was 1′3″ [38 cm] below the surface. Stratigraphically, the two burials were quite distinct. The description of the placement of 3A-4 is clear. The burial was in the topmost shell level, 10 in. [25 cm] within the shell (Jackes and Lubell, 2014; Fig. 2). The shell level, however, was not continuous above the skeleton which was covered with a mixture of black dirt and loose shell. The records on the burial from Wilford's diary and field notes, and from Brown's diary, are sufficiently detailed to allow us to conclude that it was intrusive into the Capsian deposits, with the burial pit cut into the upper shell level. The interest in the date is that, until the analysis reported here, there has been no way in which to move beyond the conclusion that "The skeleton found late last night proved to be an intrusive burial probably very recent" (Wilford, 1930b).

Although it was actually at some depth below the surface — especially the post-cranial area, which was lower than the skull and extended from south to north up and across the mound — the 3A-4 bone was friable. The condition of the bone may be partly explained by the fact that the burial was discovered late on 5th April and fully exposed early on 7th April, but was not lifted until 10th April. The night of the 7th rain began, and it snowed or rained all through the 8th and 9th April.

4. Radiocarbon dating of skeletons 3A-7 and 3A-4

In view of the apparently clear association of 3A-7 with Capsian burial practices, it was a surprise when our first attempt to date collagen from 3A-7 placed it outside the Capsian time period: TO-12196, 3090 ± 160 BP. Collagen from another skeleton, 3A-2 gave a date within the expected range: TO-12195, 7890 ± 100 BP. Two charcoal dates are also available from the site. The charcoal samples were from levels 3 and 4 in a Beloit trench excavated by the more experienced and senior students on the team. These levels lay between 1 m and 2 m below the surface, potentially stratigraphically equivalent to the deposit containing 3A-2 at just over 1 m below the surface, and the dates fit within the expected range for the Capsian: SMU-1132, 7330 ± 390 bp and SMU-1135, 7780 ± 250 bp (Sheppard, 1987).

The date for 3A-7 was therefore completely unexpected and we had no explanation for the discrepancy, unless the shellac, animal glue and wax used to conserve and reconstruct the Site 12 bones had contaminated the sample to such an extent that the collagen extraction process had been compromised. The sample, a femur fragment labelled 3A-7 (Fig. 3), was definitely from the individual: the fragment could be refitted to the anterior distal femoral shaft. The stable isotopes suggested a diet rather different from that of skeletons 3A-1 and 3A-2, but there was too little known about Maghreb stable isotope values for us to interpret those data (Jackes and Lubell, 2014).

In view of the obvious Capsian affinities of the mortuary details, our attention focused on the post-excavation treatment of the skeleton. The bone had been shellacked and the distal femur had at one point been reconstructed with wax. The wax had dried and the reconstruction had fallen apart during a long period of storage (1930–1980) in less than ideal conditions at the University of Minnesota. No wax or glue was seen on the initial dating sample, but Fig. 3 shows the generous application of shellac to the surfaces.

The Site 12 skeletons were returned to the University of Minnesota in October 2014, at which point we were given permission to undertake further analyses. Because of the multiple abnormalities in the skeleton and our concerns about the accuracy of the original date, we decided to date 3A-7 again using special procedures to ensure there was no contamination from shellac, glue or wax. While it has not been possible to confirm from the Minnesota records exactly what preservation products were used, and the Beloit records are no longer available, we assume all of these had a biological origin.

4.1. Determining possible contamination

In order to examine the depth of penetration of the shellac, a cross-section of a sample of a 12th rib from 3A-7 (Fig. 4), labelled 3A-7.01, was imaged using the low vacuum mode (30 pa at 20 kV) of the JEOL 6610LV SEM at the Earth Sciences MicroAnalytical Laboratory (University of Ottawa — Canadian Museum of Nature). A small piece of the animal glue which had been submitted as sample 3A-7.02 was also analysed, but no defining characteristics were observed: there were only a carbon and an oxygen peak.

The SEM image revealed a distinct, 10–20 μm-thick layer of shellac on the exterior of the bone (Fig. 5). Chemical characteristics from spectrum 1 (shellac) and 2 (bone) reveal that the distinguishing characteristics of the shellac are higher carbon and much lower phosphorous and calcium. Results from the elemental analysis are shown in Table 3. Spectrum 2, analysing the bone, was very encouraging, in that the calcium phosphorus ratio of the bone at 1.8 is close to what can be expected of bones from a

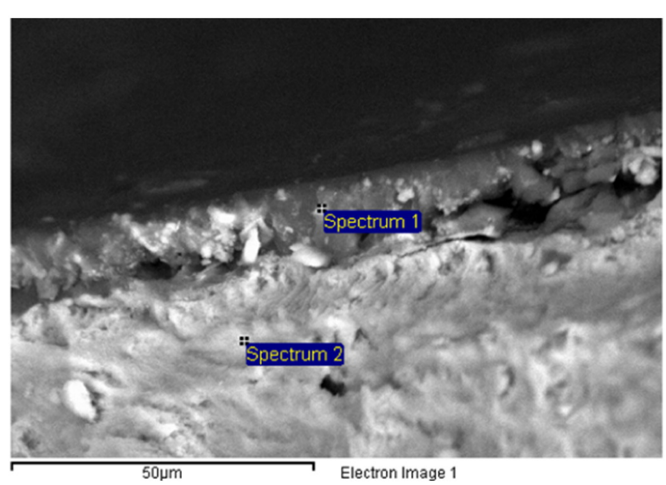

Fig. 5. SEM image of cross-section of sample 3A-7.01, showing layer of shellac (spectrum 1) overlying bone (spectrum 2).

Table 3
Chemical composition of the shellac (spectrum 1) and the bone (spectrum 2) shown in Fig. 5. Oxygen by stoichiometry (normalized). All results in weight %.

	C	Na	Si	P	S	Cl	K	Ca	Ti	Zn	O	Total
Spectrum 1	26.67		0.09	0.23	0.07	0.21	0.18	0.51	0.05	0.13	71.86	100
Spectrum 2	17.17	0.57		7.31	0.36			13.34			61.25	100

midden site rich in bone and shell (Jackes et al., 2001). We could anticipate that the sample would provide a good date and that the shellac could be removed by physical abrasion, which would be cleaner and possibly more thorough than a Soxhlet-type extraction.

4.2. A new date for skeleton 3A-7

In 2015, a new set of samples for radiocarbon dating was sent to the A.E. Lalonde AMS Laboratory (University of Ottawa). This set included a 12th rib from 3A-7 (3A-7.01), two non-human bones associated with 3A-7 (3A-7.04 and 3A-7.05) and a rib fragment from 3A-4 (Fig. 6). Based on the results of the SEM analysis, the shellac was removed using a dremel tool set to low speed.

Following Brock et al. (2010), the bones were first decalcified with 0.5 N hydrochloric acid (3 or 4 rinses over ~18 h, room temperature), treated with 0.1 N sodium hydroxide (30 min, room temperature), and 0.5 N HCl again (30 min, room temperature). Each step was followed by three rinses with MilliQ water. The samples were gelatinized at 70 °C overnight at pH 3, then filtered using a cleaned glass Whatman™ autovial syringeless filter. A sample of the 3A-7 rib and 3A-4 bone also underwent ultrafiltration in order to test whether further contaminants would be removed by isolating the longer chain collagen proteins. The ultrafilters (Vivaspin™ 30 kDa MWCO) were cleaned by centrifuging with MilliQ two times, 15 min of ultrasonic cleaning in MilliQ, then centrifuged again three times with MilliQ (Bronk Ramsey et al., 2004). The sample was then centrifuged in the ultrafilter and the >30 kDa fraction was removed and freeze dried.

After sampling for radiocarbon dating, the extracted collagen was submitted to the GG Hatch Stable Isotope Laboratory (University of Ottawa) for carbon and nitrogen stable isotope analysis by isotope ratio mass spectrometry (IRMS, Delta Advantage). One of the non-human bones (3A-7.05) as well as both samples from 3A-4 lacked sufficient collagen for stable isotope analysis.

A portion of the 3A-4 rib sample (Fig. 6) processed without ultrafiltration yielded no collagen. A second portion that was extracted and ultrafiltered, did provide collagen that could be analysed and resulted in a date with a midpoint of the full 2σ range of around 3800 cal BP. While the more friable condition of the bone and the large standard error for UOC-0426 resulting from low CO_2 yield and low current on the AMS mean the date for 3A-4 is not precise, we can suggest that the upper level extended burials excavated in 1930 are neither Capsian nor Islamic.

The cultural differences from the Capsian practices being evident, the 3A-4 date provides some resolution to the question raised earlier as to whether or not extended burials found in Capsian sites are "Arabic". While they are known at other Capsian sites (Aoudia-Chouakri, 2013), the best documented are two (H2 and H3) at Medjez II (Camps-Fabrer, 1975: 301–314), neither of which appears to have had tooth evulsion. Unfortunately, none of the known extended burials is well controlled chronologically. Camps-Fabrer (Camps-Fabrer, 1975: 304) believed that "On a trop souvent…rejeté tous les squellettes trouvés en position allongée dans les gisements capsiens", but the AMS date for 3A-4 reported here may help to resolve the question.

Fig. 6. The rib fragment used for dating 3A-4.

5. Stable isotopes: the Capsian context

There are no comparative data for the inland Algerian Capsian diet to work with, apart from a previously unpublished series of mammalian herbivore samples collected in 1978 from Kef Zoura D (Jackes and Lubell, 2008). Table 5 shows the material analysed so far. KZ-a to KZ-e, from deposits both within (KZ-a, x and d) and a test trench in front of the shelter (KZ-b, c and e), were analysed in the 1980s at MacMaster University and had a collagen % yield range of 0.5 to 17 (collagen extracted using the modified Longin method, data provided by H.P. Schwarcz, pers. comm. 06/05/1985). The associated charcoal dates were run at the Southern Methodist University Radiocarbon Laboratory (Haas, 1987: 233–234). The KZ-f and KZ-g bone samples were analysed in 2015 (collagen extracted by Crann, dated at the A.E. Lalonde AMS Laboratory, stable isotope analysis at the Hatch Laboratory). These two samples have excellent C:N ratios of 3.1 and 3.2.

The stable isotope data for mammalian long bone fragments given in Table 5 are broadly comparable with the value for the 3A-7.04 faunal bone shown in Table 4. Further values are provided by Aïn Misteheyia H1, a burial from a Capsian site in the same valley as Kef Zoura D (Table 6), and around 90 km (as the crow flies) from Aïn Berriche. However, this skeleton may be post-Capsian: the 2σ range at 100% probability of 5334–5890 cal BP, would require a redefinition of "Capsian" were the burial to be inarguably identified as Capsian (Lubell et al., 2009). Aïn Misteheyia H1 was complete, in left lateral decubitus and flexed, without evidence of dental evulsion (Meiklejohn et al., 1979).[1] This appears to be true also of Skeleton 8 in the Beloit Main Trench at Site 12 (Jackes and Lubell, 2014). Whether the flexed burials represent a tradition which is different, and older, than that of the extended skeletons laid on the right sides cannot be determined at present. Undated skeletons from Tunisia are reminiscent of certain Beloit Main Trench burials (Jackes and Lubell, 2014; Munoz et al., 2013).

Fig. 7 shows the stable isotope values for skeletons 3A-1, 3A-2 and 3A-7 and eight non-human mammalian bones from grazers with a predominantly grass diet (the area generally lacks C_4 plants, cf. Shipp et al., 2013). The expected trophic level shift for the human samples cannot yet be determined, especially because of the complication introduced by the uncertain proportion of land snails in the human diet. The species of land snails in these sites today live on senescent grasses, juniper and other low growing vegetation (Lubell, 2004), and this would tend to give consumers of snails more negative $\delta^{13}C$ values, as will be explained below. Snails were certainly part of the human diet, but the Kef Zoura D and Aïn Misteheyia faunal assemblages show that mammalian herbivores were common sources of animal protein — hartebeest (*Alcelaphus buselaphus*) is an important food item at Kef

[1] The left lower central incisor is missing, but abnormal wear was not noted on the opposing or neighbouring teeth. The Aïn Misteheyia individual is adult and therefore had not had normal Capsian evulsion in early adolescence (Jackes and Lubell, 2014: 99). Poor preservation no doubt explains the missing tooth.

Table 4
Radiocarbon dates and stable isotopes for human and non-human bones from Site 12, Minneapolis trench.

Sample ID	Lab ID	^{14}C age BP	cal BP 2σ range and probability[a]	Collagen yield%	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C %	N %	Atomic % C:N
3A-7.01 human rib	UOC-0422[b] B1415-478-001	8043 ± 58	8700–9092 p = 98.9%	16.6	−19.48	8.97	36.82	13.14	3.3
3A-7.01 UF[c] human rib	UOC-0423 B1415-478-002	8024 ± 55	8695–9030 p = 98.0%[d]	12.2	−19.36	9.12	30.02	10.68	3.3
3A-7.04 non-human	UOC-0424 B1415-478-003	7812 ± 57	8430–8771 p = 100%	20.07	−20.49	5.02	20.23	7.16	3.3
3A-7.05 non-human	UOC-0425	6940 ± 708	6309–9330 p = 99.5%	12.58					
3A-4.01 UF[c] human rib	UOC-0426	3435 ± 416	2752–4836 p = 100%	2.05					
3A-4.01 human rib	UOC-427			0.49					

[a] Calibration using CALIB 7.0.2 (Stuiver and Reimer, 1993) and IntCal13 (Reimer et al., 2013).
[b] Stable isotopes — average of 2 analyses for this sample only.
[c] Ultrafiltration processing.
[d] Compare with date of 3640–2865, 2σ range at 99.9% probability, for TO-12196.

Zoura D and dominates the Aïn Misteheyia mammalian fauna (Lubell et al., 1976; Jackes and Lubell, 2008: Fig. 6). The diet of 3A-7 may well have been slightly unusual, in that his mobility would have been severely restricted by abnormalities and trauma in his feet, ankles, back, arms and shoulder girdle.

The diet of Aïn Misteheyia H1, some thousands of years later (5334–5890 cal BP), apparently differed from what we know of the Capsian period in inland Algeria, and it is very unfortunate that no information could be recovered from Skeleton 3A-4 which may also date to a later period. We are thus not able to comment reliably on dietary change, possibly involving some dependence on sheep/goat herding. Aïn Misteheyia H1 may indicate that a change from the Capsian consumption of land snail flesh did not result in a very marked change in $\delta^{13}C$ values, at least, as long as terrestrial herbivores consuming C_3 plants made up a substantial part of the diet, in that the trophic level offset appears minimal. However, it is of interest that the Aïn Misteheyia H1 $\delta^{15}N$ value is higher than that of the two human skeletons from Hergla, a Capsian site on the Tunisian coast dated between ca. 8000 and 7000 BP (Saliège et al., 2013: Table 10.1), where collagen content and atomic % C:N ratios suggest that the values of $\delta^{13}C$ (−14.5‰) and $\delta^{15}N$ (10.4‰) for skeleton SHM-2 may be the most reliable result (Mannino and Richards, 2013: Table 24.1).

While no analyses have been done on snail flesh from the area of the Algerian sites, there is published information on the $\delta^{13}C$ of living

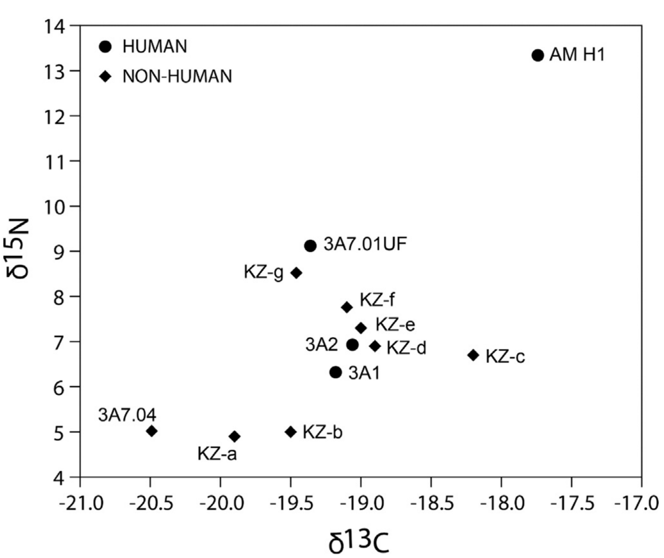

Fig. 7. Stable isotope values (‰) for human and non-human bone: AM = Aïn Misteheyia, KZ = Kef Zoura D. For KZ samples, see Table 5; for AM H1, Table 6.

Helix melanostoma (the most common snail in Capsian sites) from Gebel al-Akhdar region in Cyrenaica near the modern Libyan coast (Prendergast et al., 2015). The flesh of the snails had $\delta^{13}C$ values (mean − 25.3 ± 1.6‰) that were not significantly different from those of the surrounding soil and plants (with limestone bedrock and calcareous soils, as at Aïn Misteheyia, Kef Zoura D and Site 12). The small offset of the Site 12 human bone against the mammalian bone could indicate that land snails provided a greater amount of animal protein in the human diet than previously estimated (cf. Lubell et al., 1976), but the data are too limited. Furthermore, the continuing disturbance of Capsian burials, and the inclusion of extraneous hearth sediments and other materials, means that the dates for 3A7.01UF and 3A7.04 (a faunal fragment accompanying the burial) are significantly different (p = .044 one tail T test).

The relative humidity of the climate for inland Capsian sites may be relevant to the snail $\delta^{13}C$ values which varied through time, judging from the work of Faber (2012); see also Faber et al. (2008) on *H. melanostoma* shells dating to the Capsian period. Faber also analysed the aragonite of modern *H. melanostoma* collected in 1973 from Aïn Misteheyia (Table 7).

The Télidjène Basin, where both Aïn Misteheyia and Kef Zoura D are located, is now extremely dry, but the modern shell figures are within the range for the Libyan sample. Analyses of charcoal from Kef Zoura D (D'Andrea et al., forthcoming) show that juniper, buckthorn, pine, pistachio and willow were present at the time of the Capsian occupation, confirming the general similarity to vegetation in the area of collection of the Libyan samples. The work of Prendergast et al. (2015) on the *H. melanostoma* $\delta^{13}C$ body values allows us to make some inferences using the data in Table 7. We infer that Aïn Misteheyia 1973 shell $\delta^{13}C$ values indicate 1973 snail flesh $\delta^{13}C$ of −23.6‰ to −25.6‰.

Faber (2012) worked on Capsian snail shells from several species, but we will focus on the *H. melanostoma* samples from Aïn Misteheyia Square M8 (depth below datum from 20 cm to 160 cm) and the Kef Zoura D samples (from around 1 m below datum within the rock shelter to 4.25 m below datum in test pits below the rock shelter). While the Table 7 data suggest a mean difference between the archaeological and modern shells which might be ascribed to the effects of industrialization on the atmosphere (Suess effect), the following discussion focusses on predictions of body from shell $\delta^{13}C$ values in one species from sites with indications of similar plant availability.

The Capsian shell values varied through time, but never fell below a predicted snail meat $\delta^{13}C$ of −24.0‰ (based on the shell value predicted at −10.6‰ by Prendergast et al., 2015: Table 4). We might expect that Capsian *H. melanostoma* flesh $\delta^{13}C$ values ranged to a high of at least −20‰ since Prendergast et al. (2015) have suggested that *H. melanostoma* shell values are on the order of 14–15‰ higher than

Table 5
Kef Zoura D 1978 excavations, herbivorous mammalian bone samples from the rock shelter and a test trench. Calibration using CALIB 7.0.2 and IntCal 13.

Bone sample and provenance	Unit/cm bd	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	Associated radiocarbon dates cal BP 100% 2σ range
KZ-a: C20	Unit I	−19.9	4.9	6533–7156 (1 charcoal date)
KZ-x: F20D#377	Unit IIIb/120	−22.0	–	8186–8341 (pooled mean of 4 charcoal dates)
KZ-d: G20A#479	Unit IV/139	−18.9	6.9	9139–9739 (pooled mean of 2 charcoal dates)
KZ-b: T20-5	170–180	−19.5	5.0	10,259–11,088 (1 charcoal date 270–280 cm bd)
KZ-e: T20-5	260–270	−19.0	7.3	
KZ-c:T20-5	280–290	−18.2	6.7	
KZ-f: T20-5	170–180	−19.10	7.76	8415–8949 (UOC-0911 on bone)
KZ-g: T20-5	240–250	−19.46	8.52	9094–9463 (UOC-0912 on bone)

Table 6
Radiocarbon dates and stable isotope values for Aïn Misteheyia H1.

Site	Sample	cal BP	Collagen %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C %	N %	Atomic % C:N
AM H1	Pta-MC1225[a]	5000 ± 220		−18.7				
AM H1[b]	TO-12,194	4890 ± 80	1.6	−17.74	13.34	40.64	14.54	3.26

[a] Not AMS (J.C. Vogel, pers. comm. 22/07/1977).
[b] Collagen extracted by Garvie-Lok (University of Alberta); stable isotopes analysed by Environmental Isotope Laboratory (University of Waterloo).

body values: they published a mean snail flesh $\delta^{13}C$ of −25.3 ± 1.6‰, compared with a mean snail shell $\delta^{13}C$ of −10.8 ± 0.07‰. On these grounds, the Capsian human bone $\delta^{13}C$ values no doubt reflect both snail meat and mammalian herbivore flesh in the diet. Lubell et al. (1976) estimated that snail flesh would provide no more than 17% of the animal protein in the Capsian diet at Aïn Misteheyia, but Fig. 7 appears to suggest that the proportion of snail meat might have been sufficient to partially negate the trophic level offset of human from faunal bone and influence dietary $\delta^{13}C$ values in human bone. The extremely limited information from Site 12 shows some offset but we are unable to analyse the bone chemistry of the one human skeleton known from Kef Zoura D and it needs to be emphasized that the Kef Zoura D faunal samples cover thousands of years (Table 5) of climate change.

6. Conclusions

It is important that we do not ignore the collections of human material from old excavations held in museums and universities. Such collections, however, hold particular drawbacks for researchers of modern chemical analysis, besides documented problems with "museum taphonomy" (e.g., Roksandic and Jackes, 2014: 116). The use of modern dating techniques and chemical analysis can provide much needed assistance in two areas: 1. The reconstruction of old excavations for which there are inadequate coordinated records, with a better understanding of the stratigraphic relationships among burials (Jackes et al., 2014b); and 2. More extensive data on dietary and other factors now available through enhanced techniques.

There can be problems associated with chemical analysis of museum collections from old excavations. These lie in the earlier methods used to stabilize, conserve and reconstruct human and other bones using biologically based materials. In the case of Skeleton 3A-7 from Aïn Berriche, an important individual was first given a date and stable isotope values far outside expectations for an individual with the burial mode characteristic of the Capsian. The redating and reanalysis presented in this paper bring that individual into the time period and the stable isotope value ranges consonant with the site, the stratigraphic level and the burial mode. Whatever the cause of the original erroneous results, it is obvious that the extra care taken in the current analysis of 3A-7 was important in demonstrating good preparation methods for collagen extraction in samples with conservation and reconstruction contamination.

While ultrafiltration did not result in a dramatic change in the quality of the collagen sample for 3A-7, it provided confirmation of the results and tightened the age estimate, so that we can be confident in using 9000–8700 cal BP (3A-7.01 UF, Table 4) as a reasonable range for the date. In the case of 3A-4, however, ultrafiltration was vital in at least producing a date, the most important piece of information for this individual. For 90 years or so, burials like 3A-4 have been problematic for those researching the Capsian. It was completely unclear whether they were intrusive, perhaps nineteenth century, or mediaeval, or Neolithic, or in fact a mode of burial in the later phases of the Capsian. As imprecise as the date achieved by ultrafiltration preparation of the collagen is, we now know that some extended lateral decubitus burials in Capsian shell mounds are from around 3000 to 5000 years old, and thus younger than the Capsian by at least 1000 years. This constitutes a breakthrough in our understanding of burials similar to 3A-4.

It is important also to confirm that what we understood to be Capsian burial practices of a unique character, do actually represent a certain time period. The importance of confirming that Skeleton 3A-7, with its multiple traumatic changes, is Capsian, is a clear advance for the interpretation of survival and lifeways in the face of palaeopathological conditions during the Capsian. Dating of associated faunal bone, while in one case not fully successful, allows us to realize that the post-mortem manipulation of one human burial took place over an extended period.

Finally, the paper provides the opportunity to bring together a range of published and unpublished information on an important inland area in the Maghreb. Our results establish a firmer footing for the study of Capsian bone chemistry and diet.

Table 7
Helix melanostoma shell $\delta^{13}C$ values (Faber, 2012).

Site/sample	n	range	mean
Aïn Misteheyia/modern	3	−10.2‰ to −9.6‰	−9.9‰
Aïn Misteheyia/archaeological	23	−10.6‰ to −5.8‰[a]	−9.0‰
Kef Zoura D/archaeological	8	−10.8‰ to −8.1‰	−9.3‰

[a] Only one outlier sample fell below −7.0‰.

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